

# HOLISTIC APPROACH TO REEF PROTECTION

## Coral Nurseries and Coral Restoration at Anantara Dhigu and Anantara Veli

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## Executive Summary

Between April 10-25, 2018 Coral Reef CPR, in partnership with Silver Sands (Aquafanatics) and Anantara (Dhigu and Veli), completed the next phase of coral nursery and coral restoration work, as part of the Holistic Approach to Reef Protection (HARP) program. All of the work was undertaken within the shallow lagoonal and reefal habitats surrounding Anantara, in South Malé Atoll, Maldives. The nursery (1-4) and restoration locations (1, 2, 4) are shown below. The field activities focused on four aspects: 1) nursery maintenance; 2) expansion of coral nurseries through addition of new fragments to coral ropes and coral tables; 3) outplanting of nursery-grown corals onto degraded reefs; and 4) maintenance and expansion of the Aquabar snorkel trail.



Corals within the four nurseries (Aquabar, Advanced Snorkel Area, Veli lagoon and Dhigu House Reef) have all shown substantial growth, with over 97% survival since establishment of the nurseries and a 500-1000 fold increase in biomass of corals. Coral fragments were 9-18 months old and had increased in size from single, unbranched 3-8

cm fragments to highly branched juvenile and adult coral colonies ranging in size from 12-80 cm diameter (depending on species and age). Many of the ropes containing the fastest growing staghorn corals had shown so much growth and were now so heavy that they were lying on the sand and at risk of mortality due to burial.

All ropes and tables within four coral nurseries at Dhigu and Veli, South Male Atoll were cleaned to remove algae, sediment and competing invertebrates, corals were elevated off the sediment (for those ropes that were now lying on the bottom; left image), and coral colonies were monitored and photographed. Nurseries were in extremely good shape, with minimal problems with fouling organisms. Some corals showed minor bleaching, as this was the period of seasonally elevated water temperatures and temperature meters at nurseries recorded temperatures of 31-32° C during April.



A total of four coral tables (400 corals total) and 27 coral ropes were established within existing nurseries on Veli, Aquabar and Dhigu House Reef. These contained 1484 coral fragments. All fragments are second generation clippings from nursery grown corals. The fragments are pieces that broke off during the translocation of the corals, and rescued from the sand. No new corals were sampled to expand the nursery.

Corals from one table and eight ropes at Veli Nurseries were transplanted onto the dead staghorn framework around the water villas, targeting four restoration areas. Additional ropes of staghorn coral (n=6) were transported from the Aquabar nursery to Veli restoration sites. Large staghorn coral colonies now exist adjacent to the walkway between water villas (in 0.5-1 m depth) in two locations, and they form two dense thickets, each 25 X 10 m in size, within the central part of the lagoon. Four new tables (100 corals per table) were established near the pontoon dock and ten new ropes were attached to three nursery frames. All coral fragments used to expand the nursery were second generation corals pruned from existing colonies within the nursery, and no coral was removed from natural reefs.



Three ropes were transplanted from three frames at Dhigu House Reef onto a degraded section of reef (right). This included six species of *Acropora*, and 120 corals. Three new ropes were established to replace those removed. All fragments placed on the new ropes were taken from the existing nursery-grown corals (2<sup>nd</sup> generation fragments).

All of the ropes (n=10) from two nursery frames at Aquabar were transplanted onto two reefs, Veli and Aquabar Snorkel trail. Six ropes of staghorn coral were moved to Veli reef and four ropes containing five different species of *Acropora* were transplanted to the Aquabar snorkel trail. Ten new ropes were established on the existing two frames using broken branches that were salvaged during the transplantation process.

Aquabar snorkel trail has done extremely well since first established in February 2017, with branching corals showing high rates of growth. Nursery-grown staghorn and table acroporid colonies planted on this reef increased from 15-20 cm colonies to bushes that were 60-150 cm in height/diameter. Maintenance of the trail was minimal, consisting primarily of addition of reef substrate, overturning corals that had become dislodged from the trail, removal of coral eating snails from four corals, removal of two corals infected with black-band disease, and removal of one crown of thorns starfish that was consuming

staghorn coral colonies. The trail was expanded in length (5 m at the beginning and 5 m at the end) and width (three new areas were added). Dead coral branches and boulders were collected from an adjacent shallow reef and used to build a new reef framework. Nursery-grown *Acropora* corals were planted onto the new reef framework to create a dense thicket of staghorn coral and a thriving living reef structure.

The work undertaken by Coral Reef CPR through our HARP program, as a CSR initiative implemented by Minor Hotels and Anantara Resorts in the Maldives, has been highly successful and demonstrates the feasibility of a simple, low-tech, low cost coral restoration effort. Following the devastating 2016 coral bleaching event, we established coral nurseries using small coral fragments that were rescued from locations and



conditions where they would have died. By attaching these to plastic mesh covered tables and ropes suspended off the bottom, we were able to preserve this genetic stock of corals and grow them into large sexually mature colonies that could be transplanted onto the reef, restoring badly degraded habitats. In the first phase of our coral restoration we successfully created a diverse, flourishing snorkel trail and have established large staghorn thickets on a reef that sustained >99% coral loss. Both of these are located close to shore and are frequently visited by resort guests. We also transplanted corals onto the house reef, transforming a rubble/hardground area that had died during 2016 into a high-relief coral forest now occupied by hundreds of reef fish. Thousands more of our nursery-grown corals are ready to transplant back onto the reef, and the nurseries contain enough coral to provide 2<sup>nd</sup> generation fragments that can be used to expand the size of these nurseries.

## Acknowledgements

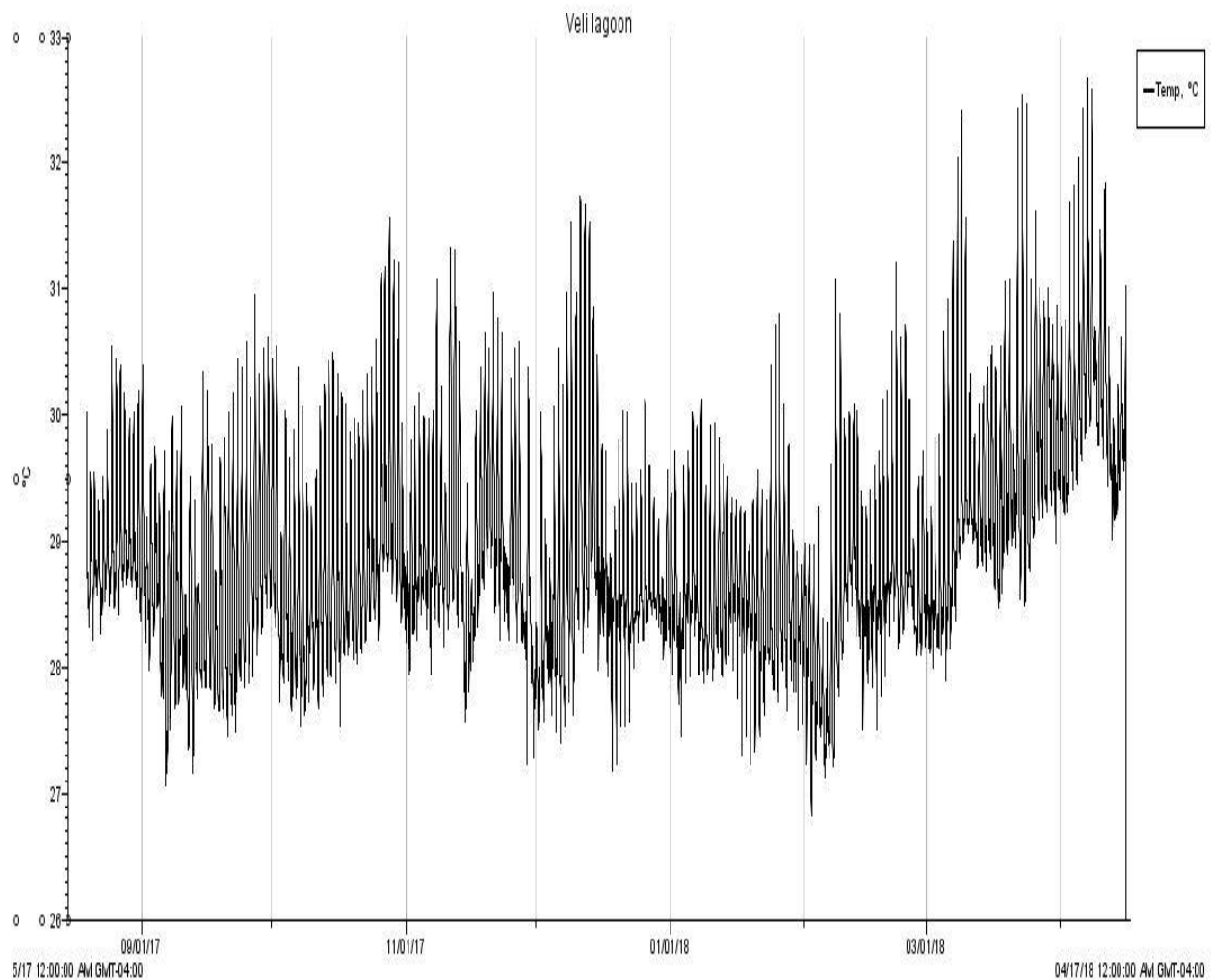
The work undertaken by Coral Reef CPR could not have been accomplished without the support of Anantara Dhigu Resort, Anantara Veli Resort and Aquafanatics. During the current mission, the two marine biologists from Aquafanatics (Silver Sands; Paula Berenguer Hidalgo and Fabio ) worked diligently with Coral Reef CPR lead scientist on all aspects of the nursery and restoration efforts. Additional in-water support was provided by Juliane Pach and Matteo Lingua. We are grateful for the support provided by **Anantara's** Engineering team including production of materials (coral tables) used to expand the nurseries. Thanks to **Anantara's Launch** section for use of a small boat and a captain. SCUBA support was provided by Aquafanatics.



Special thanks to Coetzer Deysel, Gauderic Harang and John Roberts, who have all continued to support the HAPR program and the work undertaken by Coral Reef CPR. I would also like to acknowledge Lisa Jackobson and Karl Webster, along with the film crew for their efforts to photo-document and publicize this CSR initiative through Minor Hotels and associated social media sites.

## 1. Veli Water Villas

A very important shallow lagoonal reef surrounds the water villas at Veli. This reef was constructed by tall (50-200 cm) densely branched stands of staghorn coral forming a “forest” that supported over 100 species of juvenile reef fish and many larger schooling fish. Over a month long period in April 2016, the reef bleached and >98% of the corals died. Coral Reef CPR salvaged small, surviving branch ends, most which were under attack by coral-eating snails, and planted the pilot nurseries in August 2016. These were expanded in October 2016, February 2017 and August 2017 using 2<sup>nd</sup> and 3<sup>rd</sup> generation fragments from the nursery, and rescued fragments salvaged from surrounding areas. During April 2018, restoration of Veli Lagoon began using nursery grown corals.



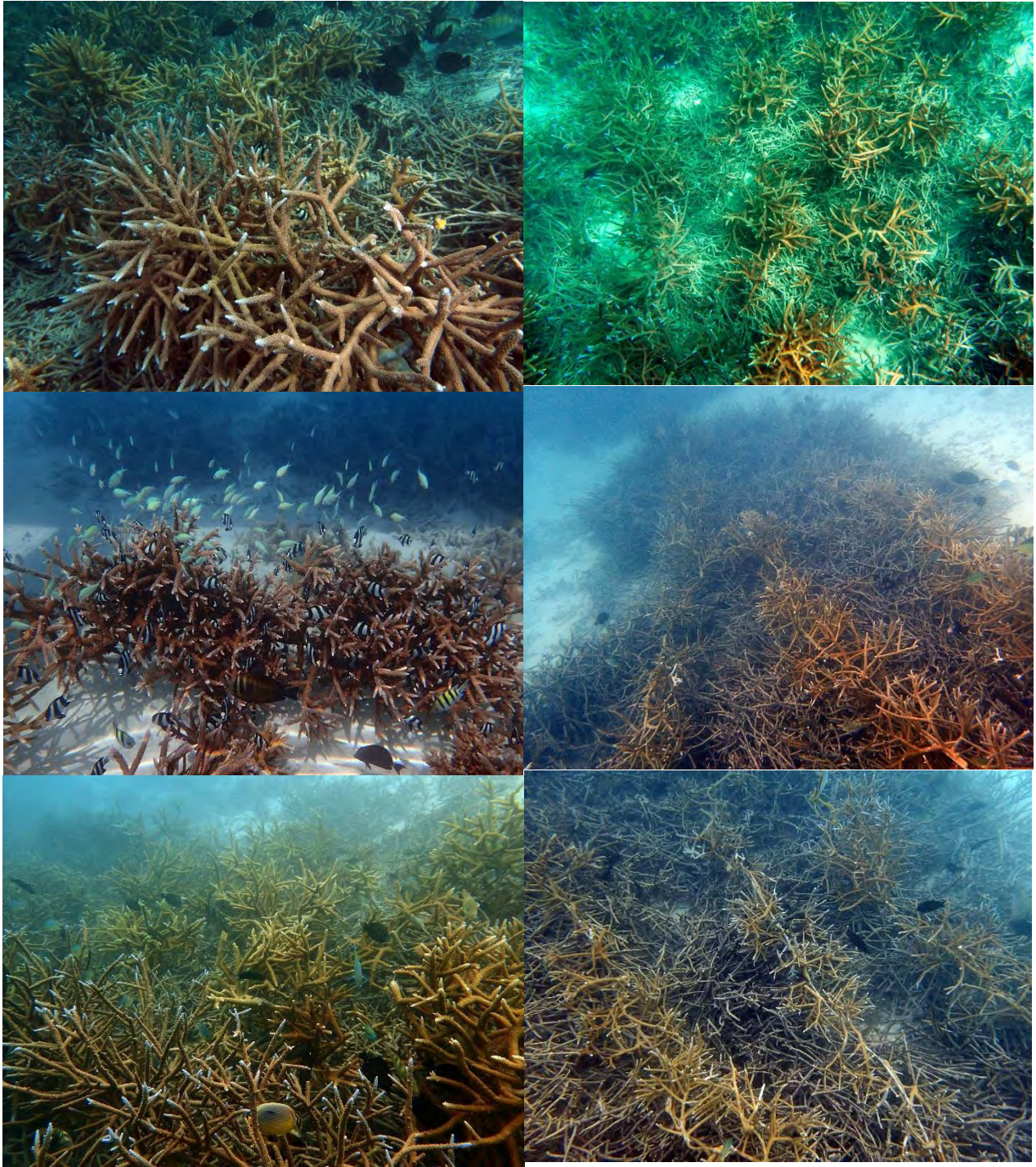
Water temperatures between August 2017 and April 2018 at Veli Lagoon near the pontoon jetty (1.5 m depth).



Aerial image of the lagoon surrounding the water villas. The dark areas are dead patches of staghorn coral. All the coral was live prior to the 2016 bleaching event. Coral nurseries were established in three locations, and consist of tables (T) and rope nurseries (N). Four restoration areas were established in April 2018 (R).

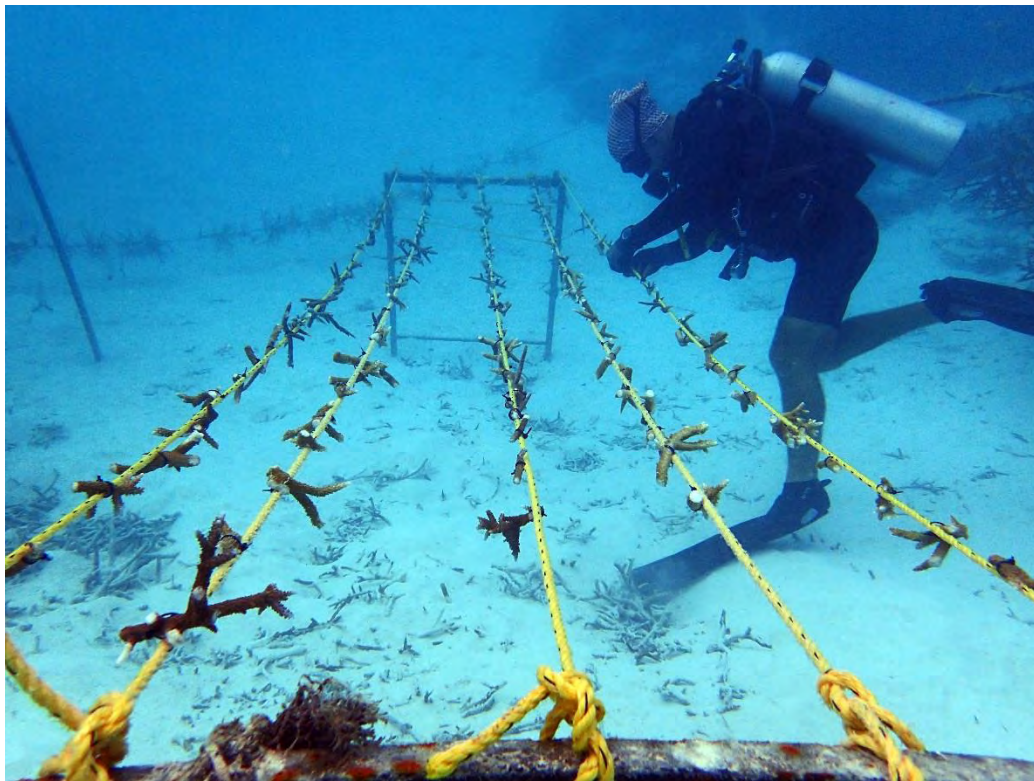


Veli reef at the onset of bleaching in March 2016 (left) and same area one month later, April 20, 2016



Coral restoration plots at Veli. Side (top left) and top view (top right) of one shallow restoration site; Small rope on jetty prior to transplantation (center left), and one deep restoration site (center right and bottom) adjacent to the water villas at Veli.





Coral nursery at Veli Lagoon showing one of the original frames with two new ropes (top) and a frame after the original corals were transplanted and new fragments were attached to the ropes (bottom).

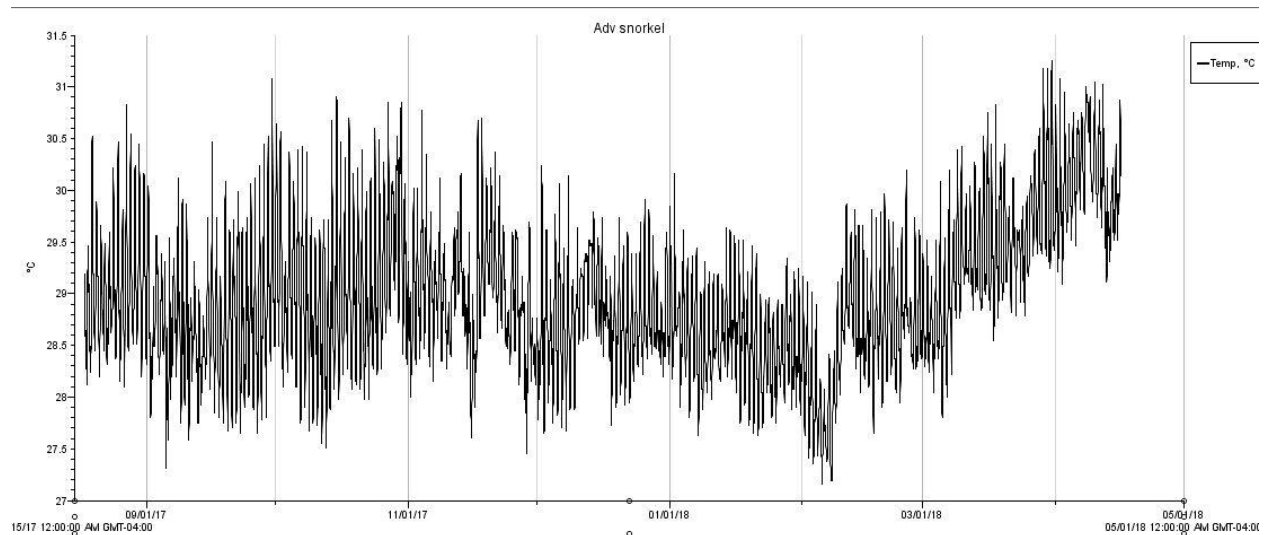


A coral table at Veli after 20 months (above). These corals were transplanted and four new tables (below) were set up, each containing 100 fragments.



## 2. Advanced Snorkel Area

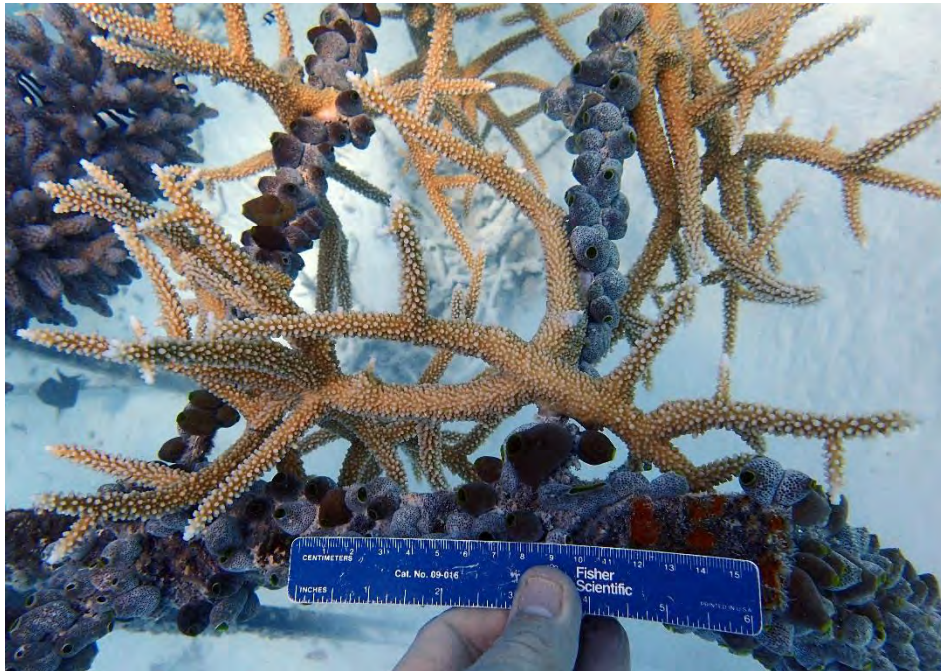
A coral nursery was first established in the deeper channel next to the Dhigu Water villas in October 2016, with additional ropes added in February and August 2017. The coral fragments have shown incredible growth rates, slightly higher than Dhigu House reef nursery and slightly lower than Aquabar nursery. This nursery has more settlement of tunicates onto the ropes, however, they have not settled on or killed any of the corals. One of the tables broke due to the weight of the corals and this was repaired. No new corals were added to this nursery. While many of the corals are ready to transplant, no corals were outplanted from this nursery due to time constraints.



Water temperature at the Advanced Snorkel Area, 7 m depth from August 2017-April 2018. Unlike Aquabar, temperatures did not reach 32° C at this site.



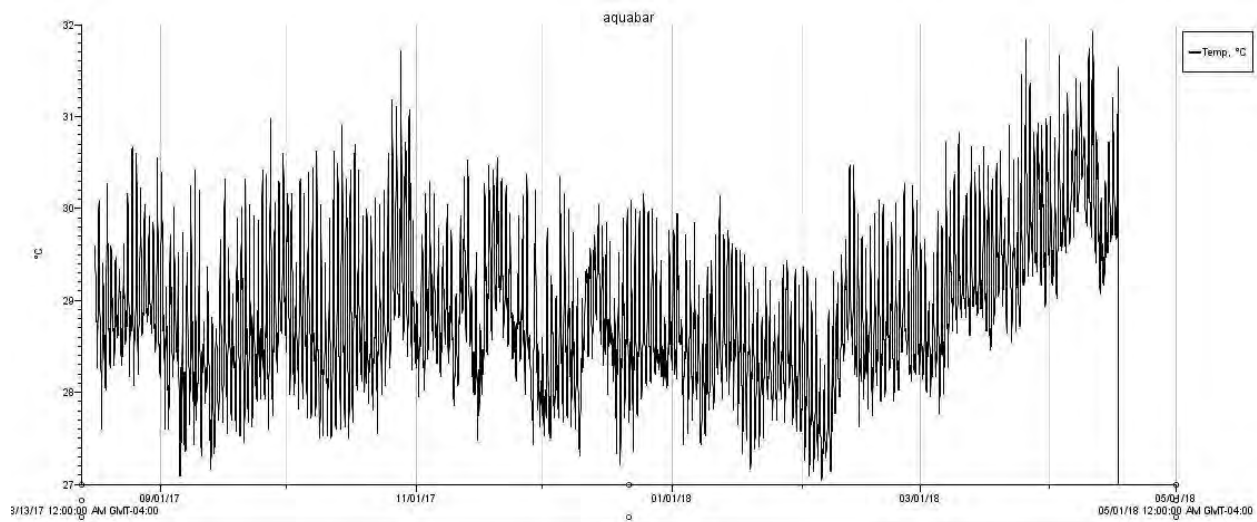
A coral nursery table at Advanced Snorkel Area provides important habitat for small reef fish.



Several nursery ropes at the Advanced Snorkel Area before maintenance. These include ropes added in October 2016 and February 2017. This was the only site that had extensive colonization by tunicates (visible in between the corals, bottom). These were removed as part of the maintenance.

### 3. Aquabar Snorkel Trail and nursery

The nursery at Aquabar was established in February 2017. There are four nursery frames each with 5 ropes. The ropes are 12 m in length (most other ropes at the other nursery sites are 6 m). This site has shown the most rapid rates of growth and over 98% survival for the 15 month period. All of the ropes from two of the four frames were transplanted to the Aquabar snorkel trail and Veli Lagoonal reef and new ropes were added to these frames.



Water temperature at the Aquabar snorkel trail, 3 m depth, from August 2017-April 2018. As in all other locations, April 2018 marked the peak for water temperatures, with a few short periods when temperatures reached 32°C.



A section of one of the nurseries at Aquabar established in August 2017.



One nursery frame with five ropes at Aquabar Nursery 14 months after it was established (February 2017).



Process of translocating nursery-grown staghorn corals from Aquabar Nursery to Veli Lagoon.



Aquabar Snorkel trail in April, 2018, 14 months after it was created. The acroporid corals have shown substantial growth.





New coral rubble framework used to create a reef substrate in a sandy habitat. The dead coral skeletons were collected at the Advanced Snorkel Area using a whaler (top) and transported to the Aquabar Snorkel Trail (bottom).



The expanded Aquabar Snorkel Trail with nursery grown staghorn coral (*Acropora muricata* and *A. grandis*) along with bushy *A. aculeus* and *A. tenuis* planted on top of the reef framework.

## Reef stressors

Reef temperatures were at their annual maximum during nursery and restoration work. Bleaching was not observed on any of the corals on the rope and table nurseries. There were numerous coral frames with attached staghorn corals that had been placed by Aquabar marine biologists (AMB) near the Veli coral tables that were severely bleached, as were staghorn corals AMB had transplanted from Dhigu House reef one to two months prior to Coral Reef CPRs visit. There also were numerous reports of small crown of thorns starfish in the shallow habitats adjacent to Marina and Nalahdu. One COTS was collected from the Aquabar Snorkel Trail; this starfish had consumed a small patch of staghorn coral. Cushion starfish (*Culcita*) were rare, although we collected a juvenile (2 cm) cushion star from the Advanced Snorkel Area. Black band disease was recorded on three boulder corals on the Aquabar Snorkel Trail (below) , and BBD was also seen on at the Advanced Snorkel Area.



Black band disease on *Psammocora* (sand paper coral) on the Aquabar Snorkel Trail.



#### 4. Dhigu House Reef

Dhigu House Reef is a protected lagoonal reef with the deepest coral nursery (8.8 m; 27 feet) that includes four nursery frames and four coral tables. This nursery contains additional *Acropora* species not found in the shallow nurseries, as well as other slower growing coral species (*Turbinaria*, *Porites rus*, *Porites cylindrica*, *Pocillopora*). The main nursery area is a sand patch surrounded by reef framework and large *Porites lobata* colonies, along with large coral heads colonized by numerous branching, plating and encrusting corals. This reef showed moderately high survival of acroporids, but there are still large rubble patches devoid of living corals. All nursery frames and tables were cleaned, three ropes were transplanted onto a rubble field, and three new ropes were attached to the frames.



A fragment of staghorn coral attached to a new nursery rope at 8.8 m depth.



One nursery frame when first established in October 2016 (top) and the same frame in April 2018, 18 months later.



One coral rope from this frame was transplanted onto the adjacent reef in a rubble area, and a new rope was added with additional fragments of staghorn coral.



A 14 month old coral table at Dhigu House Reef



Two restoration plots on Dhigu House reef with outplanted staghorn coral (*A. muricata*), knobbed staghorn (*A. hemprichii*).

Table 1. Total number of new corals added to the nurseries at Dhigu and Veli, South Male Atoll.

Aquabar		Dhigu		Veli	
Rope	No coral	Rope	No coral	Rope	No coral
1	45	1	39	1	35
2	48	2	26	2	27
3	60	3	25	3	28
4	60			4	28
5	65			5	29
6	48			6	31
7	54			7	32
8	54			8	31
9	59			9	26
10	45			10	31
11	55			11	27
				12	41
				13	35
				Table 1	100
				Table 2	100
				Table 3	100
				Table 4	100
Total	593		90		801
Grand Total					1484