Public-Private Partnership for the Saint Lucia Coral Restoration Programme for Resilient Ecosystems and Sustainable Livelihoods

Final Report

Report prepared by Owen day and Newton Eristhee of CLEAR Caribbean Ltd, April 2020

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Summary

This final report outlines the activities carried out by CLEAR Caribbean Ltd. for the period from February 21st 2019 to March 31st 2020 under the agreement with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), for the project entitled **Public-Private Partnership for the Saint Lucia Coral Restoration Programme for Resilient Ecosystems and Sustainable Livelihoods.** This project is part of the Caribbean Aqua-Terrestrial

Solutions (CATS) programme and is a partnership that also includes the Department of Fisheries (DOF) in the Ministry of Agriculture, Fisheries, Physical Planning, Natural Resources and Co-operatives, the Soufriere Marine Management Association (SMMA), the Caribbean Public Health Agency (CARPHA) and Sandals Foundation.

The CATS programme is funded by the German Federal Ministry of Economic Cooperation and Development (BMZ) and implemented by the Caribbean Public Health Agency (CARPHA) on behalf of the Caribbean Community (CARICOM), and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) in association with a number of other partners.

The overall aim of this project was to establish a public-private partnership for a coral restoration programme that would create livelihood opportunities in vulnerable fishing communities and increase the resilience and ecosystem functionality of inshore coral reefs around Saint Lucia.

The activities in this project focused on the following:

- Expand coral nurseries and restoration programmes with local partners
- Propagate second generation clonal lines of all corals, and use only second-generation corals for restoration programmes
- Develop a monitoring plan to track the progress and performance of out-planted corals
- Develop manuals and implement training workshops for local partners
- Train local partners in scuba diving, coral restoration techniques and basic coral reef ecology using relevant modules from the National Vocational Qualification (NVQ) in Coral Reef Restoration
- Develop a communication strategy for the nursery and outplanting programmes
- Develop a sustainable financing mechanism with Sandals Foundation and Sandals Resorts International
- Analysis of coral genotypes by specialist laboratory and coral geneticist

Background

The Caribbean is considered to be one of the most vulnerable regions in the world to the impacts of climate change with coastal communities and low-lying areas being particularly exposed to the combined threats of sea level rise (SLR) and extreme weather events [1]. The economic cost of adapting to SLR have been estimated to be between US$26 and 61 billion in capital costs and US$4 and 6 billion in annual costs by 2050, increasing rapidly thereafter [2]. The magnitude of these costs will depend largely on the fate of the region's coastal ecosystems, which in many cases are the only coastal defence. Healthy coral reefs can provide highly effective coastal protection, dissipating over 80% of wave energy, producing

sand to replenish protective beaches and dunes, and able to grow vertically at the same rate as SLR [3].
The dramatic decline of Caribbean coral reefs in the past four decades is therefore a major threat to the region's ability to adapt to climate change. The decline in live coral cover (50% reduction since the 1970s) is not only accelerating coastal erosion, with 80% of beaches currently eroding, but is also having profound impacts on the region's tourism and fisheries sectors, and potentially undermining the economic sustainability and food security of many small islands. The annual value of the ecosystem services provided by Caribbean coral reefs has been estimated to be around US$2.7 billion for tourism, $400 million for fisheries and between US$1 billion to US$2.8 billion for shoreline protection even as assessed in their current, degraded state [4A]. In St Lucia in 2008, these values were estimated to be between US$160-194 million for tourism, US$0.5-0.8 million for fisheries and US$28-50 million for shoreline protection [4B].

If left unchecked, the rate of decline of Caribbean coral reefs is expected to increase in the coming decades because of climate change and the combined effects of mass coral bleaching and ocean acidification [5-9]. The World Bank has placed the magnitude of the economic losses at about 8 to 11 billion dollars per year by mid-century if 90% of the reefs disappear. Interventions that slow down or reverse the loss of coral reefs are increasingly recognised by CARICOM and the Caribbean Community Climate Change Centre as priorities for adaptation to climate change.

New approaches in coastal management are changing the outlook

A growing body of evidence has shown that overfishing and pollution have been the main causes in the decline of Caribbean coral reefs, and that once these local stressors are reduced, coral reefs are more able to recover and adapt to the impacts of climate change [10-12]. Protecting and restoring populations of herbivorous fish has been found to be particularly important in improving the ecological resilience of coral reefs and their ability to recover after major disturbances, such as bleaching events, storms or sedimentation [13-15].

There are over 250 MPAs in the Caribbean, but only a minority of those have been effective at restoring coastal ecosystems. Effective MPAs tend to be those established with policies that encourage local communities to benefit from the resulting improvements in fishery and tourism revenues [15-18]. Highly successful MPAs have been established in Belize, Jamaica, Bonaire, Bahamas with spectacular recoveries in fish biomass (1300% increase in 3 years in Oracabessa in Jamaica) and in some cases rapid increases in coral cover. In all cases, community involvement was central to their success, and economic diversification a key driver of local support. Not surprisingly, a recent review by FAO [19] found that policies that provide incentives for communities to support and engage with the management of MPAs and fisheries generally produce much better results. In SIDS worldwide, there appears to be a growing policy consensus towards Locally Managed Marine Areas (LMMAs) that secure greater local ownership, encourage compliance and support livelihood diversification. These advances in marine policy can also benefit from new technologies for spatial planning, enforcement, monitoring and communications that not only reduce management costs but also engage a wider circle of stakeholders with a vested interest in the future of reefs.

New financing mechanisms and private sector partnerships are being established that support MPAs with a focus on tangible results and benefits [20]. In Jamaica and the Eastern Caribbean, functional partnerships between governments, local communities and the private sector were established as part of the C-FISH Initiative. The C-FISH partners had a vested interest in the success of their local MPAs and participated in supporting sustainable financing for the MPA and the economic diversification of local fishing communities [21].

Corals can now be actively grown and restored at scale

The recovery of coral reef ecosystems can also be greatly accelerated by actively restoring key coral species. Developed initially in the Indo-Pacific and Red Sea regions, coral gardening methods have been increasingly implemented in the Caribbean, where efforts have targeted almost exclusively on the branching corals Staghorn (*Acropora cervicornis*) and Elkhorn (*Acropora palmata*), that were once the dominant reef-building corals in the region. Due to a combination of biological and anthropogenic stressors, both Acroporids suffered significant declines with estimated population losses of up to 95% [22], leading to their listing as threatened in the US under the Endangered Species Act in 2006 and as critically endangered in the International Union for Conservation of Nature (IUCN) Red List of Threatened Species in 2008 [23]. Acroporids exhibit particularly high growth rates relative to other corals, enabling sustained reef growth during previous sea level changes (e.g. Pleistocene). Additionally, both species have large branches, providing essential habitat for other reef organisms, particularly fish. They are critically important for the Caribbean, in terms of reef growth, island formation, fisheries habitats, and coastal protection.

Value of Acroporids for coastal protection

A recent review [3] provided the first quantitative meta-analysis of the role of coral reefs in reducing wave energy across reefs in the Indian, Pacific and Atlantic Oceans. Combined results across studies showed that coral reefs dissipate 97% of the wave energy that would otherwise impact shorelines. Most (86%) of the wave energy is dissipated by the shallow reef crest - making this relatively high and narrow geomorphological area of the reef the most critical in providing wave attenuation benefits. After depth, another critical factor in wave attenuation is bottom friction, which is a function of bottom roughness. The branching structure of Acroporids makes them particularly effective at dissipating wave energy (i.e. lattice turbulence). The loss of Acroporids across the Caribbean has decreased both the height and roughness of reefs, particularly the reef crests, and hence their ability to dissipate wave energy and reduce coastal erosion. Coral restoration projects designed for coastal protection and hazard mitigation, and not just for tourism and fisheries, are now recommended as an adaptation strategy [3].

Analyses done by the re-insurance industry on the economics of climate adaptation across eight Caribbean nations [24] examined the costs and benefits of some 20 different approaches for coastal risk reduction and adaptation, from reef restoration to new building codes. The study found that reef restoration was always substantially more cost effective than breakwaters across all eight nations considering only coastal defence benefits. As living structures, reefs also have the potential for self-repair and thus lower maintenance costs as compared with artificial structures, but reef restoration is still a comparatively new field. The addition of ecosystem benefits and considerations of maintenance costs in a full benefit:cost analysis would likely add to the relative cost effectiveness of reefs for coastal defence.

Advances in coral restoration techniques

A recent review of coral restoration in the Caribbean [25] highlighted the improvements in coral propagation and out-planting methods that have allowed the restoration of several hundreds of thousands of corals, with high survival (>90%) and rapid growth (>20cm per year) in Belize, Jamaica, Florida, Dominican Republic, and many other countries - see summary of results in Appendix 1. The cost of propagating and out-planting corals has been greatly reduced in recent years. The most effective techniques are low-tech methodologies, utilizing inexpensive and readily available materials such as wire mesh, PVC, plastic cable ties, cinder blocks, nails, fishing line, and ropes – see photos 1 and 2. It has also been shown that these low-tech propagation and restoration activities can be an empowering education tool when integrated into community-based management [26].

Photo 1-2. *Low-cost coral nurseries using, from left to right, steel tables (Petit St Vincent),* and coral trees *(St Lucia)* . *Photos Owen Day 2018*

Recent work carried out in Belize with coral biologists and geneticists has also found that thermal tolerance (bleaching resistance) is associated with the genotype of the coral host rather than the symbiotic microalgae [27], opening up the possibility that restoration projects that select and propagate resilient coral genotypes could help Caribbean corals adapt to climate change.

The aim of reef restoration should be to restore genetically diverse populations of corals, which incorporate bleaching and disease resistant parent stock able to reproduce sexually and repopulate surrounding areas. By strategically placing these restored coral populations in locations where currents disperse their fertile eggs to suitable reef areas, coral restoration may have the potential to significantly contribute to the overall success of sexual reproduction and recruitment of Acroporid corals regionally. Natural spawning of restored corals has been observed in several locations in the Caribbean, for example in Belize, Jamaica and Florida. At the latter, an estimated 1,500 corals grown in nurseries off Key Largo and outplanted to local reefs by the Coral Restoration Foundation were reported to have spawned in 2009 (Nedimyer, Coral Restoration Foundation, personal communication).

Recent reviews of coral restoration activities in the Caribbean [25] and worldwide [28] identified two fundamental priorities for the future development of reef restoration. These are:

- First, low-cost restoration methodologies are essential to improving the number, length, and success of restoration activities.
- Second, restoration activities must be conducted in conjunction with ecosystem-based management and conservation practices, such as MPAs, in order to mitigate the impacts of anthropogenic and natural disturbances.

Creating livelihoods and synergies between coral restoration and MPAs

There is increasing evidence that undertaking coral restoration inside well-managed MPAs not only produces better survival and growth rates among the restored corals, but also produces other ecological, social and economic benefits. By taking advantage of the habitat provided by the restored corals, fish and shellfish populations increase even more rapidly inside the MPA than they would without active restoration. Restoration activities have also been found to interest and engage local stakeholders, in particular fisherfolk, much more actively in the management of their MPAs as seen recently in Jamaica and Carriacou.

The adoption of coral propagation and restoration projects by fishermen, local communities, dive shop operators and resort owners are recognised as key components to the long-term success of restoration programmes. Understanding and integrating the socioeconomic needs and perspectives of local stakeholders who depend upon coral reefs in the Caribbean is therefore an important step in successful coral reef restoration [26].

Project Activities

Task 1. Inception meetings

The main project stakeholders met on March 6th, 2019 for a project inception meeting to discuss initial start-up activities and explain the aims of the project (Photos 3, 4, 5 & 6). The participants were given information on coral restoration and invited to engage with various aspects of the project. Various concerns and suggestions were then reviewed and discussed. Those present included:

- Mr. Michael Bobb (Manager SMMA)
- Mr. Windel John (Manager, Sandals Water Sports)
- Dr. Camille David (GIZ CATS)
- Mr. Chester Nathoniel (Action Adventure Divers)
- Mrs Rhonda Giraudy (Sandals PR)
- Mr. Newton Eristhee (Clear Caribbean)
- Ms. Bianca Young (Sandals Foundation)
- Ms. Ornella Zepherin (Department of Fisheries)

Key project activities were discussed - these included: The expansion of the coral nursery and outplanting programme; the development of a Coral Nursery Dive for recreational divers; the training of community members in scuba diving and coral restoration techniques; Water quality testing by CARPHA and coral genotyping,

The feedback received during this meeting focused on the following:

- Education & Public Awareness – how to tap into and use stakeholders' networks to increase awareness.
- The use of Soufriere Radio station that is linked to a local TV Station for Coral Nursery Dive launch.
- Importance of project synergy with key stakeholders and related projects


Photos 3 and 4 Inception meeting at Sandals Watersports HQ, March 2019

Photos 5 and 6 Inception meeting at Sandals Watersports HQ, March 2019

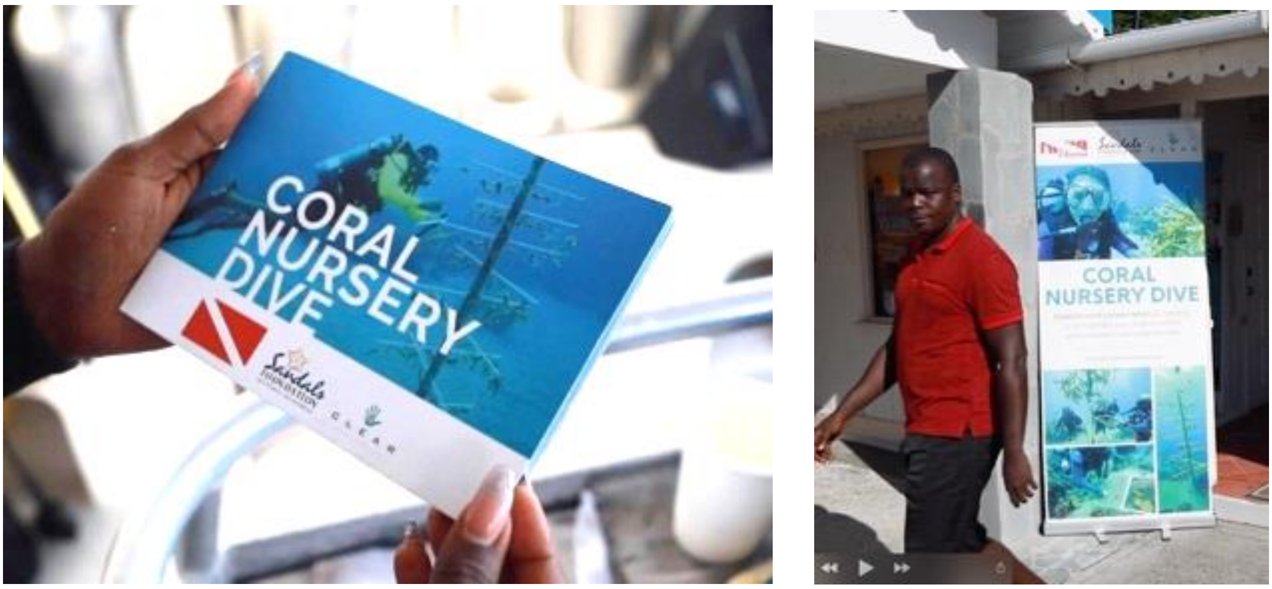
Task 2. Operationalize Financing Mechanism

The Coral Nursery Dive was launched on March 13th, 2019 at Sandals in Saint Lucia. This specialty dive was created as a sustainable financing mechanism to support the Coral Restoration Programme being executed by CLEAR Caribbean and Sandals Foundation through partnership with the Fisheries Department (Government of St. Lucia), GIZ Caribbean Aqua Terrestrial Solutions (CATs), Soufriere Marine Management Association (SMMA) Inc, ANBAGLO, Action Adventure Divers, and CARPHA.

Representatives of the media, including DBS and The Star, were invited to the launch of the coral nursery dive. They interviewed the project partners and collected video footage onboard the Sandals dive-boat in Castries. Later, as arranged at the inception meeting, the communications team from the Ministry of Agriculture and Fisheries joined the team and traveled to Soufriere in order to gather content for their media coverage of the project. They were also joined by representatives from the Soufriere Radio station. The dive took place on the coral nursery as a training opportunity for the Sandals Dive Team and to collect underwater footage to share with the media.

Since the launch in March 2019, Sandals guests have participated in the Coral Nursery Dive (see photos 7 to 10), and many promotional activities were arranged by Sandals Foundation and Sandals Watersports to further increase guest participation. A brochure and banner were produced to display at Sandals Dive Centers (see photos 11 and 12 below).

Photos 7, 8, 9 10. Sandals guests with Sandals instructors, collecting corals, mixing epoxy putty and outplanting elkhorn coral



Photos 11 and 12. Brochure and Banner to promote the Coral Nursery Dive

Despite efforts to promote the nursery dive, the level of participation was lower than expected and several meetings were held between CLEAR, Sandals Foundation and Sandals Watersports Team to try and increase the numbers of guests taking part. It was agreed that the best way to remedy the situation was to make the coral nursery dive a certified PADI Specialty Dive.

Developing a "tailor-made" PADI Specialty Dive for the St Lucia coral restoration activities would allow guests to get an official certificate from PADI and therefore have something tangible and internationally-recognised to keep as a memento of their vacation. Many Sandals guests chose to do PADI Specialty Dives at a cost of around US$200, so the expense was not considered to be a major obstacle to participation.

Staff of CLEAR and Sandals Watersports proceeded to develop the methodology and manual for this new specialty dive in consultation with officials from PADI, which was named the *PADI Coral Nursery Diver Distinctive Specialty*. The methodology and teaching outline were presented by staff of CLEAR to all the scuba diving instructors at Sandals Watersports in January 2020. Following discussions and feedback, the final draft of the outline and training manual were produced. These were then reviewed by officials at PADI Headquarters in California and accredited as a PADI Distinctive Specialty in mid-February 2020.

There was interest from many guests at Sandals Resorts International as well as from guests of Action Adventure Divers in Soufriere in doing this PADI Coral Nursery Diver Distinctive Speciality. These were not quantified owing to the fact that, while PADI had approved the PADI specialty Dive, the 15 diving instructors from Sandals and AAD had yet to be certified for this speciality. The applications to certify the Sandals instructors were submitted to PADI in February but not processed until March when the COVID-19 pandemic forced Sandals to close all the resorts.

Despite the very disappointing disruption due to COVID-19, Sandals are committed to continuing with this speciality once the travel restrictions have been lifted. Sandals have assured the project partners that they will continue to develop and promote this speciality dive as soon as their activities resume. The agreement with Sandals Foundation is that 50% of the fees collected from the sale of the Speciality Dive (US$200) will be paid to the instructor who sells the dive (this is to incentive the instructors) and the other 50% will be transferred to CLEAR. CLEAR will keep 5% for Administration fees, and the remaining 45% of the fees raised will be used to pay the coral gardeners and associated costs of coral restoration.

It is anticipated that the *Coral Nursery Diver Distinctive Specialty* will not only help support coral restoration activities in St Lucia, but also in other Caribbean countries. The specialty dive and training manual provide a very practical and relevant training programme for local marine stakeholders and fishers, including our trainees in Soufriere who will be among the first to be certified. Information promoting this new Specialty Dive can be found on the Sandals website – see Figure 1 below. The *Manual for the Coral Nursery Diver Distinctive*

Specialty and the *Coral Nursery Diver Distinctive Specialty Instructor Outline* are shown in Appendices 1 and 2 respectively.

Figure 1. Sandals Website for PADI Coral Nursery Diver Distinctive Specialty
https://sandalsfoundation.org/coral-nursery-dive

Photo 13. Training with CLEAR and Scuba Diving instructors from Sandals

Task 3. Water Quality Surveys

Twenty-four coastal water samples were collected in three locations, during two sample periods, over ten months of the project. The first sampling period coincided with the dry season (May 2019) and the second with the wet season (Feb 2020). Water samples were collected one meter from the surface and one meter from the bottom at three locations using SCUBA. Sample locations (total of six sample points) corresponded to the most Southern end of the coral nursery, the middle of the coral nursery and the northern end of the coral nursery.

All water samples were collected between 7 and 9 am, transported in a cooler filled with ice to the laboratories of the Caribbean Public Health Agency in St. Lucia where they were analyzed to determine the levels of seven biological and physical parameters (*E. coli, Enterococci,* total coliforms, potassium, phosphates, nitrates and pesticides). The results of the water quality sampling exercise for three significant parameters (two biological and one physical) are summarized in the table below. A copy of the laboratory results is attached in the Appendix 4

Water quality results:
All water samples from the first sampling exercise met the criteria for recreational water quality. It should be noted that this sample was taken during the dry season and corresponded with the end of the yachting season in Soufriere.

Water samples from the second sampling exercise (Feb 2020) were taken during the rainy season as well as **during the peak season for yachting in Soufriere**. Water samples from the both the Southern and Northern ends of the coral nursery did not meet the standards for recreational water quality. Notably *E. coli* counts more than doubled the recommended limits for recreational water quality (126 CFU/100mL). Enterococci counts also exceeded the recommended limit of 35CFU/100mL.

Table 1. Summary of water quality results for selected parameters

LOCATION	PARAMETERS	RESULTS	
		SAMPLING (MAY 2019)	SAMPLING (FEB 2020)
PINN1MA (ST)	E.coli count (CFU/100ml)	4	**304 (H)**
	Enterococci (CFU/100ml)	1	**48 (H)**
	Nitrates (mg/L)	4.3	**5.20 (H)**
PINN1MB (SB)	E.coli count (CFU/100ml)	5	82
	Enterococci (CFU/100ml)	<1	**45 (H)**
	Nitrates (mg/L)	4.0	3.1

DHWM1MA (MT)	E.coli count (CFU/100ml)	2	80
	Enterococci (CFU/100ml)	1	17
	Nitrates (mg/L)	4.4	3.3
DHWM1MB (MB)	E.coli count (CFU/100ml)	<1	60
	Enterococci (CFU/100ml)	25	21
	Nitrates (mg/L)	4.6	4.1
DHW1MA (NT)	E.coli count (CFU/100ml)	6	54
	Enterococci (CFU/100ml)	3	17
	Nitrates (mg/L)	4	**5.4 (H)**
DHW1MB (NB)	E.coli count (CFU/100ml)	2	**296 (H)**
	Enterococci (CFU/100ml)	<1	**38 (H)**
	Nitrates (mg/L)	4.0	4.7

The Key to the water quality results is as follows:

ST - South Top	PINN1MA : Pinnacles (where coral nursery tables are located) 1 meter below surface
SB - South Bottom	PINN1MB: Pinnacles 1 meter above the seabed
MT - Middle Top	DHM1MA: Devil Hole Nursery South end 1 meter below the surface
MB - Middle Bottom;	DHM1MB: Devil Hole Nursery south end 1 meter above seabed
NT - North Top	DHW1MA: Devil Hole North end 1 meter below the surface
NB - North Bottom.	DHW1MB: Devil Hole North end 1 meter above the substrate.

Surface water samples at the Southern and Northern ends of the nursery both exceeded the recommended limit of 5mg/L for nitrates in acceptable recreational waters.

Enterococci and *E. coli* are bacteria that live in the intestinal tracts of warm-blooded animals, including humans, and therefore indicate possible contamination of the coastal waters by fecal waste. Sources of fecal indicator bacteria such as enterococci include wastewater treatment plant effluent, leaking septic systems, stormwater runoff, sewage discharged or dumped from recreational boats (US EPA).

The presence of Enterococci and *E. coli* in the environment may indicate that other disease-causing agents such as viruses, bacteria, and protozoa may also be present. It is therefore possible that these bacteria working in conjunction with nitrates can lead to conditions that negatively affect the health of corals.

It is highly probable that the high levels of Enterococci and E. coli were a result of dumping of raw sewage by yachts moored in close proximity to the nursery. Yachts often overnight on buoys supplied by the SMMA and continue their journey to the Grenadines early in the morning. As sampling sessions were conducted in the early morning it is likely that this resulted in the capture of data indicative of the human impact on the coastal waters. The levels of nitrates may also be accounted for in the same manner as the biological components; however, it is highly likely that the high nitrate levels emanated from a stream that influences the coastal waters. This is believed to be the case owing to the fact that the high levels of nitrates were found in the surface samples and they are no buoys to the Northern end of the nursery for yachts to be accommodated.

Task 4. Expand and Maintain Coral Nurseries

The coral nursery was expanded with ten new coral trees - six new coral trees of elkhorn (*Acropora palmata* AP) and four trees of staghorn (*Acropora cervicornis* AC). These new trees are listed as 17 to 26 in Table 3 below. On these ten trees a total of 1,000 fragments of corals were added to the nursery. These fragments were collected from different sites (see photos 14 and 15) - the location and GPS coordinates of these sites are shown in Table 2.

One of the key objectives in our coral enhancement exercise is to ensure survival of as many coral fragments as possible in the nursery to support out-planting efforts on the reefs. To-date there are 26 coral nursery trees in the nursery in Saint Lucia. Each coral nursery tree has approximately 100 fragments in various stages of growth. Approximately 25 percent of those fragments are *Acropora palmata* (elkhorn) and the remaining 75% *Acropora cervicornis* (staghorn).

Photos of the coral trees taken in February 2020 can be seen or downloaded at the link below – some are shown in Appendix 5.

https://www.dropbox.com/sh/1rn99avpsyp1ue3/AAAIoiqoSwGDBnyrW_V4uiBga?dl=0

Table 2. Sites of source colonies used in nursery expansion

Source	Species	Lat.	Long.	Notes
Site L1	AP	13 44 56.598N	60 59 55.026 W	Laborie, 5 colonies sampled approximately 100 m apart
Site L2	AP	13 44 56 560N	60 59 55.126 W	
Site L3	AP	13 44 56 622N	60 59 55.200W	
Site L4	AP	13 44 56 656N	60 59 54.865W	
Site L5	AP	13 44 56 532N	60 59 54 800W	
Site K	AC	13 51 55.932N	61 4 47.099W	Turtle reef infront of Anse Chastanet

Table 3. Metadata for North Site Coral Nursery

Tree Number	Species code*	Number of corals	Location of source (genotype)	Date of collection	Generation No.
Tree 1	AC	87	Site A	14/06/2018	2nd
Tree 2	AC	63	Site B	06/07/2017	1st
Tree 3	AP	73	Site C	06/07/2017	1st
Tree 4	AP	36	Site D	06/08/2017	1st
Tree 5	AP	35	Site E	06/08/2017	1st
Tree 6	AC	98	Site F	14/06/2018	2nd
Tree 7	AC	90	Site F	14/06/2018	2nd
Tree 8	AC	99	Site F	05/08/2018	2nd
Tree 9	AP	38	Site C	07/08/2017	1st
Tree 10	AP	32	Fragments found on Seabed in nursery	06/07/2017	1st
Tree 11	AC	90	Site F	05/08/2018	2nd
Tree 12	AC	90	Site F	05/08/2018	2nd
Tree 13	AC	90	Site A	05/08/2018	2nd
Tree 14	AC	85	Site A	06/08/2018	2nd
Tree 15	AC	89	Site A	06/08/2018	2nd
Tree 16	AC	90	Site A	08/08/2018	2nd
Tree 17	AC	100	Site K	24/06/2019	1st
Tree 18	AC	100	Site K	28/06/2019	1st
Tree 19	AC	90	Site K	28/06/2019	1st
Tree 20	AC	100	Site K	28/06/2019	1st
Tree 21	AP	100	Site L1	08/07/2019	1st
Tree 22	AP	100	Site L2	08/07/2019	1st
Tree 23	AP	100	Site L3	09/07/2019	1st
Tree24	AP	100	Site L4	09/07/2019	1st
Tree 25	AP	100	Site L5	09/07/2019	1st
Tree 26	AP&AC	65 AP& 35 AC	Site K & L5	10/07/2019	1st

Photo 14. Colonies of staghorn (*Acropora cervicornis*) from Turtle reef used for nursery expansion

Photo 15. Colonies of elkhorn (*Acropora palmata)* from Laborie reef used for nursery expansion.

Photo 16. Harvesting coral fragments to be placed in nursery

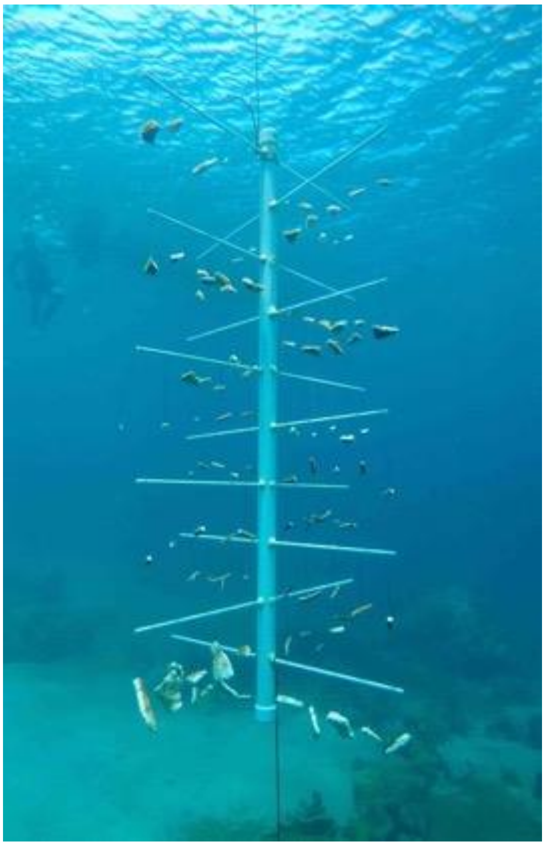


Photo 17 and 18. Newly populated tree (left) and one ready to harvest (right)

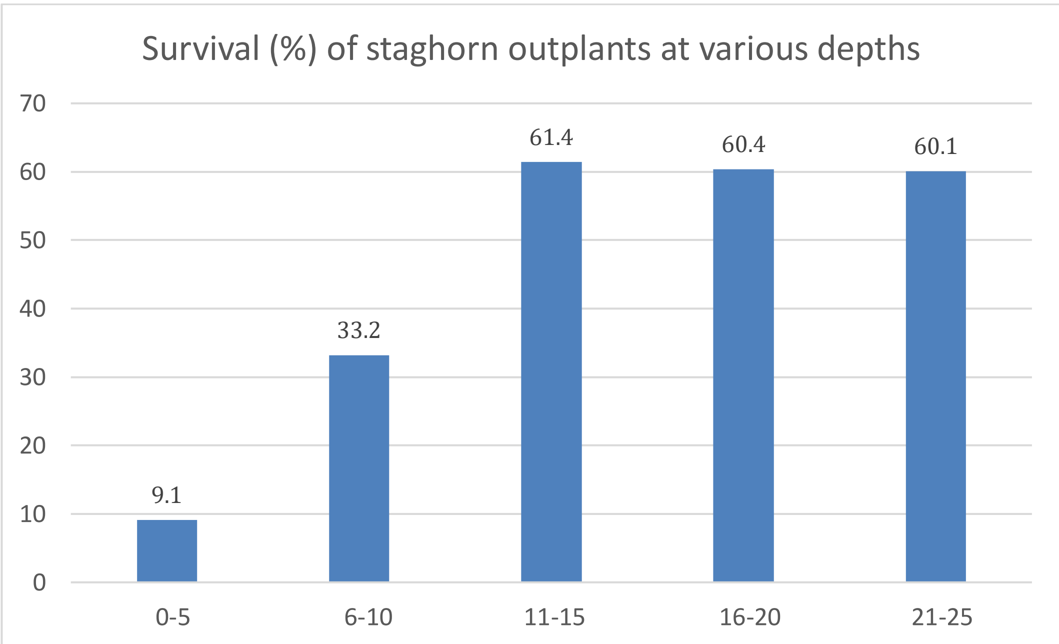
Task 5. Outplanting

Coral outplanting was done throughout the year when sea conditions permitted and when there was a suitable supply of large coral fragments in the nursery. The methodology for outplanting is given in detail in the Training Manual in Appendix 1. Outplants were monitored periodically by a SCUBA diver using an underwater camera and a measuring device made from PVC, to give an indication of scale. Percentage of coral colony showing live tissue was estimated to give a measure of colony survival. The main objective of monitoring is to estimate the level of survival of the outplanted corals, as the overall aim of the project is to restore coral populations. A second objective of monitoring will be to ensure that the corals are reproducing sexually, and this will be done in July and August when the outplants are two years old. The survival of the coral outplants as a function of depth is discussed in the paragraphs below and shown in Figures 3 and 4.

Staghorn corals

Outplanting of staghorn coral has progressed well with one hundred and twenty-three (123) coral fragment clusters outplanted onto the reef at various depths inside the SMMA. Each cluster had on average 10 fragments of staghorn form the nursery – so over 1,200 staghorn fragments were outplanted. Unlike elkhorn, which is outplanted individually, staghorn was outplanted in large clusters to reduce the impact of predation from fireworms, snails and damselfish.

Figure 3. Graph showing average survival (as a percentage live tissue – y axis) at various depths in meters (x- axis) for staghorn coral outplants.



Based on the current data for staghorn outplants, the trend appears to be that survival increases with depth, with the optimum depth being between 15 and 20 meters. At depths shallower than 11 meters coral survival was significantly less with an almost 50 percent decrease in survival when compared to those outplants placed four meters deeper. Therefore, future outplants for Staghorn will be outplanted along the 15-20m depth contours.

Photo 19. Outplanted staghorn coral cluster on Piton Wall.

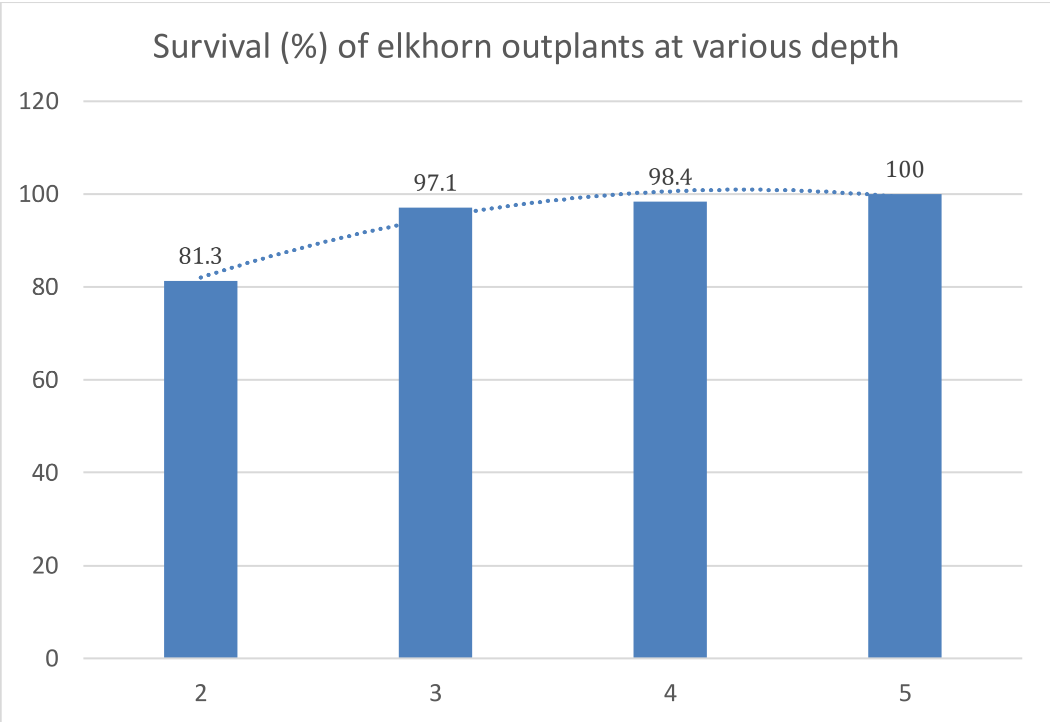
Elkhorn corals

Elkhorn is outplanted individually and at a larger size. A total of forty-three (43) elkhorn fragments were outplanted on the reef, relatively close to the surface (<3- 5 m below the surface).

Photo 20. Outplanted staghorn coral cluster on Piton Wall.

Elkhorn corals showed a significantly higher survival, as a percentage of live coral tissue (96.3%) when compared to the staghorn corals (52.3%). This was largely due to the lower vulnerability of elkhorn to predation from fireworms, snails and damselfish. A closer look at the data also revealed that survival is influenced by the depth of outplanting, similarly to staghorn – see Figure 4. At five meters depth there was 100 percent survival for elkhorn coral out plants. Mortality seems to increase as you get shallower than three meters. Future outplants for elkhorn be placed along the 5 meter depth contour.

Figure 4. Graph showing average survival (percentage live tissue – y axis) at various depths in meters (x- axis) for elkhorn coral outplants.



Task 6. Training in coral restoration and scuba diving

Ten members from the community of Soufriere were identified and trained in SCUBA diving as part of the training in Coral gardening. The training was done by Chester Nathoniel, PADI Scuba Instructor and Director of the Action Adventure Dive Centre, in Soufriere. The names of the trainees and the dates of completion of their SCUBA certification are listed below:

Table 4. Names and details of the SCUBA training coral gardeners

Name	Start date	Status	Completion date	Age	Employment
Luke Delmon Alfred	12-Jul-19	completed	18-Jun-19	19	Boat fishermen
Aquinas Sylvester	12-Jul-19	completed	18-Jun-19	18	Boat fishermen
Abdul Epiphane	12-Jul-19	completed	18-Jun-19	26	Boat fishermen
Miguel Charlemange	12-Jul-19	completed	9-Oct-19		Boat fishermen
Perry Charlemagne	12-Jul-19	completed	9-Oct-19	30	Spearfisher
Deuxmil Alexander	10-Mar-19	completed	12-Mar-19	19	Unemployed
Ian Joseph	12-Jul-19	Not yet completed		34	Boat fishermen
Curty Auguste	17-Jul-19	not yet completed		19	Unemployed
jeremiah Butcher	17-Jul-19	not yet completed		19	Street vendor
Cuthbert Michel	17-Jul-19	completed	19-Jan-20	42	Hotel worker

A sample of the PADI Open water Certificates are shown in Appendix 6.

In addition to the trainees above, the following three coral gardeners who were trained in 2018 also took part in the coral restoration activities.

- Shenella Sylvester James
- Maximillian Sylvester
- Junior Sylvester

Photo 21. Some of the coral gardeners receiving SCUBA training

All the equipment required by the coral gardeners was procured by CLEAR and shipped to Saint Lucia. This included sets of scuba diving equipment, aluminum tanks, materials for building coral nurseries, underwater cameras, etc. All the equipment was cleared through customs with the assistance of CARPHA who facilitated duty free concessions.

Photo 22. Chester Nathoniel, PADI Scuba Instructor and Director of the Action Adventure Dive Centre in Soufriere

After the participants were certified in SCUBA, they started the training in coral restoration techniques using materials from the NVQ standards developed in 2018, and more lately by the PADI Training Manual developed for the PADI Coral Nursery Diver Distinctive Specialty (Appendix 1). The Level 3 NVQ Materials can be downloaded at:

https://www.dropbox.com/sh/09tzxx54hjb0h74/AACDWkIrJxE04-3NdSudwiUna?dl=0

The coral gardeners received practical training in the following areas (these are illustrated in photos 23 to 28):

- How to build coral trees; Deploying trees at nursery site; Cleaning nurseries;
- Monitoring nurseries and outplants;
- Outplanting corals; Removing predators from outplants;
- Handling corals; Basic coral biology

The list of routine maintenance activities are summarized in Table 5 below and are provided in more detail in Appendix 1.

Table 5. Summary table of routine maintenance activities

Checking structural integrity of the coral nursery
• Check the suspended frames are all present and intact
• Check structures are sound and corals hanging as normal
• Check anchoring ropes are sound and knots are tight
• Check permanent labels (bottom of tree) are still present; replace second label with large visible number (top of tree) if needed (see photos below)
• Check PVC caps are present. Caps are recommended to avoid fire-worms or snail taking up residence inside the PVC pipes
Cleaning and Maintenance
• Gently clean the structures using small sponge, pad or brush to remove algae and sediment. Be very careful not to touch the corals.
• Monofilament can be cleaned by gently lifting the crimp above the branch. Use hand to fan off any sediment from the corals if needed.
• Cleaning should be done once every week to ensure algae does not become too established. Some algae is inevitable
• Count and remove any snails and fire-worms
Health and Survival
• Count the live corals on each tree and enter data onto form.
• Record any pale or diseased corals.
• Record number and location (tree and branch) of any diseased or dead corals on form. Diseased or dead corals should be removed from the tree and placed into a sealed zip-lock plastic bag and brought back to shore.
Photos
• Take photos of each suspended structure
• Take photos of any dead or diseased corals before removing them. Also of anything unusual.
• Ensure number on top label is visible (use new labels if needed; permanent embossed label should be left)

All the coral gardeners were paid a fee of US$40 (EC$106.80) per day (two dives) during and after the training. On average the coral gardeners worked twice a week, earning an income of US$80 per week. They generally worked in teams of six, led by Chester Nathonial. The coral gardeners all have at least one child and a partner, who benefitted from their supplementary income generated by this project.

Photos 23 to 28. Coral gardeners doing various activities during their “on-the-job” training

It should be noted that the NVQ is a competency-based qualification therefore persons have to show that they are competent in all the modules to receive the full NVQ. The Level 3 NVQ is equivalent to an Associate Degree qualification and is geared towards persons who could establish and manage a coral nursery as well as establish and monitor a coral restoration/enhancement site. Only one of the community coral gardeners completed secondary school education. Therefore, while they can be competent in some modules it was highly unlikely that they would complete the Level 3 NVQ.

The Government of St. Lucia (Department of Fisheries) as a member of the Public Private Partnership requested funding from the World Bank to facilitate the development of a Level 2 NVQ in Coral gardening to formalize the education of the coral gardeners who had been trained in Scuba diving and were participating in coral gardening activities under this project. There were administrative delays on the part of the World Bank, which necessitated a resubmission of the request in January 2020. The "No Objection Letter" from the World Bank was received by the Department of Fisheries at the end of February. The development of the NVQ was to have started in mid-March with subsequent training and certification of this cohort of Coral Gardeners after. The subsequent closure of the country owing to the COVID-19 pandemic has delayed this. However, the Deputy Chief Fisheries Officer has indicated that as soon as things normalise, the development of the Level 2 NVQ and the training of coral gardeners will be completed.

Task 7. Education and Awareness Programme

The education and awareness programme focused (as indicated in the budget) on the production of a 10-minute video entitled ***"The Saint Lucia Coral Gardeners: Building Resilient Reefs and Communities***". The video was filmed and edited by professional film-maker and underwater videographer Mr. Arthur Daniel. The video highlights the aims of the project and the activities being undertaken to restore St Lucia coral reefs, with a special emphasis of the engagement of the local community.

The video has been shared on social media and shown directly to individuals and groups. It can be seen at the following links below - the number of views currently stands at 270.

- http://www.clearcaribbean.org/resources/
- https://sandalsfoundation.org/coral-nursery-dive

In addition to the video, the project was promoted on local radio, especially Soufriere FM, a local radio station managed by the Soufriere Regional Foundation.

Several newspaper articles, including the following from the launch, were also produced:

Stluciastar.com
Headline: Sandals foundation comes out for coral restoration
Date: 17/03/19
Media: Online

The Star Newspaper
Headline: Sandals Foundation Comes Out For Coral Restoration
Date: 16/03/19
Media: Print

The Weekend Voice
Headline: Sandals Foundation and Clear Caribbean Embark on Coral Restoration
Date: 16/03/19
Media: Print

Thevoiceslu.com
Headline: Sandals Foundation and Clear Caribbean Embark on Coral Restoration
Date: 16/03/19
Media: Online

Htsstlucia.org

Headline: SANDALS AND FISHERIES PARTNER ON CORAL CONSERVATION
Date: 15/03/19
Media: Television/Online

DBS TV
Headline: Coral Nursery Dive Initiative Launched
Date: 13/03/19
Media: Television

Dbsstlucia.com
Headline: Sandals Heads Coral Reef Recovery Project
Date: 13/03/19
Media: Online

The budget for the awareness and education component of the project (Euro 3,500) was used entirely for the production of the video. Any flexibility in the budget provided by the Sandals Foundation grant to CLEAR was used to support the coral gardeners and Action Adventure Divers in the maintenance of the coral nursery during the extension period from January to March 2020 (staff of CLEAR were not paid extra for the additional time spent on the project). After the final disbursement from GIZ is received by CLEAR, 30 educational posters will be produced to help maintain support and interest in the coral restoration programme once the COVID-19 curfews and lockdowns have been relaxed. The design of the poster is shown in Appendix 8.

These posters will be displayed in suitable locations, including the following:

- The Soufriere Fisheries Complex
- Department of Fisheries
- Soufriere Marine Management Area
- Fisheries Cooperatives
- The Barons Drive community
- Sandals Resorts and Watersports Centres
- Hotels in the SMMA area, such as Sugar Beach, Anse Chastenet and Tikaye
- Soufriere Regional Development Foundation
- Ministry of Agriculture and Sustainable Development
- The St Lucia Council for Technical and Vocational Education and Training (TVET)

Task 8. Analysis of coral genotypes

The analysis of coral genotypes has been postponed until sufficient funds are available. The allocated budget for this activity was US$2,500, which came entirely from the Sandals Foundation grant. This estimate was based on discussions with Dr Iliana Baums in 2018, who indicated that samples could be analysed by her research team in her university laboratory. However, following subsequent discussions with Dr. Baums in 2019, it became clear that this analysis was no longer being offered as part of her research, but could be done by commercial companies specializing in gene sequencing, in particular Eurofins or Thermo Fisher, who both required a minimum of 96 samples. Their minimum costs are: US$6,144 and US$5,472 – see breakdown below:

Eurofins (https://www.eurofins.com/)

- 96 samples: ($56 genotyping + $8 DNA Extraction)/sample = minimum cost US$ 6,144.00

Thermo Fisher (https://www.thermofisher.com/uk/en/home.html)

- 96 samples: ($56 genotyping + $8 DNA Extraction)/sample = minimum cost US$ 5,472.00

Genotyping acroporid corals is a highly specialised activity that very few companies are capable of doing as they must have validated extraction methodologies for these corals species, and suitable sequencing tools using SNPchips (single-nucleotide polymorphisms sequences).

Genotyping of corals is useful, but not essential, in confirming that corals in the nursery are of different genetic stock and not clones of each other. A simpler and cheaper way of ensuring genetic diversity, is to ensure that the source colonies used in the nursery are separated by at least 100m. This is a "rule of thumb" approach used by many coral restoration practitioners who do not have access to large genotyping budgets. To validate this "rule", coral fragments can be attached together - if their tissues fuse they are clones, if they remain separate, they are genetically distinct from each other.

The funds that would have been used for this activity (US$2,500) have instead been used to support the coral restoration operations during the three-month extension between January and March 2020.

Impacts of project

The project has been successful overall and has had several positive impacts on the community of Soufriere and the coral reefs of Saint Lucia.

- **Increased income for the coral gardeners**. The coral gardeners are all young adults who earnt on average US$80 per week during the project. This supplementary income benefited them directly, but also provided indirect benefits to their children and partners. One of the coral gardeners is a young woman from Soufriere who has shown a high level of commitment and enthusiasm for this work.

- **New opportunities for future earnings**: The agreed sustainable financing mechanism developed between CLEAR and the Sandals Foundation (see appendices

1 and 2) will provide income for the coral gardeners when tourism activities resume after the COVID-19 pandemic subsides. The financing model that has been developed is beneficial to all the partners, including Sandals which now has a unique and exciting dive experience to offer guests. See page 11 for details.

- **New skills for coastal management**. The training provided skills in SCUBA diving for community members and specialized skills in coral restoration. These new skills helped to empower the local community, and these young adults in particular, to play a greater role in the stewardship of their coastal resources.

- **Greater awareness among community and nationals**. The education and awareness programme heightened awareness among community members and nationals of the importance of restoring coral reefs in order to increase fish catches and support tourism. Perhaps more importantly, the word-of-mouth communications between individuals directly involved in the project and their families and friends has increased local understanding of the opportunities and practical methods to protect and restore coral reefs.

- **Increased ecological resilience**. The project propagated and outplanted over 1,250 acroporid corals (approx. 1200 staghorn and 50 elkhorn), and currently has approximately 2,500 additional corals in the nursery. These corals were propagated from fragments taken from large source colonies that displayed healthy phenotypes, and which were therefore likely to be resilient to diseases and other threats. The outplanted corals have had good survival rates, and are likely to reproduce sexually in the next two years. Their offspring will contribute to the restoration and genetic resilience of acroporid populations around St Lucia, and will also help support the marine biodiversity associated with healthy coral reefs.

- **Creation of a new public-private-partnership**. The project partners are all enthusiastic about working together beyond the life of this project and to support the on-going operation and expansion of the Soufriere coral restoration programme. The COVID-19 pandemic has interrupted certain aspects of the project, but the partners have agreed to continue these activities once tourism activities resume.

Impact of project on various actors at the national and sub-national levels that have aligned their management approach to natural resources in harmony with this intervention

The project has helped improve understanding of the important role that coral restoration has in the management of coral reefs and of the urgent need to assist these ecosystems in adapting to climate change by propagating and outplanting resilient genotypes. Fisheries officers and MPA managers have appreciated the benefits of actively engaging community members, such as fisherfolk, in conservation work inside an MPA.

The SMMA is responsible for the management of 22 km of coastline and the intervention occurred within one of its highly protected marine reserves. Having taken into account their human resource constraints as well as the engagement of the dive fraternity and fishing community who are all key stakeholders, the management of the SMMA made the decision to partner and align their activities with the intervention. The benefits included active engagement of a young fishers, who obtained a supplementary income from their involvement in the intervention, as well as providing enhanced reef products for divers within the SMMA. It should be noted that 95 percent of the dives done in St Lucia are within the SMMA and there is always a strong demand for new and enhanced attractions.

From a national perspective, the Government of St Lucia is keen to enhance and replicate the success of this project and a number of other coral restoration projects are underway, including a project at Canaries. The Ministry of Agriculture, more specifically the Department of Fisheries (DOF), in recognizing their human resource constraints, have pursued the course of strategic partnerships to deliver on their mandate for coral reef management and reef enhancement. They have used this intervention to inform the work currently being done by foreign consultants to develop a coral reef enhancement plan for the Pointe Sable protected area and the west coast of St. Lucia.

The governments of other Caribbean nations are also increasingly supportive of the approach taken by this project. Staff at CLEAR have been working with the Caribbean Community Climate Change Centre on the development of a large regional proposal called *Mainstreaming Coral Reef Resilience and Restoration as an Ecosystem-based Adaptation Strategy to Climate Change in the Caribbean Region (MACREAS)* that was submitted to the Green Climate Fund (GCF). This proposal has the support of the governments of St Lucia, St Vincent and the Grenadines, Barbados, Jamaica and Belize. The current iteration of the St. Lucia component in the MACREAS proposal was finalised in 2019, following consultations with key national stakeholder, and was heavily influenced by the approach taken by the current PPP coral restoration project. MACREAS has been reviewed favourably by the GCF but implementation has been very delayed because of administrative hurdles. The 5Cs hope that implementation of MACREAS will start in late 2020 or early 2021.

Lessons Learnt and Recommendations

The project was successful in meeting its objectives despite the ambitious nature of the partnership and the impact of COVID-19 during the final extension period. The presence of multiple partners makes any project more complex, and this was no exception. The public-private partnership (PPP) was successful because we focused on good communication and coordination throughout. It was essential to communicate effectively with all the partners and understand their perspectives and incentives, which drove their willingness to contribute to the project. The DOF and Sandals Foundation were excellent in providing support and in communicating regularly to their colleagues. The Sandals diving instructors were very enthusiastic, but also very busy and perhaps too optimistic that their guests would sign-up to do coral restoration. It took many discussions to realise that the development of the PADI Coral Nursery Diver Distinctive Speciality was required to make this activity more attractive to their guests.

Key recommendations for future PPP projects are that:

(1) having Government as a partner is important to facilitate the legitimacy of activities as well as ensuring that activities fall under respective national action plans that feed into sustainable development goals as well as meet the criteria for reporting on multilateral environmental agreements

(2) engaging with the private sector is often challenging as they have limited flexibility due to staff and budget constraints, but it is also essential if we want to create larger conservation initiatives that become self-sustaining and part of normal business practices

(3) these kind of multi-partner PPP projects can take longer than anticipated, and bridging the cultural and corporate differences between the partners must be given sufficient time and resources

(4) understanding the motives and challenges of each partner is key, and one should not assume they all share the same priorities

(5) must be innovative and flexible to cater for changes and new developments

(6) Increasing buy-in from more members of the stakeholder groups at the beginning may improve the chances of gaining additional input from divers/guests at other hotels.

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Appendix 1 Training Manual for the PADI Coral Nursery Diver Distinctive Specialty

TRAINING MANUAL

CORAL NURSERY DIVER DISTINCTIVE SPECIALTY

Coral restoration is becoming one of the most popular and effective conservation activities used by marine biologists throughout the tropics to restore damaged reefs. There are many restoration techniques available, but the basic knowledge and skills can be easily learned and used by recreational divers. Helping to restore coral reefs can be an easy and fun activity that can bring a whole new dimension to your diving adventures.

Take the PADI Coral Nursery Diver Distinctive Specialty with us, and our experienced instructors will make sure you enjoy learning about coral biology, coral nurseries and reef restoration, and get you well underway to becoming a budding marine biologist and conservationist.

CLEAR CARIBBEAN

Sandals FOUNDATION Our Promise. Our Caribbean.

The Course Overview

The PADI Coral Nursery Diver Distinctive Specialty was developed by CLEAR Caribbean, Sandals Watersports and the Sandals Foundation to help protect and restore Caribbean coral reefs.

The PADI Coral Nursery Diver Distinctive Specialty is an introduction to coral nurseries and coral outplanting, and is designed to familiarize divers with the basic skills, knowledge, procedures and enjoyment of propagating corals in underwater nurseries and outplanting them on adjacent reefs.

The course teaches you about why coral reefs are in trouble, what are the main problems threatening their survival, and what can be done to help conserve and restore them. You'll learn the basics of coral biology and coral reproduction, and how simple coral nurseries can be built and maintained. You'll learn how healthy corals can be propagated and grown in nurseries, before being planted out on surrounding reefs.

- Course overview
    - The course is conducted over 2 dives, after a classroom presentation and knowledge review
- Certification
    - Upon successfully completing the course, you will receive the Coral Nursery Specialty Diver Certification. Certification means that you will be qualified to plan, organize, and make dives in conditions generally comparable to or better than, those in which you are trained.

Requirements

The PADI Coral Nursery Diver Distinctive Specialty is open to anyone who is aged 12 years or above, has the PADI Open Water Diver certification or higher, and is in good health.

KNOWLEDGE REVIEW

This section outlines the information that you are required to read to pass the **Multiple-Choice Test** on page 16.

1. Purpose of coral nurseries and coral restoration

1.1 Why are coral reefs declining?

Coral reefs are sensitive to a wide range of threats, particularly those that affect water quality and the delicate ecological interactions essential for healthy coral reef communities. Coral reefs have declined significantly in recent decades because of a combination of factors, particularly:

- **Pollution** from land and boats, often from inadequately treated sewage, agricultural runoff containing fertilizers and pesticides. Too many nutrients can cause algal blooms that smother corals.

- **Sedimentation** caused by soil erosion can cover reefs with silt and sediment, preventing them from feeding. Muddy or cloudy coastal waters make it harder for corals to get the sunlight they need to survive.

- **Over-fishing** of some reef fish and shellfish can harm the delicate ecology of coral reefs. Parrotfish, for instance, are particularly important to the health of reefs because they eat the algae that would otherwise smother the corals

- **High temperatures** caused by climate change can cause coral bleaching events.

- **Coral diseases** are caused by bacteria or viruses. They are often a problem when corals are stressed by other factors, such as pollution or high temperatures. White-band disease (right) was the main cause for the decline of Caribbean elkhorn and staghorn corals.

1.2 Why focus on restoring Caribbean populations of Elkhorn and Staghorn corals?

- Elkhorn and staghorn corals are two important species of Caribbean corals that suffered huge losses (around 95%) mainly because of White Band Disease. Both corals were designated as "threatened species" under the U.S. Endangered Species Act in May 2006.

Above: Healthy stand of elkhorn corals, once a typical sight in the Caribbean

Above: "Skeletons" of dead elkhorn corals – now an all too common sight

- Elkhorn (previous page) and staghorn (right) are both fast-growing branching corals that form dense thickets, which provide essential habitat for many reef species, especially juvenile fish. **The loss of these corals has therefore been especially damaging to Caribbean reef ecosystems, and the active restoration of both species is now seen as a regional priority.**

- Fortunately, the few wild colonies of elkhorn and staghorn corals that remain seem to be less susceptible to diseases and are well suited for propagation in underwater nurseries.

- The aim of coral restoration is to restore resilient and sexually active populations of corals, so that they can reproduce naturally and replenish surrounding reefs.

1.3 Why is it important to engage local communities and fisherfolk in coral restoration?

- Coral restoration is fast becoming established as a conservation technique for marine biologists, dive centers and tourists in more and more locations around the world. We believe it is very important to provide opportunities for local people, men and women, to obtain training in coral restoration so that coastal communities can play a greater role in the restoration of their marine environments.

Above: Shenella Sylvester James, Coral Gardener, Soufriere, St Lucia

- Coral reefs don't only provide habitats for hundreds of thousands of species, they are also immensely important for tourism, fisheries and coastal protection. The social, economic and cultural fabric of the Caribbean is intertwined with the fate of coral reefs, so it is important that local people become actively engaged in the conservation and restoration of these unique marine ecosystems on which they depend.

1.4 How can coral nurseries create mutually beneficial linkages between tourism and local communities?

- The coral restoration programme established in St Lucia * is focused on involving both tourists and local communities. Part of the fees provided by tourists doing the **Coral Nursery Diver Distinctive Specialty** course is used to provide equipment, training and pay for local fisherfolk engaged in establishing and maintaining coral nurseries. It is hoped that this partnership between tourism and local communities will make coral restoration a "supplementary livelihood opportunity" in fishing villages and coastal communities.

** The Saint Lucia Coral Restoration initiative is a public-private partnership implemented by CLEAR Caribbean and the Sandals Foundation, with support from the Caribbean Aqua-Terrestrial Solutions programme (CATS), the Department of Fisheries and the Soufriere Marine Management Association (SMMA). The CATS programme is funded by the German Federal Ministry of Economic Cooperation and Development (BMZ) and implemented by the Caribbean Public Health Agency (CARPHA) and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).*

2 Fundamentals of coral reef ecology

2.1 What are the basic features of a coral?

- Corals are colonial animals comprised of many small coral polyps (see right). Each polyp has a set of tentacles that surround a central mouth opening, and a hard skeleton that is excreted at the base. The skeleton is made of calcium carbonate and this creates the structure of reef-building corals. In time these structures build the huge framework of coral reefs, such as fringing reefs, barrier reefs or atolls.

- The thin skin of corals is packed full of microscopic plant cells. These plant cells use sunlight to make sugars which provide food to the coral. Most corals obtain the majority of their energy from these symbiotic plant cells.

- Corals also get food by filter-feeding at night, when they extend their tentacles to catch plankton.

Above right. Coral polyps, notice the tentacles and central mouth. The colour comes from plant cells in their skin

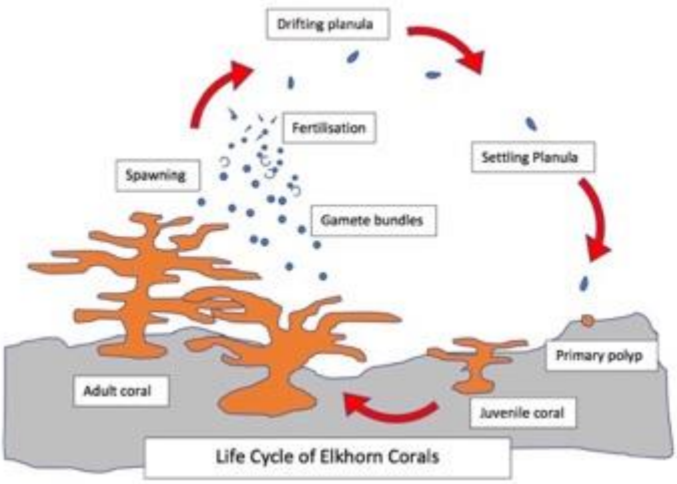
2.2 What are two ways corals can reproduce?

- Some corals, including elkhorn and staghorn, can reproduce both sexually and asexually. A coral polyp can produce another polyp in a process called budding (asexual reproduction), which is how a coral colony gradually grows and develops into a large coral, such as an elkhorn, boulder or brain coral.

- In sexual reproduction, corals release eggs and sperm into the water during a spawning event. This only happens once a year for elkhorn and staghorn.

- Sperm cannot fertilize eggs from the same coral. They need to find eggs from another coral.

- Restoration can help corals reproduce by outplanting lots of corals close together that have high genetic diversity.



3 Coral nursery methods

3.1 What factors should be considered when selecting a nursery site?

- Permits for a coral nursery and restoration programme should be prepared and submitted to the relevant agencies, whether they are a Government Ministry or a local authority that has official responsibility over the site. The permitting process may be very simple or may require the provision of detailed information about the characteristics of the site. Engaging with the relevant agencies at an early stage is always preferable and likely to simplify the process.

- The environmental parameters associated with the site should be identified and assessed. The table below highlights which are the most important.

Parameter	Optimum for coral nurseries
Water temperature	Between 24°C and 29°C
Water quality	Good water quality is important – this can be assessed by examining the quality of nearby coral reefs
Water movement	Some current is good but not so much that working on the nursery becomes difficult
Salinity	35ppt (35 g/L) for Caribbean corals
Depth	Between 2 and 10 metres depth.
Substrate type	Sand or gravel
Adjacent habitat	Close to reefs to encourage herbivorous fish to clean the nursery
Sedimentation and turbidity	The lower the better – keep away from river mouths or estuaries
Adjacent Habitat	Reef areas adjacent to the nursery site that have healthy coral populations and fish populations are a good indication that the environmental conditions are adequate for coral growth

- Once the environmental and legal issues have been assessed for a potential nursery site, it is important to identify all users of the site to assess potential conflicts or synergies (beneficial interactions). Nurseries should be located so as not to interfere with fishing activities or cause a threat to boating operations.

3.2 What types of nursery structures can be used to grow corals?

- There are many different types of nursery structure that have been used over the years, with various degrees of success. In this manual we focus on three designs that have been used extensively and proven themselves to be highly effective.

- **Tables:** Tables are a popular nursery structure to use in shallow areas (2-5m) where they are protected from swells. They usually consist of steel rebar that is cut and bent to create tables, and then anchored in sand using steel rods and a sledgehammer. Tables provide a flat surface on which Elkhorn fragments are attached to cement cookies.

- **Frames:** Domes or tunnel-like steel frames are also used regularly as nursery structures. These are suitable in the same locations as tables, and generally used for staghorn coral. Frames are not as suitable for Elkhorn corals, which prefer to be based on a horizontal surface.

- **Coral trees:** Coral trees consist of structures anchored to the seabed and suspended in mid-water by floats. Their position in the water column can be adjusted by the length of the rope above the anchor. The central "trunk" is made of PVC pipe and the "branches" are made of fiberglass rods with holes drilled in them to allow corals to be hung using monofilament nylon - like decorations on a Christmas tree. Coral trees can be installed in deeper sites (15m max) and can withstand moderate swells and currents.

3.3 How are corals collected and added to the nursery?

- Rapid surveys should be carried out in the areas around where a nursery is to be established for potential source material. During these surveys it is important to identify and locate as many coral colonies as possible to ensure a large number of genotypes are used as source material in the nursery.

- Genetic diversity in the nursery is extremely important as this will ensure that the outplants can reproduce sexually. Genetic diversity is also critically important for the resilience of a species as it increases the ability of the population to adapt to changing conditions and potential new diseases.
- The source material for the coral nursery is harvested from healthy and actively growing colonies. When the polyps are paler at the tips this often indicates fast growth. Fragments are harvested using diagonal cutting pliers.

- No more than 10% of the source colony should be harvested. Always ensure that pliers and hands are thoroughly cleaned before harvesting corals. The cutting pliers should be lubricated with vegetable oil (edible oil), not mineral oil (non-edible).

- Minimal cutting should be done at the collecting site. This is to minimize injury and stress before transport. Excessive cutting at the collecting site will also produce lots of mucus that can foul the water during transport. Further cutting of the fragments should be done after transport and just before they are attached to the nursery.

- Sometimes small fragments of coral can be found close to a large elkhorn or staghorn colony. These so-called “fragments of opportunity” should be collected for the coral nursery

3.4 What tasks are necessary to maintain a nursery?

- It is very important to manage a coral nursery in order to keep them free from algae, coral predators and diseased corals, as well as how to monitor growth and survival.

- Coral nurseries require regular cleaning to ensure that the corals are kept in optimum conditions. This involves removing algae from the nursery structures using small plastic brushes or pads. Care should be taken not to touch the corals while cleaning, and if corals need to be handled, always be gentle.

- Herbivorous fish, such as surgeon and doctorfish, can help reduce the amount of cleaning required. Fire coral often colonizes the surfaces of nursery frames and coral trees – this also greatly reduces the amount of cleaning required.

- Coral predators can cause severe damage to corals in the nursery if left unchecked. The main predators are snail*s,* fireworms, damselfishes and four-eyed butterflyfish. The snails and fireworms should be removed and disposed of a good distance away from the nursery. The best natural control of these coral predators is a healthy ecosystem, with plenty of lobsters to eat the snails and fire worms, and large predatory fish to control the numbers of damselfish and butterflyfish. Nurseries inside well-managed Marine Protected Areas should benefit from a more balanced ecosystem than in heavily fished areas.

- It is important to check all the corals and remove any diseased or dead corals to prevent the spread of disease. Dead corals rapidly become covered in algae and can be easily recognised**.**

- Any coral disease should be identified using a good coral disease guide, such as the **Western Atlantic Coral Disease Identification Field Guide** available online at:

https://cdhc.noaa.gov/_docs/Field%20Guide%20to%20West%20Atl%20Coral%20Diseases.pdf

- Growth and survival of corals in the nursery should be monitored and this is usually done on a regular basis by the nursery manager using standard methodologies (these are not part of this course).

4 Coral outplanting methods

4.1 What factors should be considered when selecting outplant sites?

- The aim of coral outplanting is to restore resilient and sexually active populations of corals. It is therefore very important to select outplanting sites that have suitable characteristics for corals to grow and survive.

- Below are some of the factors to consider when selecting an outplanting site:

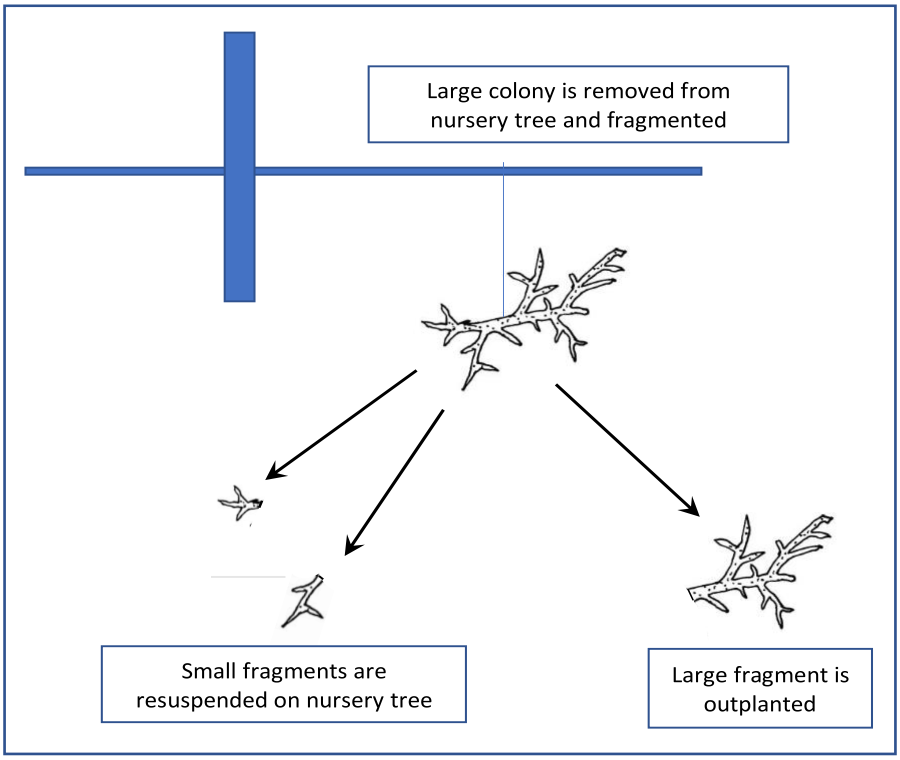
    - **Evidence of current or historical populations of *Acropora***: Outplant sites should be located close to existing populations of *Acropora* corals or where there is evidence that they once grew there.
    - **Water Quality**: Corals require good water quality with low sedimentation and turbidity and relatively minimal temperature fluctuations. An easy way to assess the water quality is to look at the health and percentage cover of existing corals in the area. If there are signs of coral diseases or extensive algal overgrowth the site should not be used.
    - **Depth**: Outplant sites should be have depths similar to the existing wild populations in the area.
    - **Bottom Type**: Hard, stable substrate that allows secure attachment of outplants. Avoid areas of coral rubble or where there are excessive algae.
    - **Predator Abundance**: Check the abundance of coral predators, such as corallivorous snails, fireworms and damselfish. Avoid sites with large populations of such predators, as these will require active predator removal as part of the routine management plan.
    - **Human Activities**: Avoid areas where human activities could damage corals. Marine Protected Areas (MPAs) are preferred locations as they should have reduced human impacts and a healthier ecosystem with plenty of herbivores and fewer coral predators – these should be controlled by their own predators (e.g. lobsters).

4.2 What are the steps involved to outplant corals from the nursery?

- When the coral colonies in the nursery are big enough they can be outplanted. For elkhorn the colonies should have branches or “ears” that are at least 5 cm in diameter. For Staghorn, the colonies should have multiple branches and be at least 20 cm long

- The optimum size of the fragments to be outplanted will depend on their chances of survival and hence the quality of the outplanting site. Generally, larger corals will have a better chance of survival, but small fragments will give a greater number of outplants. Colonies to be outplanted should be checked to ensure they are healthy and growing well, using the following criteria:
  - Show no visible signs of disease or injury
  - Have actively growing tips
  - Show good coloration (golden tan to a dark brown)

- Corals to be outplanted are harvested from the nursery and are fragmented using cutting pliers. A large fragment is put into a basket for outplanting, and small fragments are placed in a separate basket and used to repopulate the nursery – these are known as second generation fragments (see diagram below). In some cases, the nursery can be expanded during outplanting activities with large numbers of second-generation fragments.



- Coral fragments can be transported from the nursery to the outplant site using a variety of methods. If the outplant site is close, scuba divers can swim the fragments there directly in a basket. If the outplant site is further away, the fragments should be transported up to a boat and transferred to a cooler. Care should be taken to ensure that the corals are protected from physical damage and are always in clean and well-oxygenated water and kept at a constant temperature. Putting a wet towel over the cooler to protect it from sunlight is advisable.

- Corals are outplanted by attaching them to a solid surface of rock or dead coral using either cement (Portland Type 2) or epoxy putty.

- Epoxy putty is more expensive but has the advantage that it can be used in strong currents or when there is a swell. The epoxy putty is prepared prior to the dive by mixing equal amounts of Part A and Part B.

- When selecting the precise location for attaching a coral, several factors should be considered:
    - The substrate should be solid and secure, with a rough surface or “key” for good attachment
    - There should be enough space around it to allow a large coral to grow in time – avoid locations with competition from other corals or sea-fans
    - There should be direct sunlight

- The substrate should be cleaned with a wire brush to remove any loose materials and algae. It is important to get back to the bare rock or dead coral skeleton.

- The cement or epoxy is applied to the cleaned area, ensuring good adhesion.

- The coral fragment is then gently pressed into the cement or epoxy putty, ensuring that the correct surface is pointing upwards.

- Elkhorn fragments should be oriented to maximize sun-light. They can also be outplanted whole still attached to the cement cookie.

Multiple Choice Test

Please circle all the correct answers that apply. Answers given at the end.

1. Purpose of coral nurseries and coral restoration

1.1 Why are coral reefs declining?

a. Pollution
b. Sedimentation
c. Over-fishing
d. High temperatures caused by climate change
e. Diseases

1.2. Why focus on restoring Caribbean populations of elkhorn and staghorn corals?

a. They are two species of corals that suffered huge losses from a disease
b. They are important for juvenile fish
c. They look nice
d. The survivors we propagate in nurseries are more resilient and more resistant to diseases
e. They are food for fish
f. The aim of coral restoration is to restore resilient and sexually active populations of corals, so that they can reproduce naturally and replenish surrounding reefs

1.3 Why is it important to engage local communities and fisherfolk in coral restoration?

a. So local stakeholders can play a greater role in the restoration of their marine environment
b. It’s cheap labour
c. Coral reefs are very important for tourism, fisheries and coastal protection

1.4 How can coral nurseries create mutually beneficial linkages between tourism and local communities?

a. Property developers can have better reefs and exclude fishers
b. Tourism can help raise funds to support job opportunities among fisherfolk in coral restoration

2. Fundamentals of coral reef ecology

2.1 What are the basic features of a coral?

a. Corals are plants
b. Corals are colonial animals made up of individual polyps
c. Corals grow roots deep into the seabed
d. Corals have microscopic plant cells in their skin that use sunlight to make sugars
e. Corals also have tentacles and filter feed at night

2.2 What are two ways corals can reproduce?

a. Corals release eggs and sperm into the water during a spawning event
b. Corals can break away and drift in the current looking for a mate
c. Coral polyps can also produce another polyp in a process called budding - this is how corals grow
d. Corals need other corals nearby to reproduce

3. Coral nursery methods

3.1 What factors should be considered when selecting a nursery site?

Which of the following parameters are important when selecting a coral nursery site?

Answers	Parameter	Optimum for coral nurseries
A	Water temperature	Between 24°C and 29°C
B	Water quality	Good water quality is important – this can be assessed by examining the quality of nearby coral reefs
C	Water movement	Some current is good but not so much that working on the nursery becomes difficult
D	Beach bars	A good beach bar nearby is essential
E	Salinity	35ppt (35 g/L) for Caribbean corals
F	Depth	Between 2 and 10 metres depth.
G	Substrate type	Sand or gravel

H	Adjacent habitat	Close to reefs to encourage herbivorous fish to clean the nursery
I	Sedimentation and turbidity	The lower the better – keep away from river mouths or estuaries
J	Adjacent Habitat	Reef areas adjacent to the nursery site that have healthy coral populations and fish populations are a good indication that the environmental conditions are adequate for coral growth

3.2 What types of nursery structures can be used to grow corals?

a. Tables
b. Windows
c. Frames
d. Trees
e. Doors

3.3 How are corals collected and added to the nursery?

a. Surveys are done to locate good corals to provide source material for the nursery
b. There is no need to use more than one or two corals for source material
c. It's good to use lots of corals to have high genetic diversity in the nursery
d. Genetic diversity is very important in coral restoration to ensure resilience
e. Diseased corals should be selected as source material
f. Healthy corals should be selected as source material
g. No more than 50% of any one coral should be harvested as material for the nursery
h. No more than 10% of any one coral should be harvested as material for the nursery
i. Diagonal cutting pliers are used for harvesting coral fragments
j. Lots of cutting should be done at the collecting site
k. Minimal cutting should be done at the collecting site
l. Corals can be left out of water for long periods of time

3.4 What tasks are necessary to maintain a nursery?

a. Nursery management is important to keep corals free of algae and coral predators, such as snails and fireworms
b. Monitoring survival in the nursery is not important
c. Nurseries require regular cleaning to look nice and shiny
d. Nurseries require regular cleaning to keep the coral healthy
e. Gentle cleaning is important to prevent damage to the corals
f. Some fish can help clean the nurseries

g. Fish are not welcome on the nursery
h. Diseased corals can be left in the nursery as they increase resilience
i. A healthy reef ecosystem near the nursery can help reduce predation and the need for cleaning

4 Coral outplanting methods

4.1 What factors should be considered when selecting outplant sites?

a. It's important to select outplanting sites that have suitable characteristics for corals to grow and survive
b. Outplant sites should be located close to existing populations of elkhorn or staghorn corals or where there is evidence that they once grew there
c. Areas of coral rubble or where there is lots of algae are best for outplanting corals
d. Water quality is important. If there are signs of coral diseases the site should not be used
e. Outplant sites should be much deeper to the existing wild populations in the area
f. Hard, stable substrate that allows secure attachment of outplants
g. Chose sites with large populations of coral predators, such as snails and fireworms
h. Avoid areas where human activities could damage corals

4.2 What are the steps involved to outplant corals from the nursery?

a. The best size to outplant elkhorn is when the coral has branches or "ears" that are at least 5 cm in diameter
b. The best size to outplant staghorn is when the coral has multiple branches and is at least 2cm long
c. It's good to outplant some diseased corals
d. If the outplant site is close, scuba divers can swim the fragments there directly
e. If the outplant site is further away, the fragments should be transported by boat in a cooler
f. Corals are outplanted by attaching them to a solid surface of rock or dead coral using either cement or epoxy putty
g. Duct tape can also be used for attaching corals
h. When selecting the precise location for attaching a coral, the substrate should be solid and secure, with a rough surface or "key" for good attachment
i. There should be space around it to allow a large coral to grow in time
j. Shaded locations are best for outplanting
k. There should be direct sunlight
l. The substrate should be cleaned with a wire brush to remove any loose materials and algae.

m. The cement or epoxy is applied to the cleaned area, ensuring good adhesion. The coral fragment is then gently pressed into the cement or epoxy putty, ensuring that the correct surface is pointing upwards.
n. Elkhorn fragments should be oriented to minimize exposure to sunlight.

Answers

Purpose of coral nurseries and coral restoration

1.2 Why are coral reefs declining?

Correct answers: a, b, c, d, e

1.2. Why focus on restoring Caribbean populations of elkhorn and staghorn corals?

Correct answers: a, b, d and f

1.3 Why is it important to engage local communities and fisherfolk in coral restoration?

Correct answers: a and c

1.4 How can coral nurseries create mutually beneficial linkages between tourism and local communities?

***Correct answers*: b**

Fundamentals of coral reef ecology

2.2 What are the basic features of a coral?

Correct answers: b, d and e

2.3 What are two ways corals can reproduce?

Correct answers: a, c and d

Coral nursery methods

3.1 What factors should be considered when selecting a nursery site?

Correct answers: All the parameters in table are important except for D - "beach bars' are desirable but not essential!

3.2 What types of nursery structures can be used to grow corals?

Correct answers: a, c and d

3.3 How are corals collected and added to the nursery?

Correct answers: a, c, d, f, h, i, and k

3.4 What tasks are necessary to maintain a nursery?

Correct answers: a, d, e, f, and i

Coral outplanting methods

4.1 What factors should be considered when selecting outplant sites?

Correct answers: a, b, d, f, and h

4.2 What are the steps involved to outplant corals from the nursery?

Correct answers: a, d, e, f, h, i, k, l, and m

CORAL NURSERY DIVER DISTINCTIVE SPECIALTY INSTRUCTOR OUTLINE

Introduction

How to Use this Guide

This guide speaks to you, the **Coral Nursery Diver Distinctive Specialty** instructor. The guide contains three sections – the first contains standards specific to this course, the second contains knowledge development presentations, the third details the open water dives.

All required standards, learning objectives, activities, and performance requirements specific to the **Coral Nursery Diver Distinctive Specialty** course appear in **boldface** print. **The boldface assists you in easily identifying those requirements that you *must* adhere to when you conduct the course.** Items not in boldface print are recommendations for your information and consideration. General course standards applicable to all PADI courses are located in the General Standards and Procedures section of your PADI *Instructor Manual.*

Course Philosophy and Goals

This specialty is an introduction to coral nurseries and coral outplanting, and is designed to familiarize divers with the basic skills, knowledge, procedures and enjoyment of propagating corals in underwater nurseries and outplanting them on suitable reefs.

The goals of the **Coral Nursery Diver Distinctive Specialty Course** training are:

A. Acquire knowledge relevant to the propagation and outplanting of corals
B. Perform skills to clean coral nursery and collect suitable coral fragments for outplanting
C. Perform skills to effectively outplant coral fragments

Course Flow Options

This course contains knowledge development, and two open water training dives. You should conduct the knowledge development session before any open water training.

There are **two** open water dives to complete. You may rearrange skill sequences within each dive; however, the sequence of dives must stay intact. You may add more dives as necessary to meet student divers' needs. Organize your course to incorporate environment friendly techniques throughout each dive, to accommodate student diver learning style, logistical needs, and your sequencing preferences.

Section One

Course Standards

This section includes the course standards, recommendations, and suggestions for conducting the PADI **Coral Nursery Diver Distinctive Specialty** course.

Standards at a Glance

Course Standards

Minimum Instructor Rating:	**PADI Coral Nursery Diver Distinctive Specialty Instructor**
Prerequisites: certification	**PADI (Junior) Open Water Diver or qualifying**
Minimum Age:	**12 years**
Ratios Open Water:	**8:1.**
Depth:	**Maximum Depth 18 meters/60 feet.**
Hours:	Recommended: 2-4
Minimum Open Water Dives:	**2**

Materials and Equipment - Instructor and Student::

• ***CORAL NURSERY Diver Distinctive Specialty Course Instructor Outline*** (Instructor only)

• **Student and Instructor equipment as outlined in the PADI Instructor Manual, General Standards and Procedures**

• Specialty equipment and supplies:

a. Spare parts kit

b. Extra weights in small increments - for student trim

c. Wire cutters

d. Two-part epoxy putty or cement/sand mix

e. Wire brush

f. Plastic basket

g. Coral fragments (collected from nursery)

Instructor Prerequisites

To qualify to teach the **PADI Coral Nursery Diver Distinctive Specialty** course, an individual must be a Teaching status PADI Open Water Scuba Instructor or higher. **PADI Instructors may apply for the Coral Nursery Diver Distinctive Specialty Instructor rating after completing a Specialty Instructor Training course with a PADI Course Director, or by providing proof of experience and applying directly to PADI.** For further detail, reference Membership Standards in the General Standards and Procedures section of your PADI *Instructor Manual.*

Student Diver Prerequisites

By the start of the course, a diver must be:

1. Certified as a PADI (Junior) Open Water Diver or have a qualifying certification from another training organization. In this case, a qualifying certification is defined as proof of entry-level scuba certification with a minimum of four open water training dives. Verify student diver prerequisite skills and provide remediation as necessary.
2. Be at least 12 years old.

Supervision and Ratios

Open Water Dives

A Teaching status PADI Coral Nursery Diver Distinctive Specialty Instructor must be present and in direct supervision of all activities and must ensure that all performance requirements are met. After all student divers have successfully demonstrated the required skills, the Instructor may exercise indirect control over the balance of the dive.

The ratio for open water dives is 8 student divers per instructor (8:1).

Site, Depths, and Hours

Site

Choose sites with conditions and environments suitable for completing requirements. Shallow dives will provide divers with more time to complete tasks. Use different open water dive sites, if possible, to give students divers experience in dealing with a variety of environmental conditions (incorporate environment friendly techniques throughout each dive) and logistical challenges.

Depths

Maximum Depth: 18 metres / 60 feet.

Hours

The PADI Coral Nursery Diver Distinctive Specialty course includes 2 open water dives. Conduct dives during daylight hours between sunrise and sunset. The minimum number of recommended hours is 2 hours.

Assessment Standards

The student diver must demonstrate accurate and adequate knowledge during the open water dives and must perform all skills (procedures and motor skills) fluidly, with little difficulty, in a manner that demonstrates minimal or no stress.

Certification Requirements and Procedures

By the completion of the course, student divers must complete *all* performance requirements for the Coral Nursery Diver Distinctive Specialty course Open Water Dives One and Two. The instructor certifying the student diver must ensure that all certification requirements have been met. The certifying instructor obtains **Coral Nursery Diver Distinctive Specialty** certification by submitting a completed, signed PIC t or PIC online o the appropriate PADI office.

Section Two

Knowledge Development

Conduct

Use the following teaching outline as a road map of the conduct, content, sequence and structure for the **Coral Nursery Diver Distinctive Specialty** course. The result should be student divers with theoretical knowledge and pragmatic experience who can adapt what they have learned to assist in the propagation and transplanting of corals. **Student divers will be able to explain the following learning objectives.**

Knowledge Development

Learning Objectives

By the end of knowledge development, student divers will be able to explain:

I. Purpose of coral nurseries and coral restoration
   a. Why are coral reefs declining?
   b. Why focus on restoring Caribbean populations of Elkhorn and Staghorn corals?
   c. Why is it important to engage local communities and fisherfolk in coral restoration?
   d. How can coral nurseries create mutually beneficial linkages between tourism and local communities?

II. Fundamentals of coral reef ecology
   a. What are the basic features of a coral?
   b. What are two ways corals can reproduce?

III. Coral nursery methods
   a. What factors should be considered when selecting a nursery site?
   b. What types of nursery structures can be used to grow corals?
   c. How are corals collected and added to the nursery?
   d. What tasks, tools and monitoring are necessary to maintain a nursery?

IV. Coral outplanting methods
   a. What factors should be considered when selecting outplant sites?
   b. What are the steps involved to outplant corals from the nursery?

Knowledge Development Teaching Outline

A. Course Introduction

1. Staff and student diver introductions

Note:

Introduce yourself and assistants. Explain your background with coral nurseries and outplanting if your student divers aren't familiar with you.

Give times, dates and locations as appropriate for classroom presentations and open water dives.

1. Course goal

This specialty is an introduction to coral nurseries and coral outplanting, and is designed to familiarize divers with the basic skills, knowledge, procedures and enjoyment of propagating corals in underwater nurseries and outplanting them on suitable reefs.

2. Course overview
   a. Classroom presentations
   b. Open water dives. There will be two open water dives.
3. Certification
   a. Upon successfully completing the course, you will receive the Coral Nursery Specialty Diver Certification.
   b. Certification means that you will be qualified to plan, organize, and make dives in conditions generally comparable to or better than, those in which you are trained.

Note:

Use the PADI Continuing Education Administrative Document. Explain all course costs and materials, and what the costs do and do not include, including equipment use, dive site fees, etc. Explain what equipment student divers must have for the course, and what you will provide. Cover and review points about scheduling and attendance.

5. Class requirements
   a. Complete all paperwork.
   b. Course costs.
   c. Equipment needs.
   d. Schedule and attendance.

B. Course Content (See Training Manual – Appendix 1)

Section Three

Open Water Dives

General Open Water Considerations

1. Involve student divers in dive-planning activities. Give special attention to student diver anxiety and stress levels, in addition to student diver equipment preparedness.
2. Conduct a thorough briefing. The better the briefing, the more smoothly the dive will proceed. Assign buddy teams according to ability (weak with strong) and establish a check-in/check-out procedure.
3. Assign logistical duties to staff and review emergency protocols.
4. Remind divers to familiarize themselves with their buddy's equipment.
5. Evaluate diver's thermal protection for appropriateness for the dive site and expected conditions.
5. Make yourself available to answer questions during equipment assembly, safety checks and gear-up.

Dive One

Performance Requirements

By the end of the Open Water Dive One, student divers will be able to:

- **Demonstrate good buoyancy skills so as not to disturb sediments and avoid accidental contact with nursery structures or coral fragments.**
- **Practice and then demonstrate how to clean a coral structure using the correct tools, and safely working around coral fragments to prevent any damage.**
- **Collect fragments* of coral from the nursery and place in a basket**
- **Safely transport fragments to dive boat**
- **Place coral fragments in cooler and maintain with regular exchanges of clean seawater**

A. Briefing
   1. Evaluation of conditions

2. Facilities at dive site
3. Entry technique to be used – location dependant
4. Exit technique to be used – location dependent
5. Bottom composition and topography around training site
6. Depth range on bottom
7. Ending tank pressure – when to terminate the dive
8. Interesting and helpful facts about the dive site
9. Sequence of training dive – review Dive One skills
    a. Suiting up
    b. Predive Safety check
    c. Buoyancy check at the surface
    d. Demonstrate good buoyancy skills so as not to disturb sediments and avoid accidental contact with nursery structures or coral fragments.
    e. Practice and then demonstrate how to clean a coral structure using the correct tools, and safely working around coral fragments to prevent any damage.
    f. Collect fragments of coral from the nursery and place in a basket
    g. Safely transport fragments to dive boat
    h. Ascent
    i. Place coral fragments in cooler and maintain with regular exchanges of clean seawater

B. Predive procedures

C. Descent

D. **Dive One skills**

- **Demonstrate good buoyancy skills so as not to disturb sediments near nursery and avoid accidental contact with nursery structures or coral fragments.**
- **Practice and then demonstrate how to clean a coral structure using the correct tools, and safely working around coral fragments to prevent any damage.**
- **Collect fragments of coral from the nursery and place in a basket**
- **Safely transport fragments to dive boat**

E. Post-dive procedures

- **Place coral fragments in cooler and maintain with regular exchanges of clean seawater**

F. Debriefing

G. Log dive (instructor signs logbook)

Dive Two

Performance Requirements

By the end of the Open Water Dive Two, student divers will be able to:

- **Transport coral fragments from boat to outplanting reef**
- **Demonstrate how to select a suitable area of reef on which to outplant coral fragments**
    - **The substrate should be solid and secure, with a rough surface or "key" for good attachment**
    - **There should be enough space around it to allow a large coral to grow in time – avoid locations with competition from other corals or sea-fans**
    - **There should be direct sunlight**
- **Demonstrate how to clean the substrate with a wire brush,**
- **Apply cement or epoxy putty to cleaned area, ensuring good adhesion**
- **Fix coral fragment(s) to substrate ensuring optimal orientation of fragment**
    - **The coral fragment is then gently pressed into the cement or epoxy putty, ensuring that the correct surface is pointing upwards**
    - **Elkhorn fragments should be oriented to maximize sunlight**
    - **Staghorn fragments are best placed in a large rosette or cluster of fragments to reduce mortality from predators**
- **Take photo of coral outplants**

A. Briefing

1. Evaluation of conditions
2. Facilities at dive site
3. Entry technique to be used – location dependant
4. Exit technique to be used – location dependent
5. Bottom composition and topography around training site
6. Depth range on bottom
7. Ending tank pressure – when to terminate the dive
8. Interesting and helpful facts about the dive site
9. Sequence of training dive – review Dive Two skills
    a. Suiting up
    b. Predive Safety check
    c. Buoyancy check at the surface
    d. Dive Two Skills:
        - Safely transport coral fragments from boat to outplanting reef
        - Demonstrate how to select a suitable area of reef on which to outplant coral fragments
            - The substrate should be solid and secure, with a rough surface or "key" for good attachment
            - There should be enough space around it to allow a large coral to grow in time – avoid locations with competition from other corals or sea-fans
            - There should be direct sunlight

- Demonstrate how to clean the substrate with a wire brush,
- Apply cement or epoxy putty to cleaned area, ensuring good adhesion
- Fix coral fragment(s) to substrate ensuring optimal orientation of fragment
    - The coral fragment is then gently pressed into the cement or epoxy putty, ensuring that the correct surface is pointing upwards.
    - Elkhorn fragments should be oriented to maximize sunlight.
    - Staghorn fragments are best placed in a large rosette or cluster of fragments to reduce mortality from predators.
- Take photo of coral outplants

e. Dive for fun and pleasure

f. Ascent

B. Predive procedures

C. Descent

D. **Dive Two skills:**

- **Transport coral fragments from boat to outplanting reef**
- **Demonstrate how to select a suitable area of reef on which to outplant coral fragments**
    - **The substrate should be solid and secure, with a rough surface or "key" for good attachment**
    - **There should be enough space around it to allow a large coral to grow in time – avoid locations with competition from other corals or sea-fans**
    - **There should be direct sunlight**
- **Demonstrate how to clean the substrate with a wire brush,**
- **Apply cement or epoxy putty to cleaned area, ensuring good adhesion**
- **Fix coral fragment(s) to substrate ensuring optimal orientation of fragment**
    - **The coral fragment is then gently pressed into the cement or epoxy putty, ensuring that the correct surface is pointing upwards.**
    - **Elkhorn fragments should be oriented to maximize sunlight.**
    - **Staghorn fragments are best placed in a large rosette or cluster of fragments to reduce mortality from predators.**
- **Take photo of coral outplants**

E. Post-dive procedures

F. Debriefing

G. Log dive (instructor signs logbook)

Appendix 3 – Water Quality Data

Environmental Health and Sustainable Development Department
Caribbean Public Health Agency
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SAINT LUCIA
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Email: carphaslu@carpha.org

Certificate of Analysis

Newton Eristhee
St. Lucia.

Report #: 20190196
Date Reported: 06/18/2019
Date Sampled: 05/21/2019
Date Received: 05/21/2019
Date Completed: 06/18/2019

Test		Method	Result	Units	Analyst	Date Analysed
20190196-01	**PINN 1MA**	**Coastal Water**				
E. coli count		EPA1103.1	4	CFU/100mL	J. Evans	22/05/2019
Enterococci count		CEHILSM-4	1	CFU/100mL	J. Evans	22/05/2019
Total Coliforms		CEHILSM-1	6	CFU/100mL	J. Evans	22/05/2019
Potassium		HACH 8049	515.0	mg/L	J. Evans	03/06/2019
Phosphates		CEHILSC-6	0.11	mg/L	J. Evans	04/06/2019
Nitrates		CEHILSC-5	4.3	mg/L	J. Evans	03/06/2019
Pesticides			ND		K. Charlemagne	18/06/2019
201900196-02	**PINN 1MB**	**Coastal Water**				
E. coli count		EPA1103.1	5	CFU/100mL	J. Evans	22/05/2019
Enterococci count		CEHILSM-4	<1	CFU/100mL	J. Evans	22/05/2019
Total Coliforms		CEHILSM-1	12	CFU/100mL	J. Evans	22/05/2019
Potassium		HACH 8049	518.2	mg/L	J. Evans	03/06/2019
Phosphates		CEHILSC-6	0.17	mg/L	J. Evans	04/06/2019
Nitrates		CEHILSC-5	4.0	mg/L	J. Evans	03/06/2019
Pesticides			ND		K. Charlemagne	18/06/2019
201900196-03	**DHM 1MA**	**Coastal Water**				
E. coli count		EPA1103.1	2	CFU/100mL	J. Evans	22/05/2019
Enterococci count		CEHILSM-4	1	CFU/100mL	J. Evans	22/05/2019
Total Coliforms		CEHILSM-1	5	CFU/100mL	J. Evans	22/05/2019
Potassium		HACH 8049	411.8	mg/L	J. Evans	03/06/2019
Phosphates		CEHILSC-6	0.07	mg/L	J. Evans	04/06/2019
Nitrates		CEHILSC-5	4.4	mg/L	J. Evans	03/06/2019
Pesticides			ND		K. Charlemagne	18/06/2019
201900196-04	**DHM 1MB**	**Coastal Water**				
E. coli count		EPA1103.1	<1	CFU/100mL	J. Evans	22/05/2019
Enterococci count		CEHILSM-4	25	CFU/100mL	J. Evans	22/05/2019
Total Coliforms		CEHILSM-1	22	CFU/100mL	J. Evans	22/05/2019
Potassium		HACH 8049	405.2	mg/L	J. Evans	03/06/2019
Phosphates		CEHILSC-6	0.13	mg/L	J. Evans	04/06/2019
Nitrates		CEHILSC-5	4.6	mg/L	J. Evans	03/06/2019
Pesticides			ND		K. Charlemagne	18/06/2019

Certificate of Analysis

Newton Eristhee		Report #:	20190196
St. Lucia.		Date Reported:	07/18/2019
		Date Sampled:	05/21/2019
		Date Received:	05/21/2019
		Date Completed:	18/06/2019

201900196-05	**DHW 1MA**	**Coastal Water**				
E. coli count		EPA1103.1	6	CFU/100mL	J. Evans	22/05/2019
Enterococci count		CEHILSM-4	3	CFU/100mL	J. Evans	22/05/2019
Total Coliforms		CEHILSM-1	7	CFU/100mL	J. Evans	22/05/2019
Potassium		HACH 8049	396.5	mg/L	J. Evans	03/06/2019
Phosphates		CEHILSC-6	0.05	mg/L	J. Evans	04/06/2019
Nitrates		CEHILSC-5	4.0	mg/L	J. Evans	03/06/2019
Pesticides			ND		K. Charlemagne	18/06/2019

201900196-06	**DHW 1MB**	**Coastal Water**				
E. coli count		EPA1103.1	2	CFU/100mL	J. Evans	22/05/2019
Enterococci count		CEHILSM-4	<1	CFU/100mL	J. Evans	22/05/2019
Total Coliforms		CEHILSM-1	3	CFU/100mL	J. Evans	22/05/2019
Potassium		HACH 8049	594.8	mg/L	J. Evans	03/06/2019
Phosphates		CEHILSC-6	0.09	mg/L	J. Evans	04/06/2019
Nitrates		CEHILSC-5	4.0	mg/L	J. Evans	03/06/2019
Pesticides			ND		K. Charlemagne	18/06/2019

The reported results pertain only to the specified samples tested.
ND: not detected

Analysis and Interpretation of Results:
Coastal Water

- All samples tested met the requirements for recreational use based on the parameters tested.

Recommended Limits
The Caribbean Public Health Agency recommends the following maximum limits and ranges:

Test	**Limits**
Coastal Water	
E. coli count	126 CFU/100 mL
Enterococci	35 CFU/100 mL
Total Coliforms	1000 CFU/100mL
Phosphates	1 mg/L
Nitrates	5 mg/L
Potassium	generally about 380 mg/L

References:

- Standard Methods for the Examination of Water and Wastewater, 22nd Edition, 2012, AWWA/APHA/WEF
- Protocol Concerning Pollution from Land-Based Sources and Activities to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region.
- The Canadian Journal of Infectious Diseases & Medical Microbiology
- The Mauritius Government Gazette; Guidelines for Coastal Water Quality

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Shervon De Leon
Scientific Coordinator
Environmental Health and Sustainable Development Department

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Certificate of Analysis

Newton Eristhee
St. Lucia.

Report #:	20200058
Date Reported:	03/27/2020
Date Sampled:	02/24/2020
Date Received:	02/24/2020
Date Completed:	03/27/2020

Test	Method	Result	Units	Analyst	Date Analysed
20200058-01 ST	**Coastal Water**				
E. coli count	EPA1103.1	**304 H**	CFU/100mL	V. Sylvester	02/24/2020
Enterococci count	CEHILSM-4	**48H**	CFU/100mL	V. Sylvester	02/24/2020
Total Coliforms	CEHILSM-1	338	CFU/100mL	V. Sylvester	02/24/2020
Potassium	HACH 8049	432	mg/L	V. Sylvester	03/10/2020
Phosphates	CEHILSC-6	0.05	mg/L	V. Sylvester	03/10/2020
Nitrates	CEHILSC-5	**5.20 H**	mg/L	V. Sylvester	03/10/2020
Pesticides		ND		K. Charlemagne	03/24/2020
20200058-02 CT	**Coastal Water**				
E. coli count	EPA1103.1	80	CFU/100mL	V. Sylvester	02/24/2020
Enterococci count	CEHILSM-4	17	CFU/100mL	V. Sylvester	02/24/2020
Total Coliforms	CEHILSM-1	338	CFU/100mL	V. Sylvester	02/24/2020
Potassium	HACH 8049	462	mg/L	V. Sylvester	03/10/2020
Phosphates	CEHILSC-6	0.31	mg/L	V. Sylvester	03/10/2020
Nitrates	CEHILSC-5	3.30	mg/L	V. Sylvester	03/10/2020
Pesticides		ND		K. Charlemagne	03/24/2020
20200058-03 NT	**Coastal Water**				
E. coli count	EPA1103.1	54	CFU/100mL	V. Sylvester	02/24/2020
Enterococci count	CEHILSM-4	17	CFU/100mL	V. Sylvester	02/24/2020
Total Coliforms	CEHILSM-1	174	CFU/100mL	V. Sylvester	02/24/2020
Potassium	HACH 8049	404	mg/L	V. Sylvester	03/10/2020
Phosphates	CEHILSC-6	0.04	mg/L	V. Sylvester	03/10/2020
Nitrates	CEHILSC-5	**5.4 H**	mg/L	V. Sylvester	03/10/2020
Pesticides		ND		K. Charlemagne	03/24/2020
20200058-04 SB	**Coastal Water**				
E. coli count	EPA1103.1	82	CFU/100mL	V. Sylvester	02/24/2020
Enterococci count	CEHILSM-4	**45 H**	CFU/100mL	V. Sylvester	02/24/2020
Total Coliforms	CEHILSM-1	206	CFU/100mL	V. Sylvester	02/24/2020
Potassium	HACH 8049	436	mg/L	V. Sylvester	03/10/2020
Phosphates	CEHILSC-6	0.05	mg/L	V. Sylvester	03/10/2020
Nitrates	CEHILSC-5	3.1	mg/L	V. Sylvester	03/10/2020
Pesticides		ND		K. Charlemagne	03/24/2020

Certificate of Analysis

Newton Eristhee
St. Lucia.

Report #:	20200058
Date Reported:	07/18/2019
Date Sampled:	02/24/2020
Date Received:	02/24/2020
Date Completed:	03/24/2020

20200058-05 CB	**Coastal Water**				
E. coli count	EPA1103.1	60	CFU/100mL	V. Sylvester	02/24/2020
Enterococci count	CEHILSM-4	21	CFU/100mL	V. Sylvester	02/24/2020
Total Coliforms	CEHILSM-1	172	CFU/100mL	V. Sylvester	02/24/2020
Potassium	HACH 8049	532	mg/L	V. Sylvester	03/10/2020
Phosphates	CEHILSC-6	0.15	mg/L	V. Sylvester	03/10/2020
Nitrates	CEHILSC-5	4.10	mg/L	V. Sylvester	03/10/2020
Pesticides		ND		K. Charlemagne	03/24/2020
20200058-06 NB	**Coastal Water**				
E. coli count	EPA1103.1	**296 H**	CFU/100mL	V. Sylvester	02/24/2020
Enterococci count	CEHILSM-4	**38 H**	CFU/100mL	V. Sylvester	02/24/2020
Total Coliforms	CEHILSM-1	264	CFU/100mL	V. Sylvester	02/24/2020
Potassium	HACH 8049	421	mg/L	V. Sylvester	03/10/2020
Phosphates	CEHILSC-6	0.20	mg/L	V. Sylvester	03/10/2020
Nitrates	CEHILSC-5	4.70	mg/L	V. Sylvester	03/10/2020
Pesticides		ND		K. Charlemagne	03/24/2020

The reported results pertain only to the specified samples tested.
H: High
ND: not detected

Recommended Limits

The Caribbean Public Health Agency recommends the following maximum limits and ranges:

Test	**Limits**
Coastal Water	
E. coli count	126 CFU/100 mL
Enterococci	35 CFU/100 mL
Total Coliforms	1000 CFU/100mL
Phosphates	1 mg/L
Nitrates	5 mg/L
Potassium	generally about 380 mg/L

References:

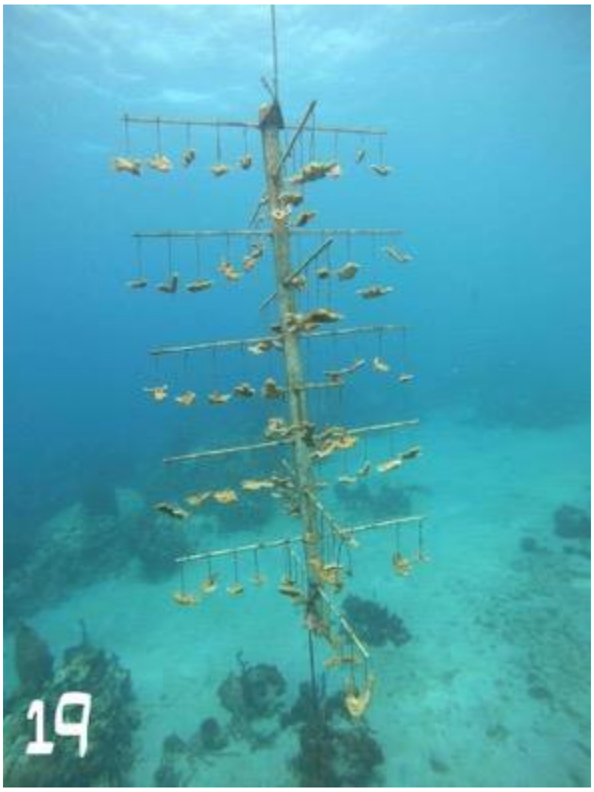
- Standard Methods for the Examination of Water and Wastewater, 22nd Edition, 2012, AWWA/APHA/WEF
- Protocol Concerning Pollution from Land-Based Sources and Activities to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region.
- The Canadian Journal of Infectious Diseases & Medical Microbiology
- The Mauritius Government Gazette; Guidelines for Coastal Water Quality

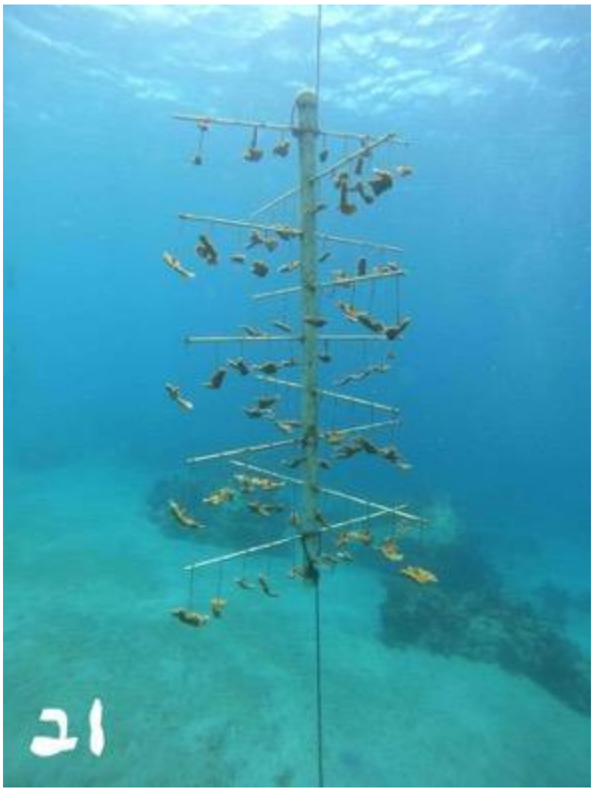
Approved By:

Kareem Charlemagne
Laboratory Manager
Environmental Health and Sustainable Development Department

Appendix 4 – Photos of Coral Nursery Trees

All photos of the coral nursery trees from Feb 2020 are available to view or download at: https://www.dropbox.com/sh/1rn99avpsyp1ue3/AAAIoiqoSwGDBnyrW_V4uiBga?dl=0





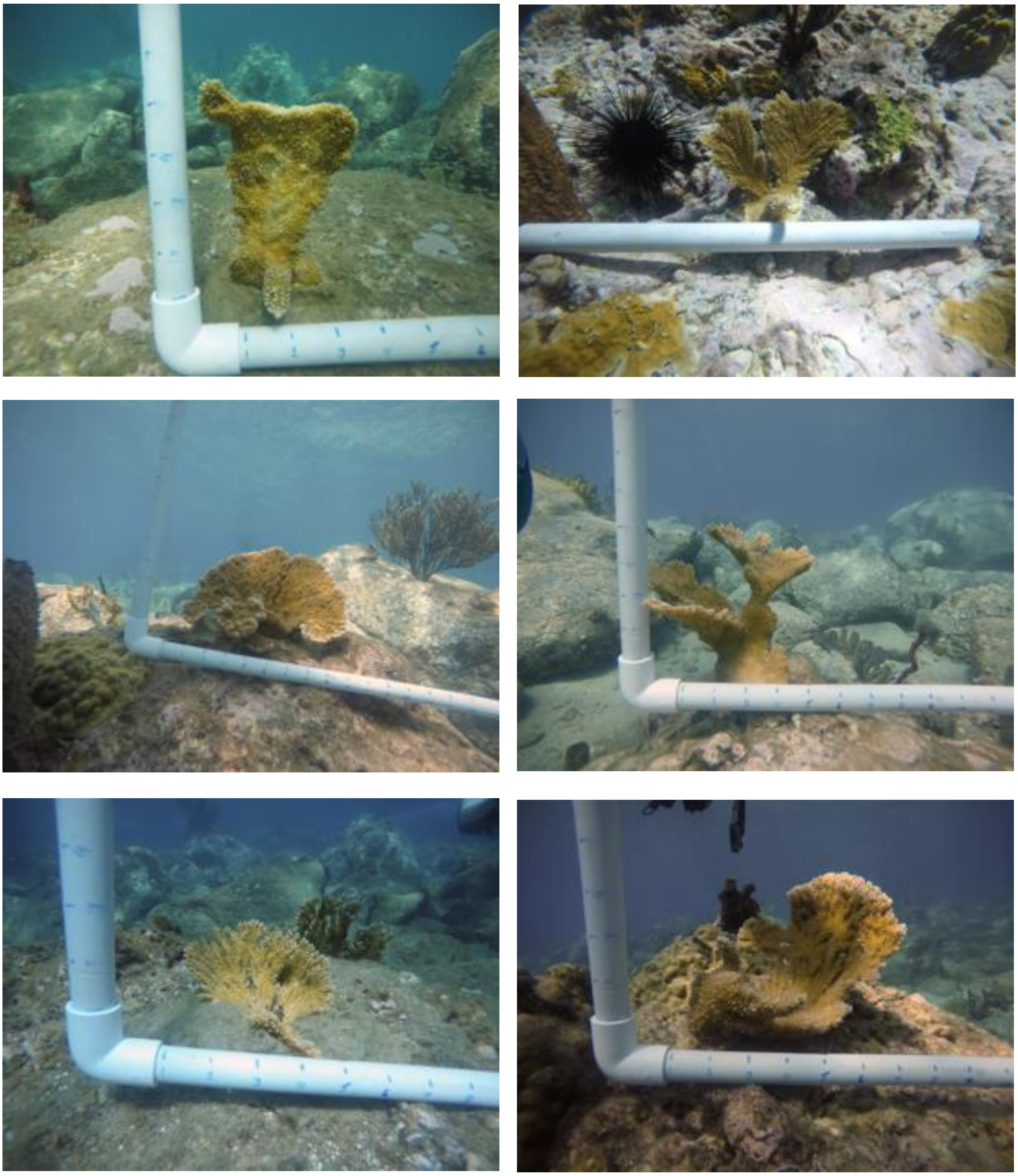
Appendix 6 – Photos of coral outplants

All photos of the coral outplants from Feb 2020 are available to view or download at: https://www.dropbox.com/sh/4hfpyxv2g17cmaz/AADX9Y2ZnqRV0D1fGhsRDcKDa?dl=0

Sample of staghorn outplants photographed in February 2020

ts

Sample of elkhorn outplants photographed in February 2020

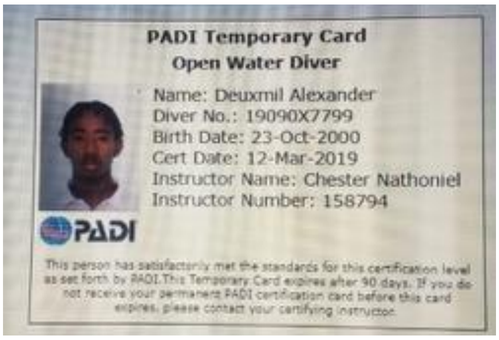


Appendix 7 – PADI certifications

Table 4. Names and details of the SCUBA training provided to the coral gardeners

Name	Start date	Status	Completion date	Age	Employment
Luke Delmon Alfred	12-Jul-19	completed	18-Jun-19	19	Boat fishermen
Aquinas Sylvester	12-Jul-19	completed	18-Jun19	18	Boat fishermen
Abdul Epiphane	12-Jul-19	completed	18-Jun-19	26	Boat fishermen
Miguel Charlemange	12-Jul-19	completed	9-Oct-19		Boat fishermen
Perry Charlemagne	12-Jul-19	completed	9-Oct-19	30	Spearfisher
Deuxmil Alexander	10-Mar-19	completed	12-Mar-19	19	Unemployed
Ian Joseph	12-Jul-19	Not completed		34	Boat fishermen
Curty Auguste	17-Jul-19	not completed		19	Unemployed
jeremiah Butcher	17-Jul-19	not completed		19	Street vendor
Cuthbert Michel	17-Jul-19	completed	19-Jan-20	42	Hotel worker

Samples of the PADI certificates:



Appendix 8 – Draft design of poster

The Saint Lucia Coral Restoration Programme for Resilient Ecosystems and Sustainable Livelihoods

CLEAR CARIBBEAN · Caribbean Aqua-Terrestrial Solutions · Sandals FOUNDATION Our Promise. Our Caribbean. · SMMA

For more information visit www.clearcaribbean.org