

HOLISTIC APPROACH TO REEF PROTECTION (HARP)

Establishment of coral nurseries at Kihavah Assessment of status of SEA Restaurant



FIELD REPORT
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Introduction

Baa Atoll is a UNESCO Biosphere Reserve that is known for housing the world's largest manta population and also contains many islands that are surrounded by flourishing coral reefs. As a result of the deep water around the atoll, and the steeply sloping reef there are also large schools of pelagic fishes and planktivores that feed near the reef.

Baa Atoll is unusual as it is one of the only atolls in the Maldives that has not been affected by crown of thorns starfish. In other atolls, these starfish have devastated entire



reef systems. Until April 2016, shallow lagoonal coral reef communities extending from the shoreline out to the reef slope had vast meadows of high relief branching and table corals (*Acropora* spp.), areas with large foliaceous lettuce coral (*Echinopora*), while outer exposed reefs were covered with high numbers of boulder corals (especially *Porites*).

Fig. 1. Healthy Shallow reef system near Kihavah in January 2016.

During April and May abnormal water temperatures caused severe coral bleaching and after one month, corals began to die. By August, the majority of the branching and table corals on the tops of the reefs were dead. These areas now consist of graveyards of coral skeletons covered in algae.

Fig. 2. Dead table corals at Hulhudhoo in July 2016.



Fortunately, the boulder corals that dominate these reefs and are the slower growing, long-lived species exhibited much higher rates of survival. Many of the outer reefs surrounding Kihavah still have high coral cover as a result.

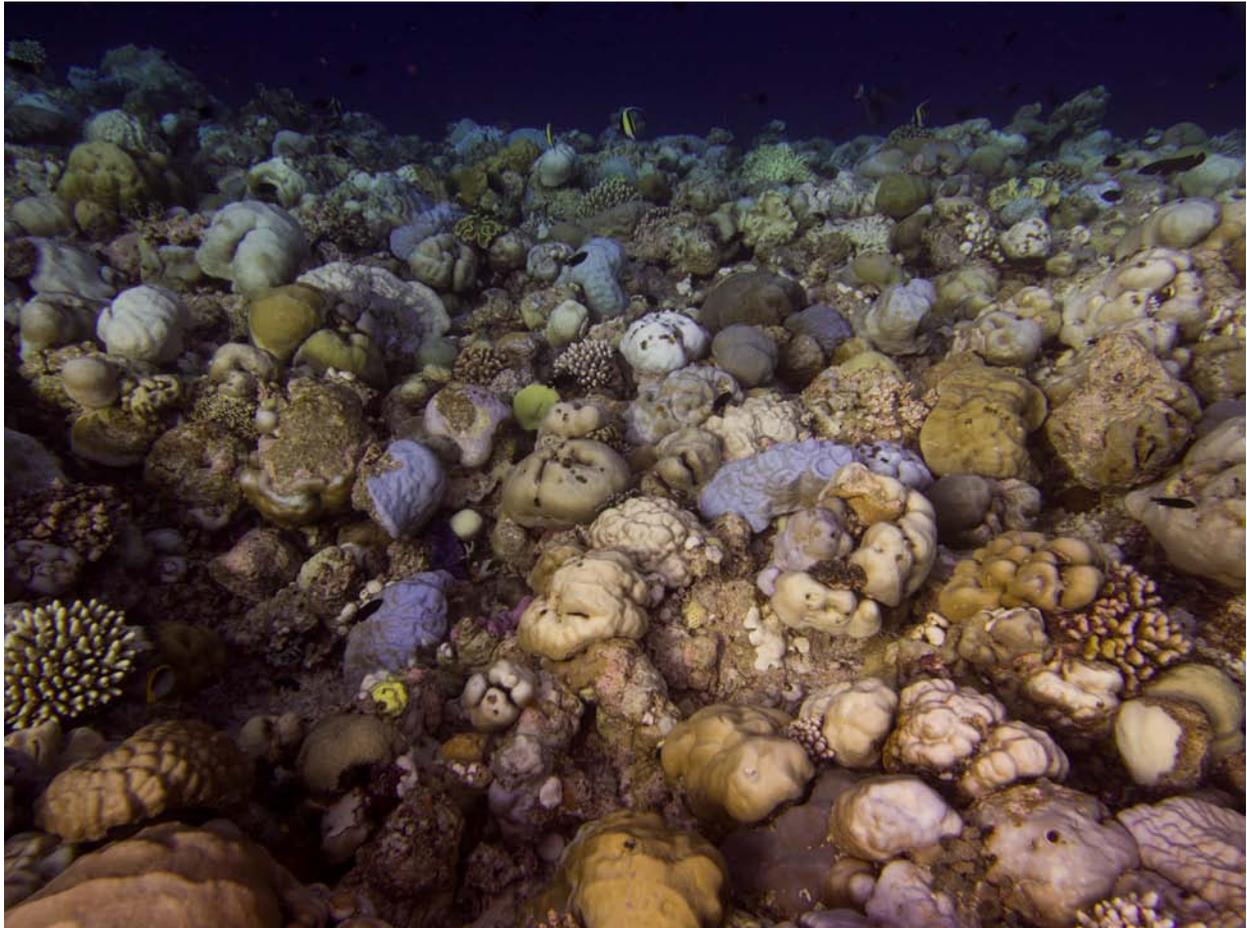


Fig. 3. A *Porites* dominated reef slope on the outer fore reef of Baa Atoll in July 2016. The branching corals have died while the boulder corals all mostly survived.

Reefs in deeper water and reef slopes exposed to high water movement still contain small colonies of the branching and table corals, as well as high numbers of juveniles. In some locations there are also numerous broken coral branches that have fallen down the reef slope and accumulated in depressions in the sand. Because a large number of these are showing signs of disease and they are being targeted by coral-eating snails they are unlikely to survive.

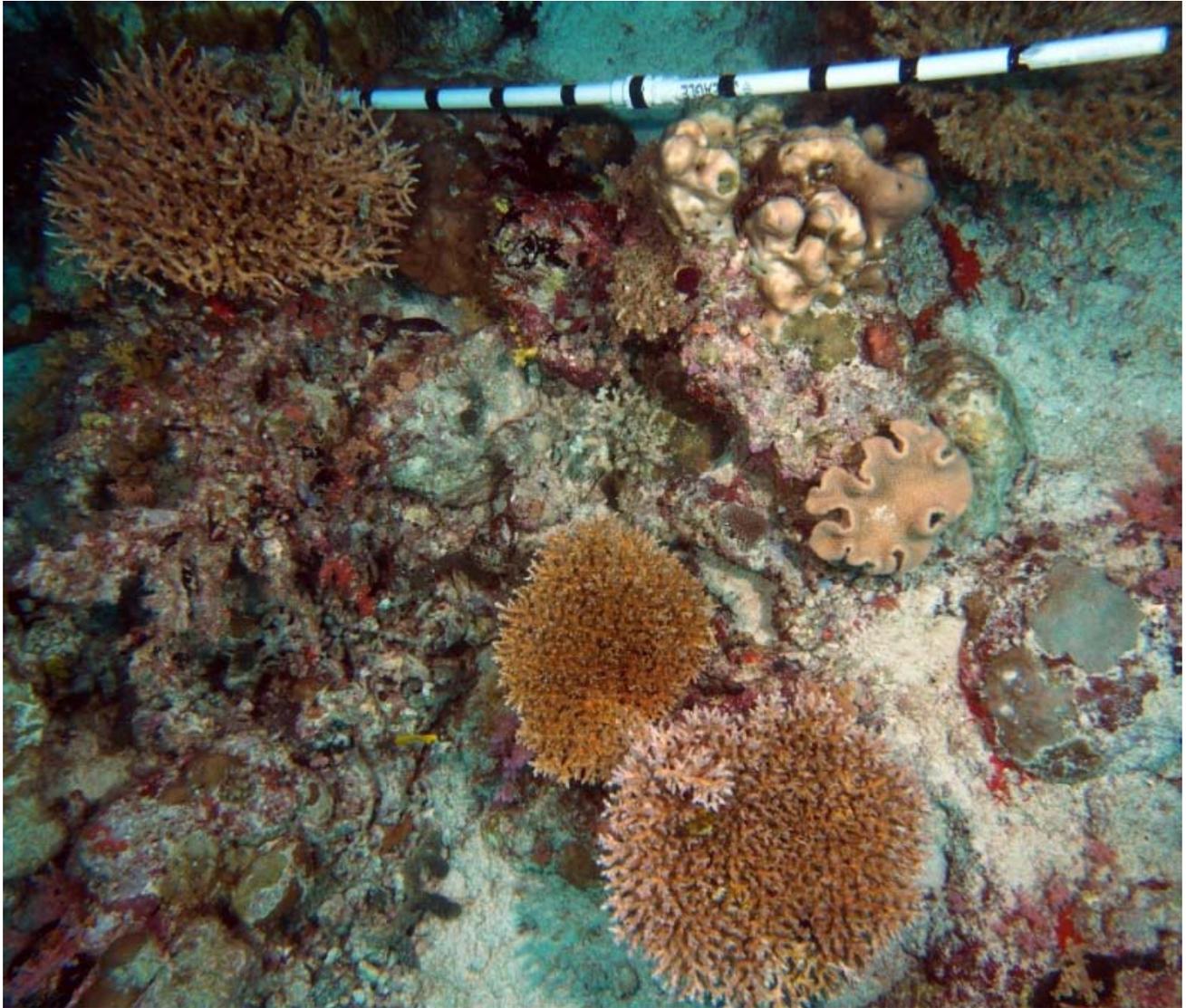


Fig. 4. Surviving table corals at the base of Yellow Wall in 25 m depth. Scale bar is 1 m.

In Kihavah, as well as many other resorts throughout the Maldives, metal rebar frames were used in 'adopt a coral' programs where small branches of corals were attached directly to the metal and their growth was followed over time. The frames at Kihavah were placed in shallow lagoonal waters between the water villas, on reef slope near the supply jetty and around Sea Restaurant. As observed elsewhere, virtually all the coral attached to these frames died this year and the frames are now slowly rusting away and are covered in unattractive algae.



Fig. 5. The metal coral frames in the middle of the lagoon surrounded by water villas in April 2016.



Fig. 6. The metal coral frames from the same location as Fig.5 with 100% dead coral in November 2016.

As part of the Holistic Approach to Reef Protection (HARP) Program, Coral Reef CPR is in partnership with Anantara Kihavah and working to rejuvenate reefs that lost coral. The first step in this effort involves establishing coral nurseries to grow corals that are more tolerant of higher water temperatures. Because very little healthy adult corals with branching, digitate, tabular or plating morphology remain, we do not want to harvest these for use in the coral nurseries. We believe that these must be left untouched to allow them to continue to grow, and reproduce, producing the next generation of corals that are critical for the successful recovery of these reefs.

As an alternative we are developing nurseries using 'fragments of opportunity', these include branches of corals that have broken off due to diver/snorkeler contact, bioerosion, wind and wave action etc. Some of these can be found underneath the adult colony and also on the reef slope often in sand channels and crevices. We also take branches from corals that are infested with coral-eating snails or that are showing signs of disease as these would otherwise die.



Fig.7. An accumulation of broken coral fragments on the reef slope.

A third source of corals includes fragments removed from sites where there is construction, dredging, burial or coastal development projects. The advantage of this approach is that our nurseries have no impact on source populations and they provide an opportunity to produce viable corals that can be out planted on to the reef. The disadvantage is that a portion of these are expected to die because they are severely stressed when collected. However, we attempt to minimize future stress to these corals by transporting them in water and carefully removing predatory snails, algae, overgrown sponges and other pests.



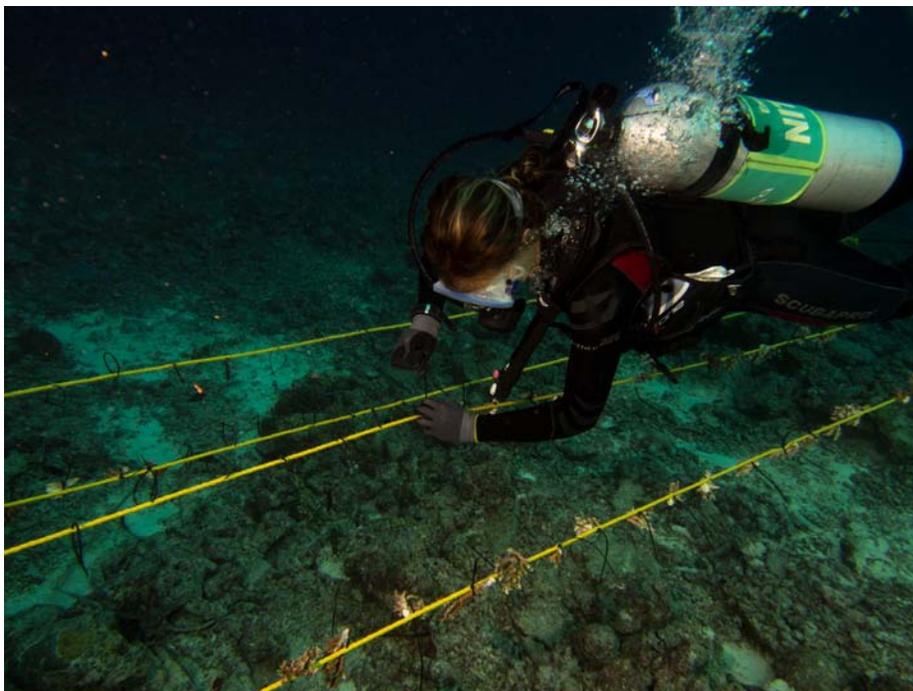
Fig. 8. Example of a juvenile *Acropora* colony that recruited onto coral rubble in the channel off Plates. All of these are likely to die if left in place due to sand extraction and subsequent burial. These corals were used in the nursery set up off Plates.

During November we worked to establish nurseries in two areas that are regularly used and highly accessible by the guests, and also conducted a reconnaissance survey of the signature restaurant, Sea to determine the current condition of the surrounding reefs and potential to rehabilitate this area following numerous guest and media complaints.

Coral Nursery Establishment

Two coral nurseries were established at Kihavah. One is located on the fore reef between the supply jetty and Yellow Wall and the second is within the lagoon in the deeper channel off Plates. The Yellow Wall nursery is located on the slope with corals planted from 5 m to 14 m depth while the lagoonal nursery is 3-4 m deep. Each nursery contains five sets of rebar "staples" positioned at a distance of 5 m apart. Each piece of rebar is 1.5 m long, with 1.5 m legs that are inserted into the sand between 50-100 cm; rebar was further stabilized by inserting 2 m angle iron bars into the sediment midway along the rebar, which was attached with cable ties. Nylon braided rope, 3/8 diameter is extended between each pair of staples, with four ropes per set at Yellow wall and 2-4 ropes at Plates. Ropes are 5 m in length and contain approximately 40 cable ties each, space apart by 12-15 cm. At the Plates nursery two additional coral tables constructed of an angle iron frame, 1 m X 2m in size with attached plastic chicken mesh. One hundred cable ties are attached to the plastic mesh, with each cable tie separated by 10-15 cm from other cable ties. The cable tie ends are clipped once the nursery is finished.

Small coral fragments are secured to the rope and plastic mesh with the cable ties. At Yellow Wall, Kihavah's famous House Reef, 18 ropes consisted of various species of branching, digitate and tabular *Acropora* and two ropes contain branching *Pocillopora* (cauliflower coral).



(cauliflower coral).

Fig. 9. The resident marine biologist, Talya, attaching coral fragments of opportunity to ropes at the House Reef nursery.

At the nursery in front of Plates Restaurant, there are a total of 14 ropes. One contains *Pocillopora* and the other 13 are *Acropora* species. One table also contains *Acropora*, while the second table contains a mix of species including two species of *Porites*, two species of *Pocillopora*, *Cyphastrea*, *Favia*, *Pavona*, and *Leptastrea*.

Corals attached to the ropes at Yellow Wall were sourced from Hulhudhoo and Funhudhoo. All fragments used were obtained from corals that had been broken off the reef and were unattached on the bottom. Many of these had partial mortality and recent feeding scars from coral-eating snails. The snails were all removed before using the corals. Corals were collected in a large plastic crate, brought up to the boat and immediately transferred to crates containing sea water. The crates were transported to the nursery and coral branches were further subdivided into small fragments using coral clippers. Branches attached to ropes ranged in size from 2 cm-8 cm.

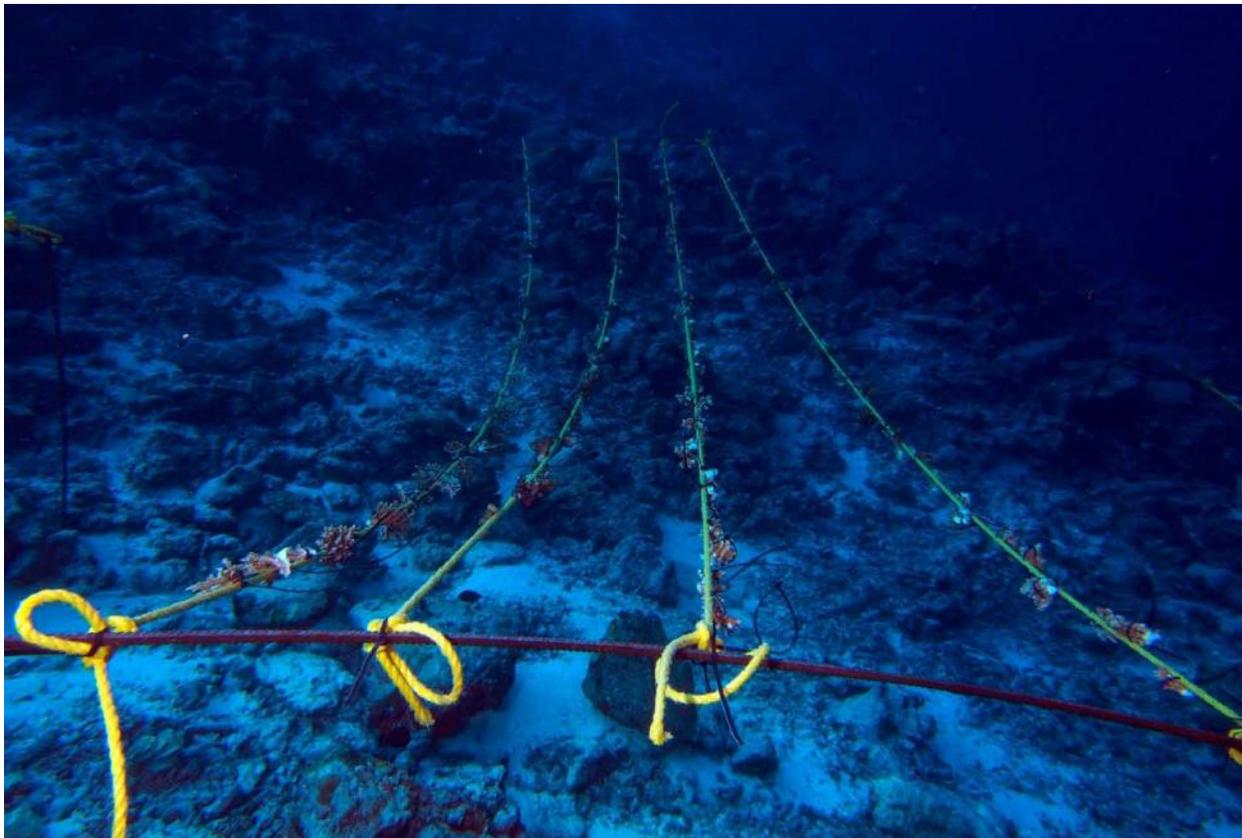


Fig. 10. Four ropes, each 5 m in length were attached to each frame at Yellow Wall. Each contained 39-50 corals.

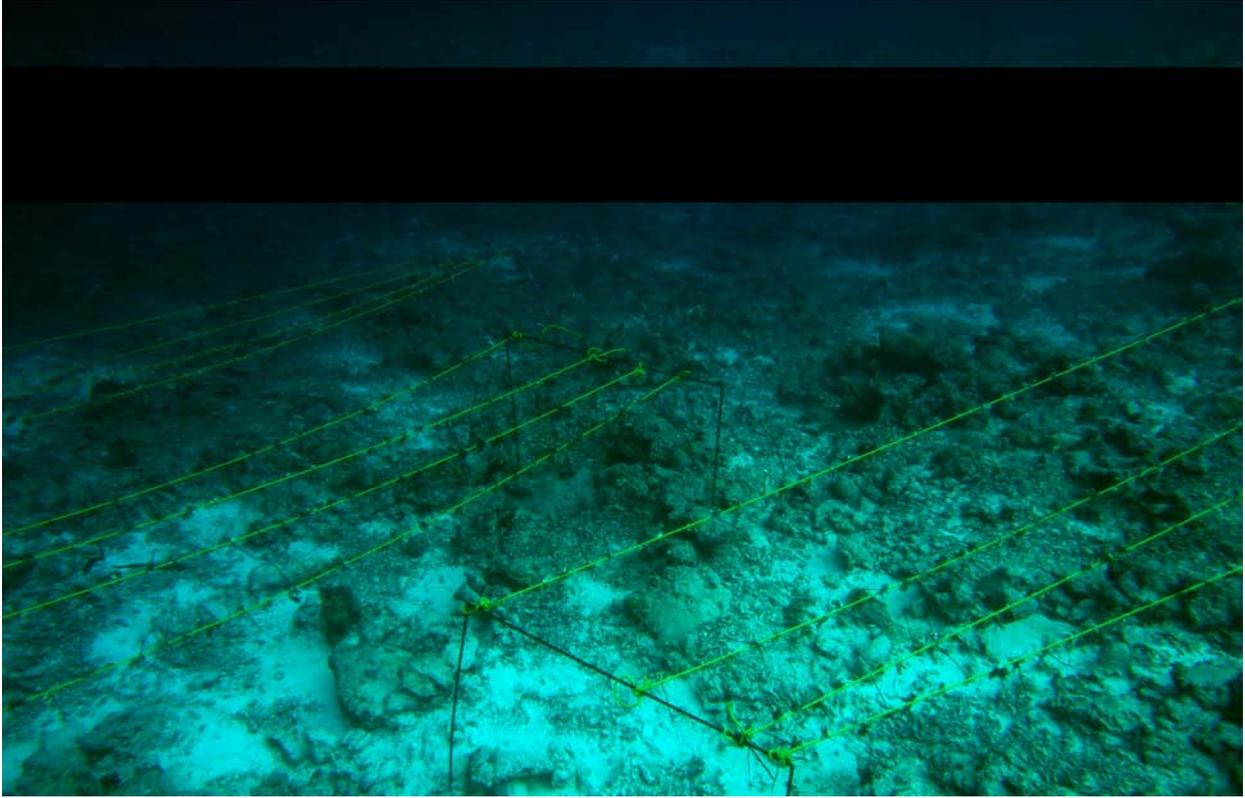


Fig. 11. Three of the rope frames positioned at 10-14 m depth. The frames were placed on the slope in an area with sand and rubble and no living coral.

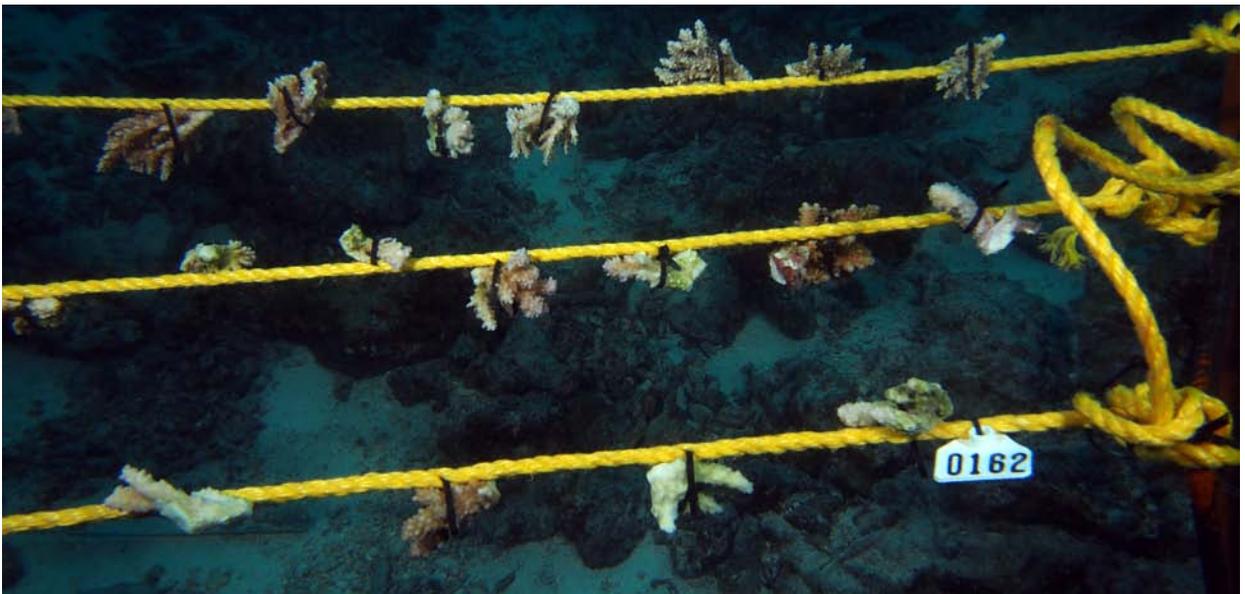


Fig. 12. Close-up of a section of three ropes showing the attached coral fragments. Branches were 2-8 cm in length.

Corals attached to ropes at Plates consisted of corals sourced from Hulhudhoo (4 lines) and locally collected corals from the deep channel. This channel was very unusual in that the bottom was littered with piles of long-dead staghorn coral branches. In undisturbed locations several species of coral larvae had settled onto the branches and these were starting to grow and produce branches or fingers. These appear to be recruits that were mostly from the March 2016 spawning with some larger colonies that settled in March 2015. Throughout the site were large depressions created by the extraction of sand. This overturns and buries the fragments and kills any young corals that had settled in the area. We did not identify any older colonies, indicating a very short survival of these corals. The majority of the corals used in the nursery were obtained from these juvenile colonies, which range in size from 1 cm - 5 cm. Prior to attaching these to ropes most of the dead staghorn skeleton was removed.

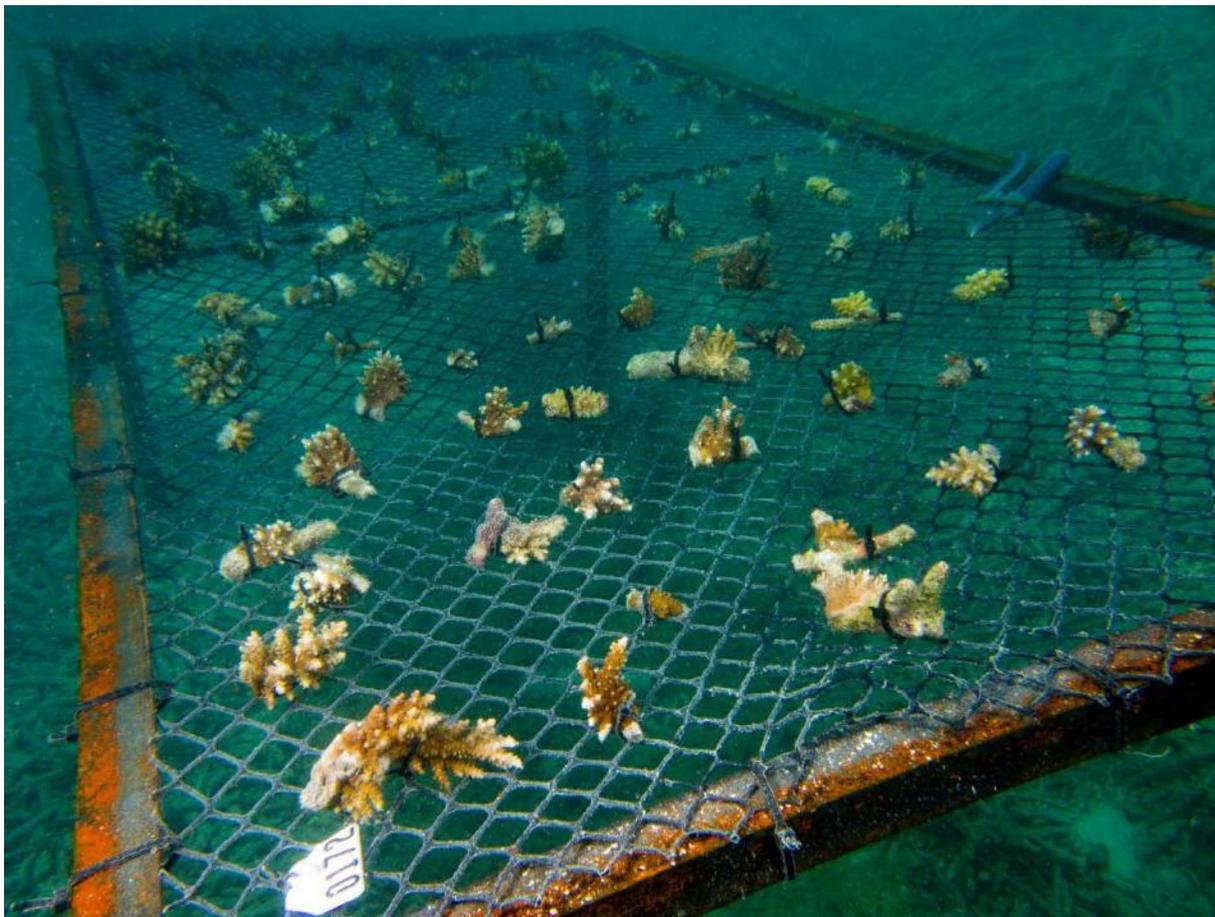


Fig. 13. One 2m X 1 m metal table, 70 cm in height with attached plastic mesh had 109 small *Acropora* branches attached with cable ties.



Fig. 14. The mesh covered table at Plates nursery with mixed species of corals.

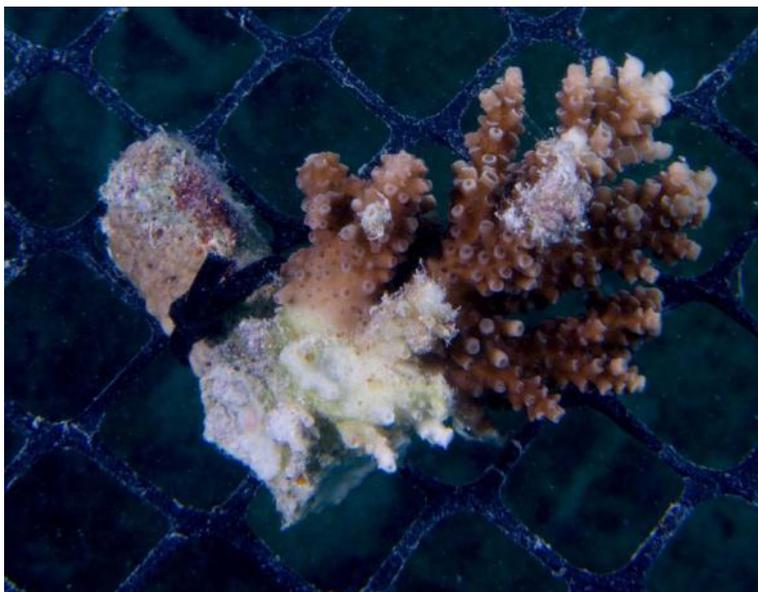


Fig.15. About 20% of the recruits we collected had 1-6 coral eating gastropods (*Drupella*) that were slowly consuming the corals. These were removed before attaching to the mesh. The white area at the base of the colony is dead, and has been eaten by the snails.



Fig. 16. Close-up of three juvenile corals collected from the surrounding rubble field and attached to ropes.



Fig. 17. Two small coral recruits that settled on dead staghorn rubble collected from the area of sand extraction and attached to plastic mesh on a coral table. The corals are 2-5 cm and some are beginning to produce branches.

Maintenance

1. **Plates:** important to gently shake the ropes to remove sediments, especially after sand pumping occurs, if using SCUBA - air from the regulator can be used to remove sediment from the tables. Also key to check for coral eating snails on the fragments and to remove these from the water (also prevents them spreading to the reefs around Kihavah).
2. **House Reef:** fragments must be examined for snails, which should be removed if found. Any clumps of algae that accumulate on the ropes or fragments needs to be scraped off. If there is a period of rough weather, where the water becomes turbid then these ropes must also be gently shaken to remove accumulated sediment.

Plates Nursery			
	Staple Number	Tag #	Number fragments
Ropes	1	175	39
	1	65	39
	2	163	44
	2	151	45
	2	170	49
	2	168	43
	3	155	42
	3	153	40
	4	159	41
	4	NA	43
	4	171	38
	5	173	45
	5	174	48
Tables	1	172	108
	2	158	107
TOTAL			771

Yellow Wall House Reef Nursery		
Staple Number	Tag #	Number fragments
6	162	36
6	1	50
6	2	41
6	152	42
7	167	35
7	3	40
7	4	38
7	165	42
8	154	38
8	5	41
8	6	47
8	161	34
9	166	31
9	7	40
9	8	32
9	169	39
10	61	35
10	9	39
10	10	37
10	156	34
Total		771