

HOLISTIC APPROACH TO REEF PROTECTION



Restoring coral reef habitat around Anantara Kihavah, Baa Atoll, Maldives

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EXECUTIVE SUMMARY

From February 23 – March 2, 2019, Coral Reef CPR continued coral nursery and coral restoration activities at Anantara Kihavah, Baa Atoll, Maldives, as part of the Holistic Approach to Reef Protection (HARP) program. All field activities occurred in shallow lagoonal and reefal habitats surrounding the resort, with emphases on: 1) outplanting of nursery-grown corals in habitats surrounding SEA restaurant; 2) expansion of coral nurseries through addition of new fragments to coral ropes at Plates Nursery and SEA Nursery; 3) maintenance of the restored coral community surrounding SEA; and 4) collection and removal of coral-eating cushion starfish (*Culcita*).

A total of 898 corals consisting of 15 species of *Acropora* and *Pocillopora verrucosa* were outplanted onto reef substrates and the cement platform surrounding SEA. Mature coral ropes were removed from Plates Nursery (15 ropes with 550 corals) and SEA Nursery (7 ropes with 348 corals) and transplanted to six locations surrounding SEA, including the platform surrounding the restaurant, the metal grid extending from the restaurant to the reef on the west side, the reef slope on the east and west side, and the reef platform at the seaward edge of the slope on the east and west side. A pilot outplanting by an Elements marine biologist was also undertaken in July 2018 involving 4 ropes and 190 corals removed from the nursery on the west side of SEA.

Following removal of mature coral ropes, nurseries were reestablished using second generation fragments that broke off the ropes during transportation or were rescued from sand and rubble areas. Twelve new ropes were placed at Plates containing 369 *Acropora* fragments, and 6 new ropes with 388 fragments were added to the nursery at SEA.

Areas that have been restored require monthly maintenance to prevent coral loss and to remove pest species, as certain coral predators are at unnatural abundances since the 2016 bleaching event. Reef habitats and the platform surrounding SEA that were restored during 2017 were maintained and rejuvenated for the first time since December 2017, with an emphasis on the removal of dead corals and other invertebrates and collection of coral-eating predators. A total of 42 *Pocillopora* colonies and 22 *Acropora* colonies were infested with coral-eating snails and had lost 30-100% of their tissue. The snails (n=189) were removed from the reef. The cushion starfish (*Culcita*) is another predator that had consumed a number of *Pocillopora* and *Acropora* colonies; 18 starfish were removed from the restored reef surrounding SEA. In addition, algal farming damselfish have colonized the habitat surrounding the windows on the front- and west-facing windows and had killed coral tissue to allow algal colonization. Corals that succumbed to the damselfish were removed. Dead corals were replaced with nursery-reared *Acropora* corals. A large parrotfish and pufferfish had consumed soft coral and hard coral tissue, targeting boulder corals (*Porites*) and leather corals.

Coral Reef CPR scientists and Elements marine biologists conducted a thorough search of shallow reef habitats surrounding Kihavah to identify and remove coral-eating starfish (*Culcita*). In Baa and Raa Atoll, these predators are at abnormally high densities and they are preventing the recovery of these reefs from the 2016 bleaching event by targeting new recruits and juvenile coral colonies, especially acroporids, pocilloporids and faviids. We began removing these in 2017, collecting 733 *Culcita*, with another 124 removed by Elements in 2018. Another removal effort

was undertaken in March 2019, with another 289 collected, bringing the total number removed from this reef system to 1146. The density of these starfish should be no more than 1-2 per 100m².

Since the coral bleaching event in 2016, Coral Reef CPR has restored the degraded environment surrounding SEA through the following actions: 1) removal of algae-encrusted rusting metal rebar “adopt a coral” frames, 2) addition of reef framework, 3) rescue and transplantation of large boulder, plating and branching corals, sponges, giant clams and soft corals from sand and rubble habitats to both the reef framework and the platform surrounding SEA, and 4) transplantation of nursery-reared corals into these habitats. The original restoration was done in three phases: Phase I focused on the platform and metal grid surrounding the windows; phase II involved the reef slope off the east side; and phase III involved the construction of a thriving reef on the seafloor and slope off the west side. During each of these missions, we conducted maintenance of the restored reef habitats and continued to expand nurseries at Plates and SEA. Coral Reef CPR was not able to work at Kihavah during 2018, and unfortunately no maintenance was done within these restored habitats. As a result a large number of corals succumbed to predation by coral-eating snails and starfish. Although we rejuvenated all of the restored habitats in March 2019, we were unable to finish all necessary work within the time constraints, and coral-eating snails are still actively feeding in this area.

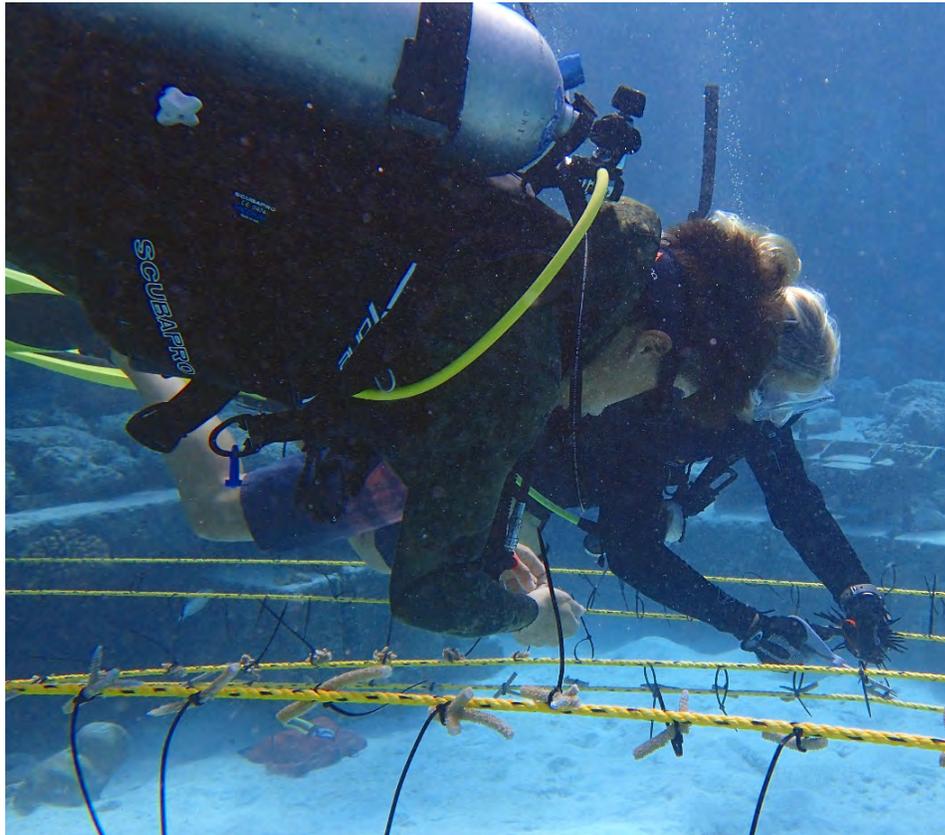
Using nursery-reared acroporid corals, we were able to substantially increased the amount of restored reef habitat surrounding SEA. We replaced corals that had been eaten by coral predators, adding important new species not formerly found within the restored habitat. We also replaced many of the nursery ropes with new corals with the intent of growing these for about 1 year and subsequently continuing to outplant them around SEA. Our goal is to cover all of the sandy areas surrounding the restaurant, as well as the remainder of the reef slope, with stony corals. This will greatly increase the diversity, complexity and beauty of the habitat for associated reef fish and invertebrates and it will lead to improved survivability and community stability. Additionally, water clarity and visibility from inside SEA will increase as the corals will filter particulate matter and stabilize the sand to prevent resuspension of sediments during rough seas.



Restored reef off the left side of SEA.

ACKNOWLEDGEMENTS

The work undertaken by Coral Reef CPR could not have been accomplished without the support of Anantara Kihavah Resort and Elements. During the current mission, Anantara Kihavah provided a small boat and a captain to transport coral nursery ropes from Plates Nursery to SEA restaurant, and SCUBA support (tanks, BC and regulator) was provided by Elements. I would like to acknowledge all of the work undertaken by Flora Blackett, the marine biologist with Elements. Flora has worked with Coral Reef CPR since 2017 on all aspects of this program and has continued to maintain the coral nurseries during our absence. Flora also transplanted several ropes from the nurseries to SEA in 2018, and has continued to expand the nursery. During this mission we are also grateful for the assistance provided by Simon (Chan King Man). Although he is a new addition to Elements staff, he was extremely interested in learning all aspects of the coral gardening efforts and helpful with cushion starfish collections. Special thanks to Giles Selves, Oskars Smitenbergs and John Roberts, who have all continued to support the HARP program and the work undertaken by Coral Reef CPR.



Elements Marine Biologist Flora Blackett and Simon attaching corals to new nursery ropes.

BACKGROUND

Coral Reef CPR has partnered with Anantara Resorts in the Maldives since 2015 with coral conservation efforts targeted at addressing impacts from outbreaks of crown-of-thorns starfish and cushion starfish, coral-eating snails and coral bleaching. In January 2016, we established permanent sites in six locations on Baa Atoll to document the extent and severity of the coral bleaching event. This event was associated with abnormally high seawater temperatures during the most severe multi-year El Niño ever documented. Between March-May 2016, seawater temperatures climbed to 32-35° C. Concurrently, there was an extended period of doldrums-like conditions with no wind, calm seas and an absence of cloud cover and precipitation. Corals began to bleach in early April, and in some areas they sustained 90-98% mortality within a month.

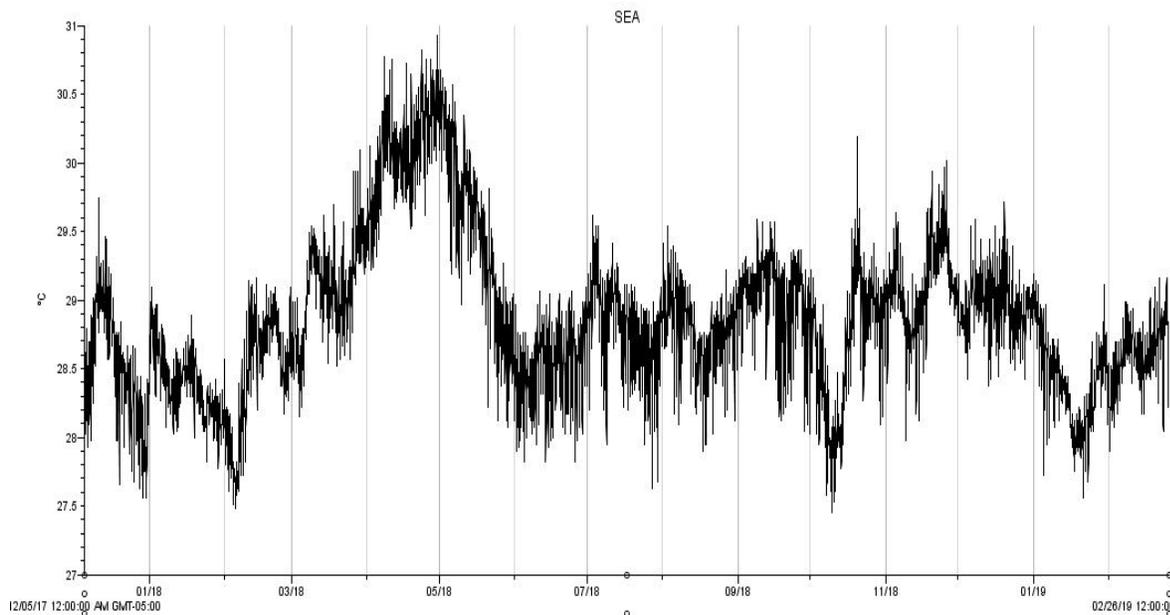
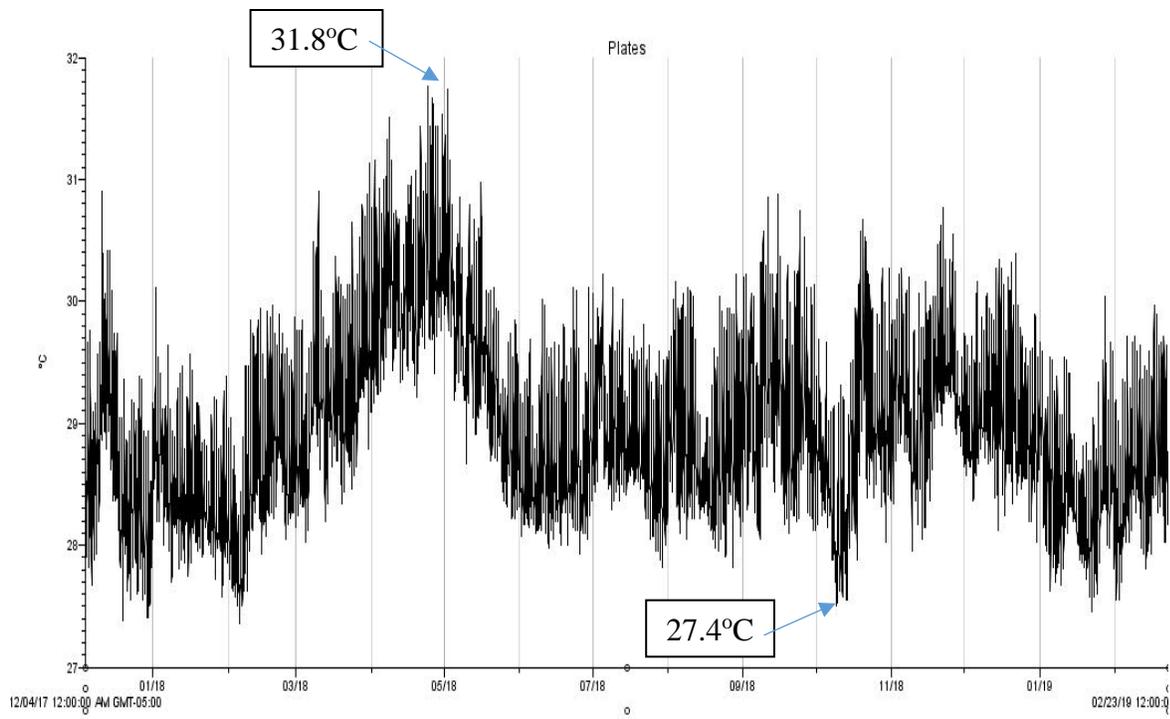
By the time the summer monsoon kicked in (May 2016) between 80-95% of the keystone corals in the genus *Acropora* as well as many of the faviid corals had died. Acroporids were formerly the dominant corals in the Maldives, with living cover that exceeded 50-80% in many locations. These corals are the most important for reef growth and provide food, refuge and habitat utilized by reef fishes and invertebrates. Fortunately for Baa Atoll, boulder and finger corals in the genus *Porites* are much more common than in southern locations, and these only suffered partial mortality.

Around Kihavah, Elements had originally placed hundreds of metal rebar frames with small coral fragments into reef habitats near the Supply Jetty, around SEA restaurant and between the Sunset Over Water Villas. The corals failed to thrive, and 98% of them subsequently died. The frames were rusting and had become carpeted in thick seaweed. We removed all of the frames from SEA restaurant and the Supply Jetty as part of our restoration work. During 2017, three nurseries were established: one off Plates in the artificial channel created via sand extraction; one off the Supply Jetty from 5-16 m depth; and one off the wine cellar at SEA restaurant.



Anantara Kihavah showing the locations of coral nurseries. 1) Plates Nursery; 2) SEA Nursery; 3) Supply Jetty Nursery

Coral Nursery and Restoration work at Anantara Kihavah, February-March 2019



Temperature meters were first deployed in January 2016 at the six permanent reefs and at Plates Nursery and SEA restaurant. We were not able to get back to our permanent sites to recover meters, but have downloaded data from those at Kihavah (above). Water temperature at Plates Nursery (3 m depth; top) and SEA restaurant (7 m depth) from December 2017 to March 2019. Water temperatures reached their annual maximum during April. Maximum daily temperatures were 0.5-1° C higher at Plates Nursery, while minimal daily temperatures are similar at both sites.

Coral Nursery and Restoration work at Anantara Kihavah, February-March 2019

ACTIVITIES AND OUTCOMES

Plates Nursery

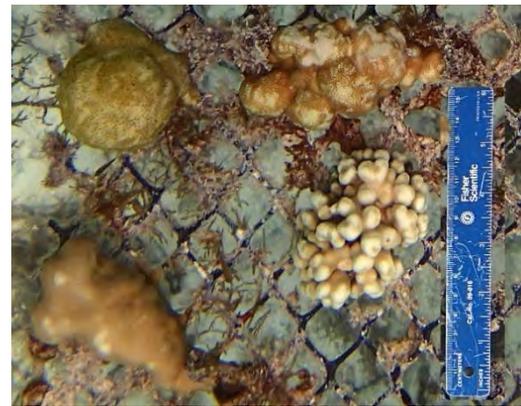
Plates Nursery was established in February 2017 and expanded in July and December 2017. Two coral tables and three frames were initially placed at the nursery, and two additional frames were added in July 2017. One table consisted of *Acropora* colonies while the second was a mixed species assemblage, including three species of *Pocillopora*, *Galaxea* sp., *Cyphastrea* sp., *Leptastrea* sp., and two species of *Porites*.



A table with fragments of *Acropora* first established in February 2017 (top left). The same table is shown in December 2017 (top right) and in March 2019 (bottom left).

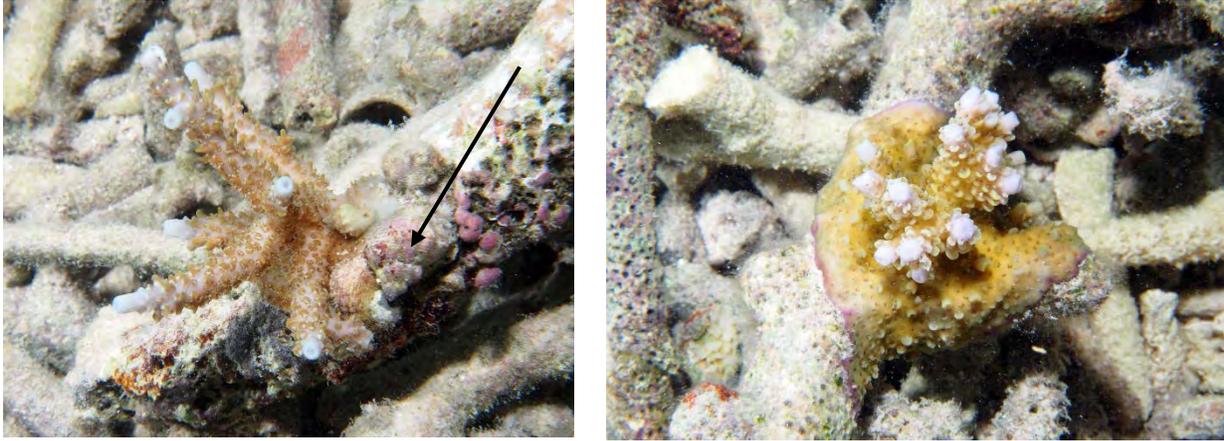


Colony of *Galaxea* attached to a coral table at Plates in February 2017. The coral is shown in July 2017 (top right) and in March 2019 (top left). The ruler is 15 cm. The coral has grown from approx. 7 cm x 3 cm to 19 cm x 11 cm.



Four colonies of *Porites* attached to the same table in July 2017 (right center) and the same corals in March 2019 (left center).

Coral species grown on nursery ropes were primarily *Acropora*, with 1.5 ropes of *Pocillopora verrucosa*. All of the corals used in the nursery were originally salvaged after the bleaching event as very small recruits and juveniles (<1-3 cm) from the rubble patches within the deeper part of the channel where sand extraction occurs. While this location has provided a continuing source of corals, any corals not removed tend to die each year once sand extraction begins due to burial and sedimentation stress.



Two juvenile *Acropora* corals rescued from a sand extraction site and used in the Plates Nursery. The corals are 3 cm long. The colony on the left has a coral-eating snail (*Drupella*) on its base (arrow).

While this nursery has been unusually successful, with virtually no coral mortality and rapid rates of growth, it has required maintenance. The site appears to be affected by high input of nutrients, possibly originating from grey water leaking from the water villas. These nutrients fuel the growth of dense mats of cyanobacteria and fleshy green seaweed. During 2017, the substrate and nursery ropes with corals were repeatedly covered in algae and had to be cleaned at least weekly. The marine biologist and other Elements staff periodically maintained this nursery when Coral Reef CPR was not present, with the last cleaning done in May 2018. While we were concerned that the corals would all die in the interim until our arrival in 2019, they have survived and grown extremely well even in absence of maintenance. The algae disappeared naturally in the fall of 2018 and were still absent in March 2019. It is unclear whether the cyanobacteria and algae are seasonal and if they will return.

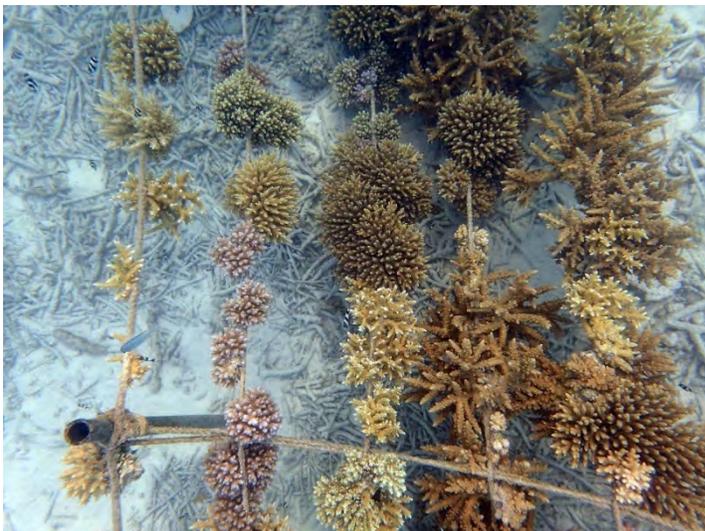


One rope photographed in November 2017 covered in algae and cyanobacteria.

All ropes planted in 2017 had fully mature corals ready for outplanting in 2019. Some ropes had become so large and heavy that they rested on the sand. Many of the corals were very large (30-50 cm diameter) and had grown onto adjacent ropes, making it extremely difficult to relocate the ropes.



Three of the nursery frames at Plates. A support was added to the middle of each rope to help suspend the corals off the substrate.



One frame with three ropes established in February 2017 (right ropes) and two ropes from December 2017 (left ropes).

During 2018, Elements marine biologists worked with guests to create new ropes (n=5). These were added to 3 frames. Twelve new ropes with 369 coral fragments were added to the nursery in March 2019.



Three mature nursery ropes and two additional ropes added to this frame in May 2018 by the marine biologist from Elements facing landward (top) and the same ropes from the opposite end facing seaward (bottom left).



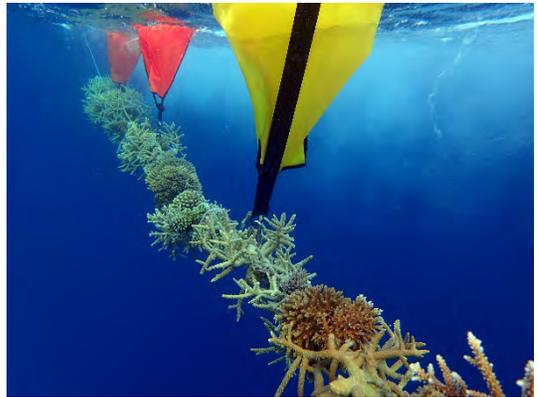
A closeup of four corals on one nursery rope that have grown together. Scale is 30 cm (above).



Mature ropes were moved from Plates to SEA for outplanting. Ropes were untied from the frame, suspended one at a time with 3-5 lift bags, and towed by small boat from Plates Nursery to SEA restaurant. In total, we moved 15 ropes (550 corals) to the right and left sides of SEA. The corals were used to restore the reef slope, deeper reef community adjacent to the drop-off and the platform surrounding the windows.

One nursery frame with five mature ropes (top left). Raising one of the ropes from the frame using a lift bag (top right). A rope suspended above the nursery using three lift bags (bottom right).



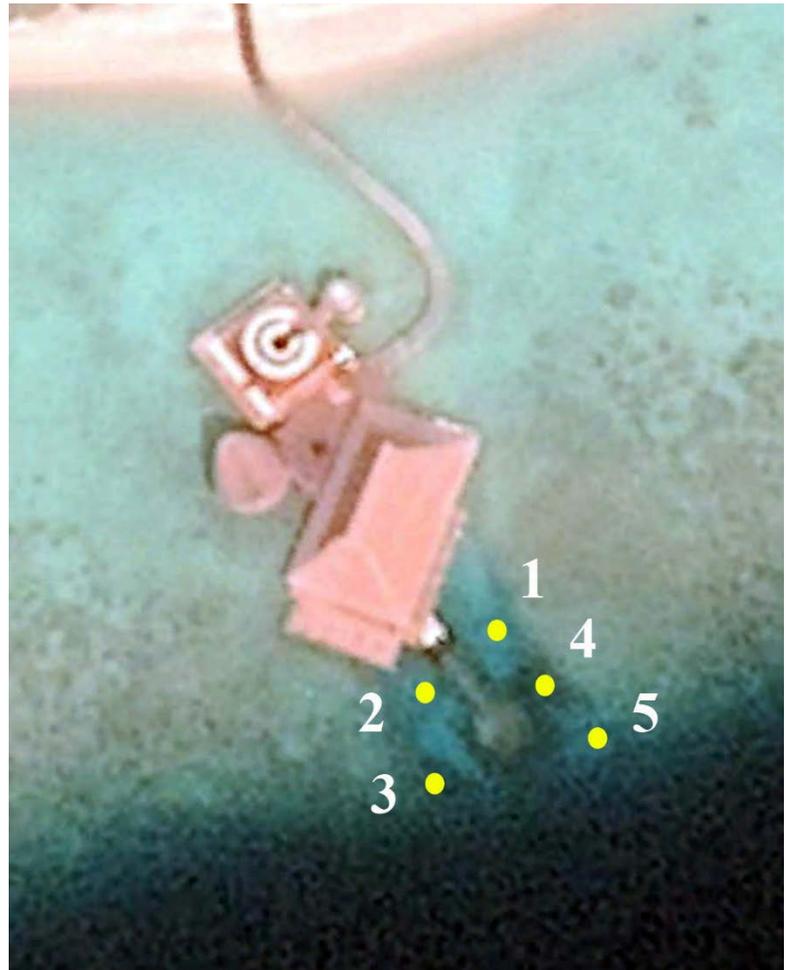


Transporting coral ropes from Plates Nursery to SEA.

Reef System Surrounding SEA Undersea Restaurant

A major emphasis of our coral conservation work during the February/March 2019 mission was undertaken in the habitats surrounding SEA restaurant, including expansion of nurseries on the right (1) and left (2) sides of the wine cellar, restoration and maintenance of the reef slope and deeper reconstructed reef off the east side (3), platform surrounding the windows and large grid off the west side (4), and replanting corals onto the reef slope and seaward edge of the reef off the west side (5).

Nursery work (1,2) and coral outplanting (3-5) areas at SEA restaurant.



Coral Nurseries

Two nurseries are located at SEA restaurant. The original nursery was established on the west side (5 ropes) and was expanded in December 2017 with 7 new ropes. Four ropes were outplanted from this nursery in May 2018 and three new ropes were added. In 2019, we outplanted one additional rope and added one new rope. The corals added to this nursery in December 2017 had high survival (92-98%), but corals added in May 2018 by the Elements marine biologist have been colonized by cyanobacteria, and about 20% of the fragments have sustained partial to total mortality.

The nursery on the east side of the wine cellar was established in July 2017 (2 ropes), and it was expanded in December 2017 with 5 new ropes. While the vast majority of the corals at this site were branching acoporids, one experimental rope contained fragments of a foliaceous *Echinopora* sp. While an important and once common coral at some locations in the Maldives, it is extremely rare in Kihavah (only two colonies have been identified around the island). We were pleasantly surprised to find the fragments not only surviving, but growing well on the nursery rope.

Coral Nursery and Restoration work at Anantara Kihavah, February-March 2019



Coral nursery on the east side before outplanting (above), and after outplanting with new ropes (below).



Three ropes just before outplanting (left) and a closeup of one new rope in the nursery on the east side of SEA (right)



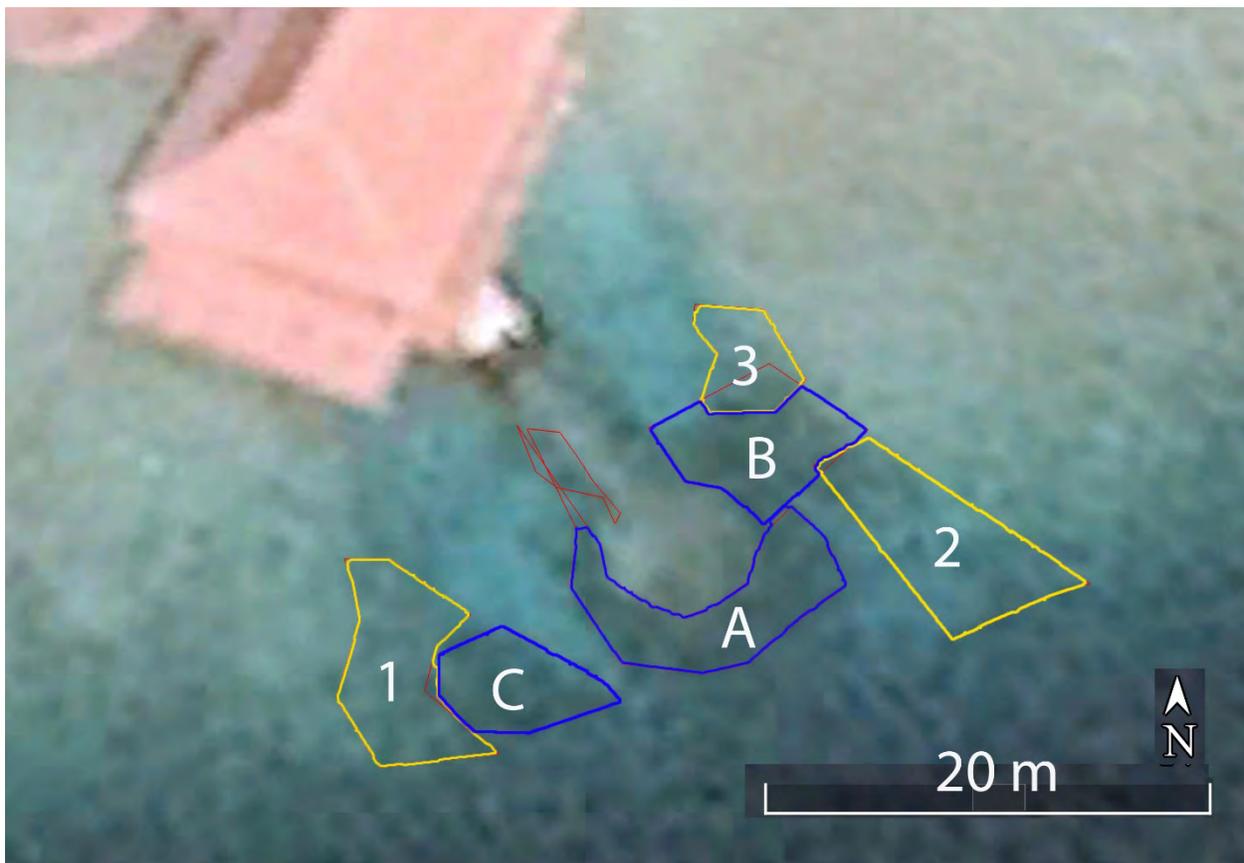
Ropes on west side added to the nursery in December 2017. These were not yet ready to be transplanted to the reef.



Ten small fragments from a locally rare species of *Echinopora* were placed on a coral rope at SEA in December 2017. Three of these are shown here (top) and the same three fragments in February 2019 (bottom). While these are still too small to outplant, they have shown considerable growth and all ten fragments have survived.

SEA Restoration

Coral reef communities surrounding SEA declined substantially as a result of the 2016 bleaching event, with near total (>99%) coral mortality on the reef slope and >90% of the stony corals that had been attached to the platform and associated metal frames. The primary survivors were magnificent sea anemones (*Heteractis magnifica*) located on the front windows along with low numbers of stony corals (primarily *Physogyra* spp. and *Porites* spp.). Restoration of the seafloor and platform has occurred in a series of phases, with the initial restoration of the platform surrounding the windows (A) occurring in February 2017, the reef extending from the west-facing windows to the shallows (B) in July 2017, and the deeper terrace off the west side of SEA (C) in December 2017. This entailed rescuing detached and broken corals and other invertebrates from the reef crest and reef slope surrounding Kihavah, transporting them to SEA, and securing them to the reef framework. The bulk of the corals were large frame-building boulder corals (*Porites lobata*), with smaller branching, plating, bushy, encrusting and boulder corals, soft corals, leather corals, anemones, sponges, and giant clams placed among the structure created by *Porites*.



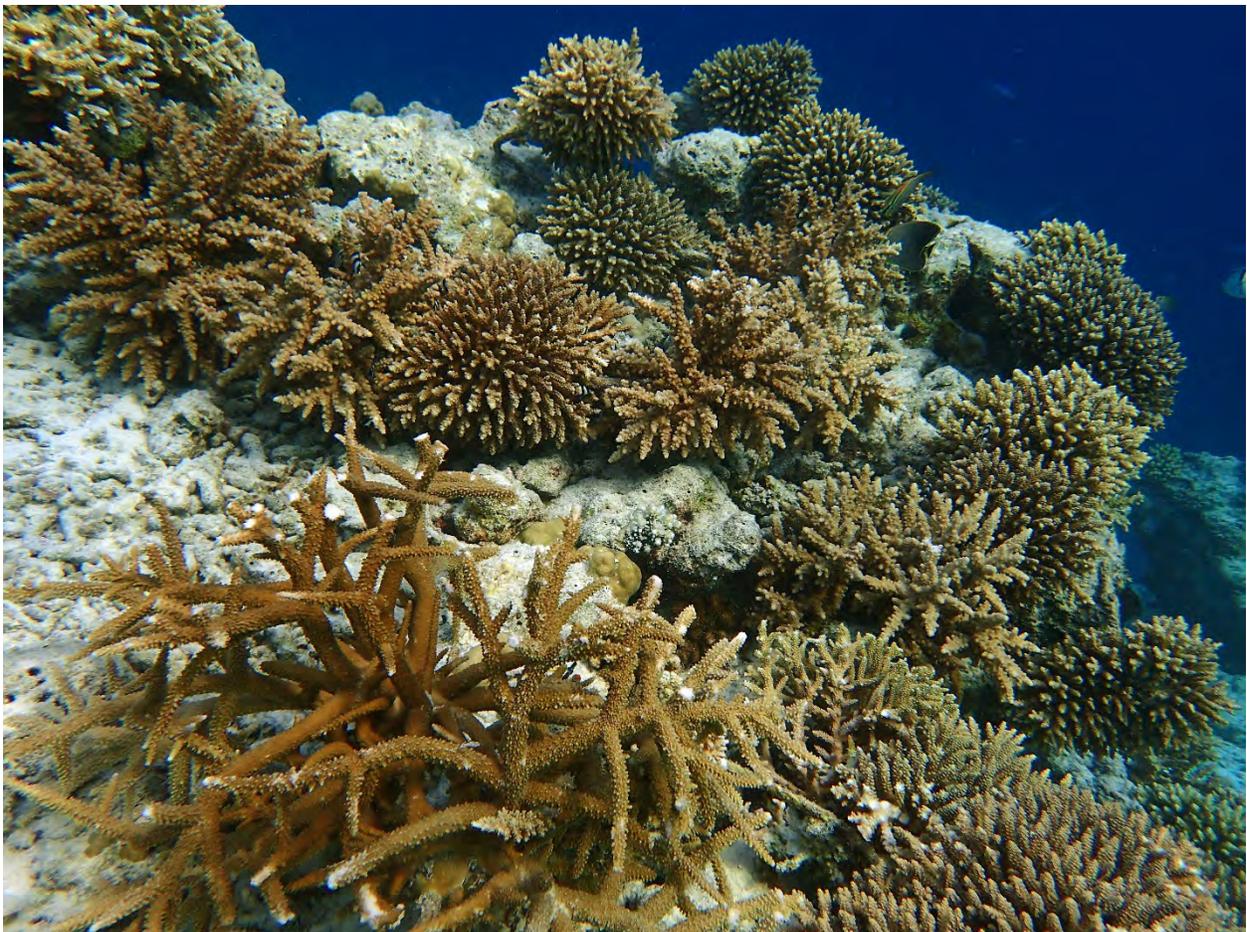
The blue polygons (areas A, B, C) were restored in 2017 with addition of new corals in March 2019. Corals from Plates Nursery and SEA Nurseries were outplanted into the yellow polygons (areas 1, 2, 3) in March 2019.

During this mission, a total of 898 corals were transplanted from the nurseries at SEA and Plates. These corals were restored in three new areas and rejuvenated areas restored in 2017. The corals used in this restoration ranged in size from 15 cm diameter (digitate colonies) to 70 cm (staghorn corals, table corals and bushy corals) and included 15 species of *Acropora* and one species of *Pocillopora*. Coral ropes were separated into single species clumps and individual corals, and these were secured to the reef framework using cement nails and cable ties.

The three new areas (1-3 above) included:

- 1) the reef slope on the west side of the metal grid (visible from the wine cellar window on the left)
- 2) the reef slope to the right of the metal grid (visible from the windows on the west side of SEA), and terrace at the edge of the drop-off reef slope off the east side
- 3) The reef slope and shallow terrace off the east side, extending from the drop-off to the coral nursery.

The three areas restored in 2017 (A-C, above) were rejuvenated by removing corals that had died, removing coral-eating snails and starfish, and positioning new corals from Plates Nursery within the total SEA habitat.



Restored coral bommie off the west side of SEA adjacent to the drop off. Five species of *Acropora* were used on this bommie.



View of the restored reef from the left (top) and right (bottom) front windows.

Coral Nursery and Restoration work at Anantara Kihavah, February-March 2019



Restored reef slope on the east side, facing the seaward edge of the reef (top) and looking towards the nursery (left).



Reef terrace on west side (above), first restored in 2017 with new corals from the nurseries added to the community.

Table 1. Total number of new corals added to the nurseries at Kihavah, Baa Atoll.

Plates		SEA	
Rope	# coral	Rope	# coral
1	21	1	62
2	21	2	56
3	23	3	68
4	23	4	71
5	33	5	55
6	26	6	76
7	46		
8	29		
9	44		
10	42		
11	38		
12	23		
Total	388		369
Grand Total		757	



Four new ropes at SEA Nursery.

Supply Jetty Nursery

This nursery is in a very exposed habitat on the outer reef slope, and includes 25 nursery frames that are placed from 5-16 m depth. Ropes were placed on this nursery in February 2017, with additional ropes added in July 2017. The site has been problematic since established, with disease and competition with other invertebrates and algae causing substantial losses (>30%) to some ropes. The site is the most heavily utilized by divers and boat traffic.

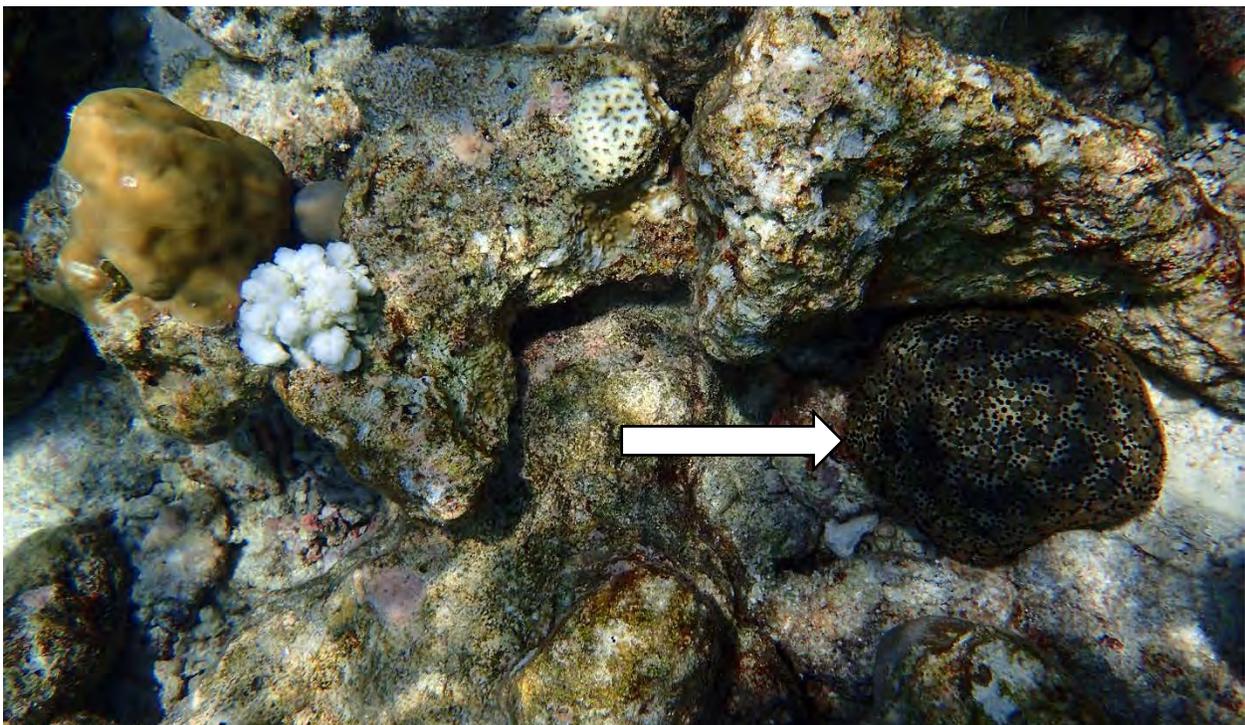
Elements marine biologists outplanted several ropes of a single species (a robust staghorn-like coral that forms large thickets extending down the reef slope) in May 2018.

During the current mission, we were unable to complete any work within the Supply Jetty. We conducted a single dive to monitor the ropes and the surrounding reef. Corals outplanted in May 2018 have shown high (>85% survivorship and are quite large (20-25 cm in height). Within the nursery, the shallow ropes have done much better than deep ropes, but growth is substantially less than at Plates or SEA. The deeper ropes have lost a large percentage of the corals (>30%) due to a disease that has progressively spread along several ropes from coral to coral, and a number of dead colonies can be seen on the ropes. Other invertebrates (sponges, bivalves, tunicates) have also colonized the ropes and are competing with the corals.

During a future mission we will conduct maintenance of the site to remove dead corals and clean off competitive algae and invertebrates, move corals to adjacent degraded reef habitats around Yellow Wall, and look into options for nursery expansion.

Cushion Starfish Removal

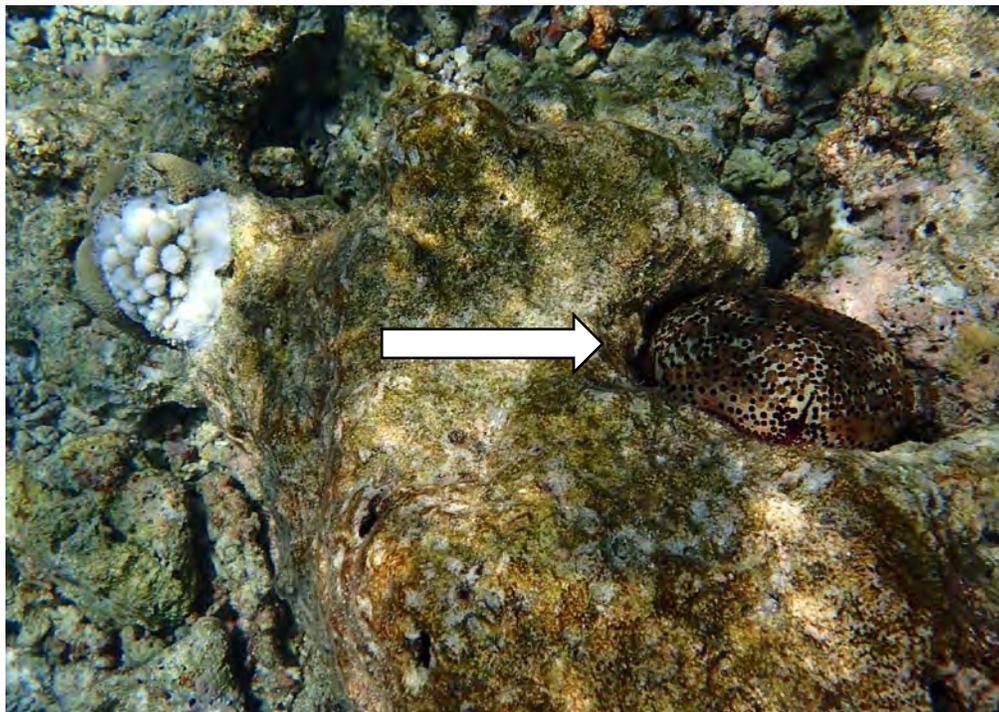
Cushion starfish (*Culcita schmideliana*) are coral predators that show a distinct preference for juvenile corals, primarily targeting species of *Acropora* and *Pocillopora*, but also observed to consume 9 other genera at Kihavah (*Porites*, *Platygyra*, *Favia*, *Favites*, *Galaxea*, *Montastrea*, *Cyphastrea*, *Leptastrea*, and *Montipora*). These were first noticed in February 2017 at our restoration site around SEA causing tissue loss to transplanted *Pocillopora* colonies. We initiated a small effort to remove these from areas adjacent to SEA, collecting 87 starfish at that time. In July 2017, we conducted a larger removal effort, collecting all starfish between Plates Nursery and the Supply Jetty, removing 368 starfish. A similar effort was undertaken in December 2017 (278 starfish) and in 2018 by the Elements marine biologist (124 starfish). They were still observed in high numbers during 2019, and additional collections were undertaken between the Sunset Over Water Villas and the arrival jetty, removing another 289 starfish. To date, 1146 *Culcita* starfish have been removed. These starfish are cryptic, hiding near their prey during the day and feeding primarily at night. Because all of the starfish are roughly the same adult size class, we do not believe there has been a recent recruitment event, and it is unlikely that the starfish can move from adjacent reef systems to Kihavah. We have not yet been able to search the entire reef system, and a dedicated effort to remove starfish to normal densities should reduce coral mortality caused by these corallivores.



A cushion starfish (arrow) had eaten a juvenile *Pocillopora* colony (white coral on the left) and retreated to an adjacent area on the reef.



Area search for *Culcita* since 2017 and the numbers removed from each section of reef. The starfish are most common on the back reef, reef flat, reef crest and shallow reef slope (<5 m depth). The numbers removed in March 2019 and the total number removed to date (in parenthesis) are shown.



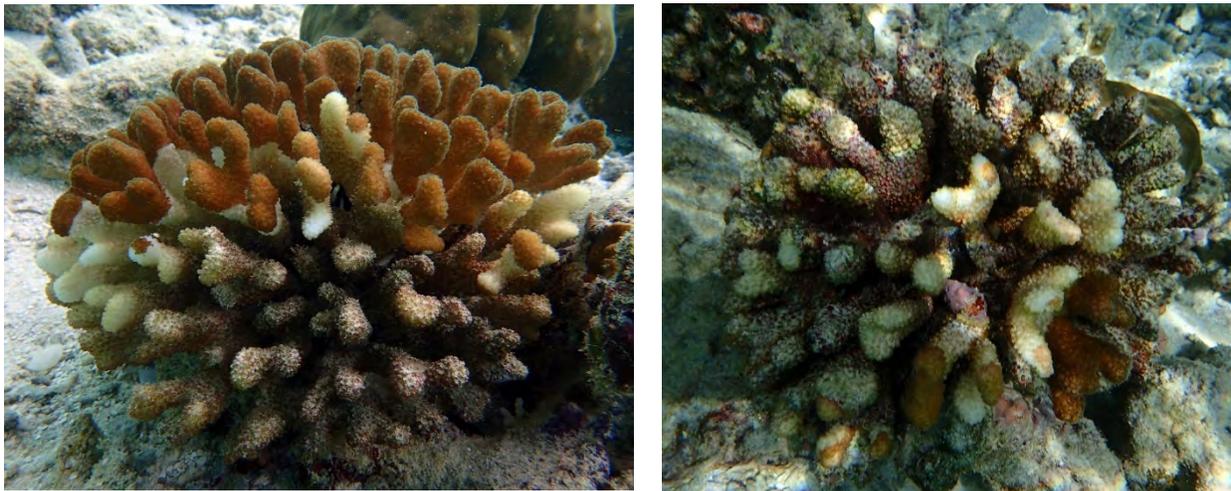
A juvenile digitate acroporid colony consumed by a cushion starfish at Kihavah, Baa Atoll. Many areas on the reef flat remain devoid of living coral, and have shown minimal recovery from the 2016 bleaching event due to high depredation on newly settled and juvenile branching corals.

Other restoration efforts

During November 2018, the marine biologist from Elements transplanted boulder corals (*Porites*), cauliflower coral (*Pocillopora*) and a few other species (*Heliopora*, *Hydnophora*) under the viewing windows of the SPA. Coral Reef CPR inspected this area in March 2019. The boulder corals showed signs of partial mortality and were paling or bleaching. Over 80% of the cauliflower corals were either dead or being consumed by coral-eating snails and approximately 10% of survivors also showed signs of a tissue loss disease. The tissue loss disease is likely a stress response from a sudden change in light intensity associated with the transplantation from open areas on the reef to heavily shaded area under the SPA buildings.

Coral-eating snails are a widespread problem in the Maldives since the 2016 bleaching event because their main food sources (*Acropora* and *Pocillopora*) have been greatly reduced. The snails aggregate on remaining corals within their branches and can occur at high densities. During this

mission, a number of *Pocillopora* and *Acropora* colonies had high numbers of snails (4-87 per coral), and snails were the most significant source of coral mortality among branching corals at SEA. The extensive loss of *Pocillopora* colonies under the SPA, within 3 months of transplantation, illustrate the importance of period inspection of nurseries and maintenance that includes snail removal.

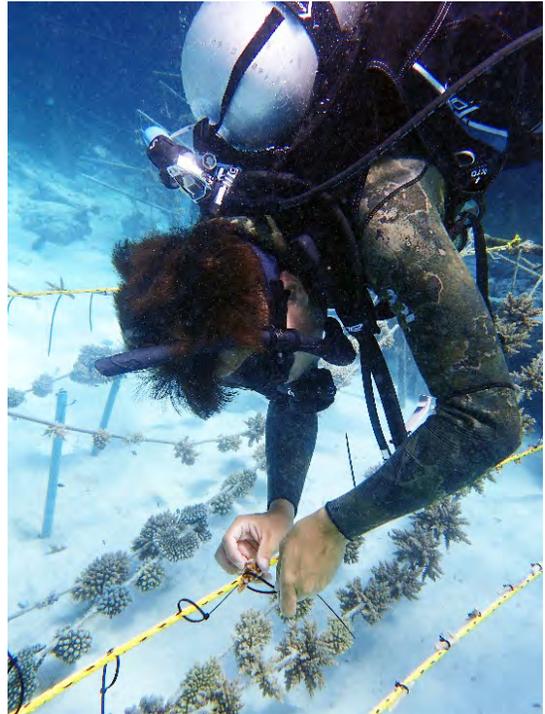


Colonies of *Pocillopora* with rapid tissue loss from disease (left) and coral-eating snails (right). These corals were located within the small patch reef created under the SPA viewing windows in November 2018.

RECOMMENDATIONS

1. Coral Nurseries

- Rope material should be switched from nylon to natural fibers made from hemp or sisal. All new ropes installed at Plates and SEA nurseries in 2019 were made of these natural fibers. This is advantageous as the rope will naturally break down after being outplanted onto the reef.
- Each time a rope is outplanted, a similar rope should be reestablished using fragments that inevitably break off the mature rope. Additional ropes created through the “Adopt a Coral” nursery program should be made using coral recruits and juveniles that settle onto the rubble adjacent to the Plates Nursery within the sand extraction area. In this manner, no healthy adult corals are removed from natural reefs.
- When establishing a new rope, coral fragments of one species should be attached linearly to a rope to the extent possible. This makes it easier to restore areas with species compatible patches. Different species grown adjacent on a rope will compete (fight) with each other, reducing growth rates and causing partial mortality when close to each other. Newly attached fragments should be a minimum of 2-5 cm in length, with all fragments roughly the same size. Fragments should be spaced apart at a minimum of 10 cm.
- Nursery maintenance is essential. All algae and encrusting organisms should be removed from the corals and ropes at minimum once per month (ideally every two weeks), and any corals that show signs of recent tissue loss (white skeleton) should be removed.
- Coral ropes should be outplanted after a minimum of one year and a maximum of 18 months for slower growing species, otherwise the corals will be too large and difficult to transport.



2. Coral Outplanting

- Corals should be outplanted after one year (fast growing staghorns) to 18 months (digitate, table, bushy acroporids) for corals in the genus *Acropora*, with colonies ranging in size from 10 cm (diameter) for digitate colonies (size of a softball) to 25 cm (staghorn corals). Corals of larger size become difficult to transport without breakage of branches and adjacent corals may begin to grow together.
- Corals should be transported underwater, as considerable breakage is likely when removing mature colonies from the water. For ropes close to the restoration site (SEA), two divers can relocate a rope from the nursery to the reef using lift bags. For Plates Nursery, ropes need to be moved at high tide using lift bags. Slowly towing the ropes behind a boat is the most efficient way to transport corals.
- All corals need to be secured to hard substrate; placing corals in sand will cause tissue death at the bases of the corals and progressive burial of the colonies may occur. In sandy areas, a reef framework using dead coral rubble should be constructed, and corals can be placed on top of the new rubble framework.
- Corals should be planted in small clusters of the same species. Placing corals of different species close to each other can result in aggression and one coral killing its neighbor over time. Ropes can be cut into smaller sections (e.g. 3-5 corals) and secured to the reef using nails. Corals will naturally fuse to the substrate over a few months.
- It is important to select the appropriate habitat to plant corals. Corals may bleach and die if 1) taken from deep habitats or nurseries and planted in shallow water or 2) taken from very bright areas and placed in low light habitats (e.g. under the SPA). The more robust digitate acroproids prefer shallow (e.g reef crest; reef flat) habitats and they can tolerate areas with strong water movement while staghorn corals occur at the base of the shallow slope or on the terrace in more protected areas. Table and bushy acroproids and *Pocillopora* can be found on the reef flat and shallow reef slope.
- Periodic inspections (weekly is ideal, minimum monthly) of all the outplanted corals needs to be performed. Any corals with recent tissue loss (white exposed skeleton) should be carefully inspected. If small snails (*Drupella*) are attached to the branches or at the base of a coral, they should be carefully removed. The area should be carefully searched for cushion starfish (*Culcita*), which should be removed. Any corals that have become detached, overturned or moved into the sand by storms should be relocated to the reef framework. Any corals with coral disease should be removed when possible, as the disease can spread among adjacent corals.

