Holistic Approach to Reef Protection (HARP)

Phase III: Impacts of Bleaching & Establishment of Coral Nurseries

Dhigu (South Malé Atoll) and Kihavah (Baa Atoll), Maldives

Field Report

July/August 2016

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Executive Summary

Coral Reef CPR, in partnership with Anantara Resorts and Aquafanatics and Elements Dive Centres implemented Phase III of the Holistic Approach to Reef Protection (HARP) Program between July 28-August 10, 2016. Our activities included a) monitoring; b) reef clean-up; c) coral gardening; and d) education:

- The impact of coral bleaching within ten permanent sites (five on Baa Atoll and five on South Malé Atoll) was assessed through analysis of permanent photo-transects and point intercept transects at 2-15 m depth. Rapid assessments were also undertaken on five reefs near Kihavah and four near Dhigu.
- Crown of thorns starfish (*Acanthaster planci*) were removed from South Malé Atoll at Raaebundi (135), Stage (120), Veli fore reef (23) and Veli Lagoon (4).
- Coral eating snails (*Drupella cornus*) were removed from corals located near the coral nursery tables at Veli, Marina, Kuda Giri and Veli Lagoon (1,928 snails).
- A restoration plot was established at Snorkel Island (Gulhifushi); coral lines with small fragments were attached between pilings of the water villas at Veli, and coral nursery tables (two per site) were placed at Dhigu House Reef, Kuda Giri, Veli fore reef, Marina, and Veli lagoon.
- An educational seminar was conducted in Malé City for 85 students from 5 local high schools.

Reef temperatures (loggers placed at 7 m depth and temperature profiles from the surface to 35 m depth on each reef) showed a progressive increase in temperature from January to March, reaching 30°C in early March and remaining at 31-32°C from April until May 5th. Similar temperatures extended to depths greater than 30m, while surface waters and shallow lagoonal areas exceeded 33°C in some locations. With the onset of the monsoon-driven winds, currents and rainfall (May 6), temperatures have slowly, but steadily declined. By early August, temperatures on most reefs ranged from 29- 29.5°C, with small variations due to waves, currents and tidal flow.

The progression and impacts of bleaching were highly variable between species and locations:

- Bleaching was first noted in April and steadily worsened with 80-90% of branching, digitate and tabular acroporids, *Pocillopora* spp., foliaceous *Echinopora*, *Montipora*, *Hydnophora, Galaxea* and other genera becoming severely bleached by the end of April.
- Over 90% of the branching corals died in some lagoonal reefs within a month, while 10-15% mortality was noted in fore reef locations.
- Only 10-20% of the massive corals, especially *Porites*, various faviid species, *Pavona*, and other taxa were fully bleached; most became pale, mottled or light blue in color.

- By late July most of the *Acropora* spp., foliaceous *Echinopora*, and 50-70% of pocilloporids had died. Living coral cover on reef tops declined to <5%. Both table corals and thickets of staghorn coral experienced near total mortality on shallow reefs, with isolated survivors seen on the reef slope and in deeper water.
- Total mortality was less common in *Porites*, *Goniastrea*, *Platygyra*, *Favia*, *Pavona* and other massive corals, although 30-50% showed signs of partial mortality.
- Many of the surviving massive corals that had bleached during April had not fully regained their pigmentation by July. Plating and encrusting genera, such as *Pachyseris*, *Leptoria*, *Mycedium*, and *Leptoseris* were pale in color in early May and fully bleached by July, and many had begun to die during August.
- Colonies that had begun to regain their pigmentation, especially surviving *Pocillopora* and *Acropora*, frequently showed signs of recent mortality from disease (white syndrome). Black band disease, which was rarely seen in earlier surveys, was noted on five different species of massive and plating corals.
- An unusually high prevalence of coral eating snails (*Drupella*, up to 150 snails per coral) was recorded on branching corals in Dhigu; snails were less common on Baa Atoll.
- A reemergence of crown of thorns starfish was noted at Raaebundi and Stage Reef, with small numbers seen at Veli and lagoonal habitats near Dhigu and Veli.
- In all cases, the skeletons of corals that died during the bleaching event were rapidly colonized by filamentous algae.

Although initial observations suggested that the situation was ominous, a detailed examination of the reefs yielded a number of positive surprises. Of particular relevance, individual colonies of certain species that were located adjacent to fully bleached colonies failed to bleach, or produced vivid fluorescent pigments. These pigments appeared to offer protection to these colonies. Several reefs offered a refuge from the bleaching, with high numbers of surviving corals on channel reefs and other locations where there was high water movement. Even in areas that were badly damaged, numerous broken branches and small colonies on the reef slope were still alive, and they had escaped bleaching. Remarkably, our sites had unusually high numbers of baby corals and 1-2 year old juvenile corals that resisted bleaching. The presence of these corals provides evidence that reefs in the Maldives are still very resilient and are likely to recover quite quickly.

In April, Coral Reef CPR tagged over 150 colonies exhibiting different color patterns to look at differential survival. While most bleached corals died, 20-30% of the corals exhibiting fluorescent colors survived and >90% of the colonies that were not bleached were still living. We used small fragments of these survivors, along with fragments taken from broken colonies that had fallen down the reef slope to begin establishing coral nurseries.

- For each nursery we placed two 1 m x 2m tables covered in plastic mesh. 100 fragments were attached to each table (8 in total on four reefs). Tables were deployed at Veli, Naladhu/Marina, Dhigu House Reef and Kuda Giri.

Fig.1. Close-up of a coral nursery table with attached fragments of different species of *Acropora*.

- Over 99.5% of the corals in Veli lagoon died in April this year. We found one small patch of surviving branches located in a shaded area under a water villa. These were under severe threat from coral-eating snails; some were also being buried by sand and were covered in thick mats of cyanobacteria. We salvaged small branch ends from these corals, attaching them to lines (5 in total, each with 5-10 fragments) and two tables (150 total fragments).

We continued our education and outreach efforts to guests, staff and Maldivian students. We conducted one interactive educational seminar in Malé City to 85 high school students and their teachers. We also completed presentations to staff at Kihavah (villa hosts) and two at Dhigu (in Marina and Veli) and four guest presentations.

Of particular note, Anantara is having a silent auction for paintings of whale sharks and manta rays created by Christopher Hogan, with proceeds supporting the HARP Program. Christopher also designed a new logo for HARP (right).

Acknowledgements

The HARP Program would not be possible without the partnership and support from Anantara Dhigu, Veli and Naladhu and Anantara Kihavah Resorts. We must thank the General Managers, Coetzer Deysel and Dylan Counsel, who are extremely enthusiastic and supportive of the Program and fully understand the need to conserve these vibrant and vital ecosystems. Thanks to the entire sales and marketing teams at both resorts for assistance in promoting HARP during and after our visits. We are grateful for all of the organizational and logistical assistance from Analiezl Lising during our Kihavah visit and Rizan Afeef whilst at Anantara Dhigu. We would like to thanks Mr John Roberts, the Director of Conservation, for visiting and working alongside us during the trip- we loved sharing this Program with him. Thank you to the team at Aquafanatics and Elements Dive Center's for providing us with diving equipment, knowledge and expertise and logistical support. A special thank you to Paula Berenguer and Talya Davidoff who dived and worked with us during the trip. Education is a key component of the HARP Program, and we would like to thank Mr Mohamed Yamany for organizing the seminars with staff and local school students.

Fig. 2. One of the Maldivian High School groups that participated in the coral reef seminar in Malé City.

Introduction

Coral Reef CPR, in partnership with Anantara Resorts and Aquafanatics and Elements Dive Centres implemented Phase III of the Holistic Approach to Reef Protection (HARP) Program in July and August, 2016. Coral Reef CPR scientists (Andrew Bruckner and Georgia Coward), with assistance of scientists from the Mai Khao Marine Turtle Foundation (Kittipan Sabkhoon and Kathryn Bimson), resident marine biologists in Kihavah (Talya Davidoff) and Dhigu (Paula Berenguer), and other dive center and resort staff, examined permanent monitoring sites to assess the impacts of bleaching, and also removed crown of thorns starfish from affected reefs (Dhigu only). We also began rehabilitation efforts on one badly damaged lagoonal reef and established small coral nurseries in five locations (Dhigu only).

Record-breaking ocean temperatures during April and May 2016 caused corals throughout the Maldives to bleach as one of the longest and most intense El Niño events to date continues into its second year. Over the month of April, doldrum-like conditions persisted; unusually calm, clear water allowed a much higher penetration of harmful ultraviolet radiation and heating of the water. The typical deep water thermocline (cooler waters) disappeared and unnaturally high temperatures extended from the water's surface to 35+ m depth.

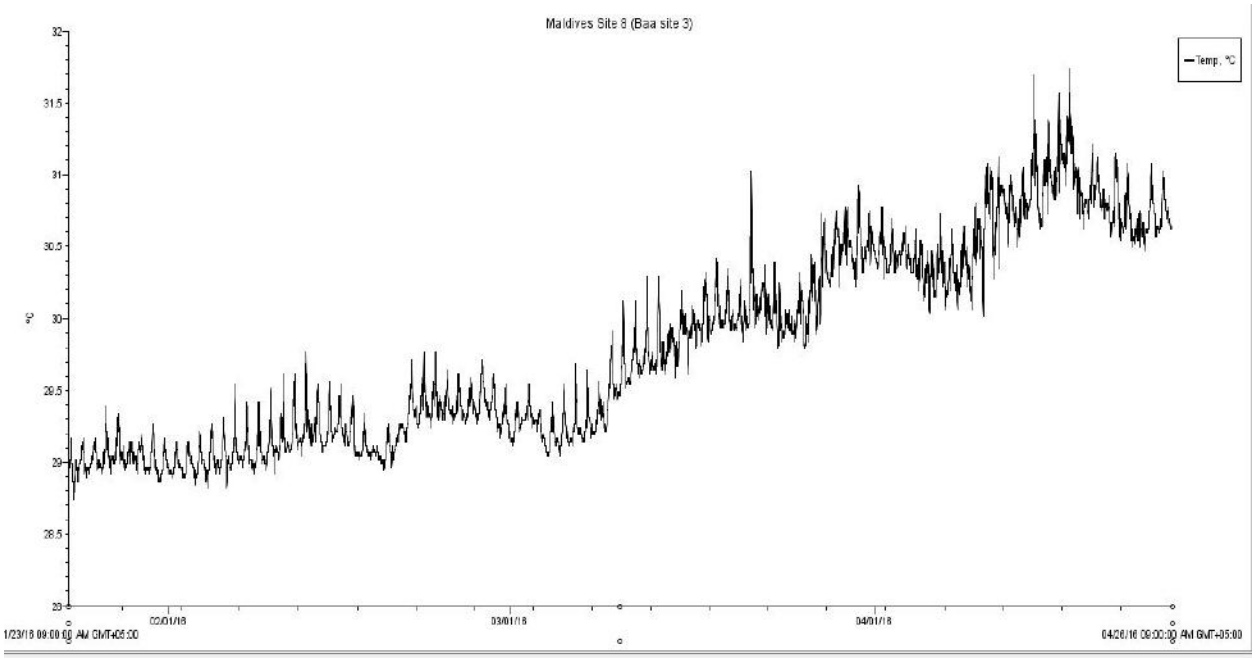

Fig. 3. Temperature profile on Baa Atoll, site 8 from January 23, 2016-April 26, 2016.

During our assessments in April and May we documented the onset of bleaching, and in some cases early mortality. There was one brief (three day) reprise (April 22-24), when a storm brought heavy rainfall and wind, cooling water by 1-2° C. Water heated back up to 31° C until the onset of the summer monsoon on May 6. With exception of a few shallow lagoonal reefs, most corals were still alive at the end of April, but bleaching severity increased from moderate to extreme, with all of the shallow table corals, branching and digitate species, and a large portion of the massive, plating and encrusting species becoming completely white.

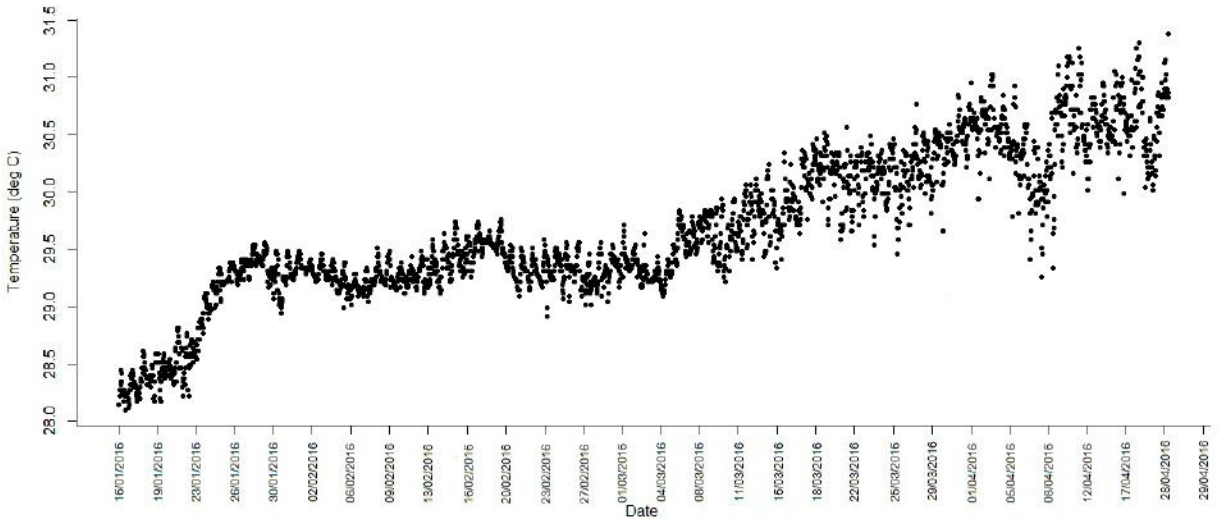

Fig. 4. Temperature profile on South Malé Atoll (Veli fore reef), January 16, 2016-April 29, 2016.

We returned at the end of July, after water temperatures had cooled, to assess losses from the bleaching and the extent of recovery. We also began our work to establish coral nurseries and to rejuvenate damaged reefs.

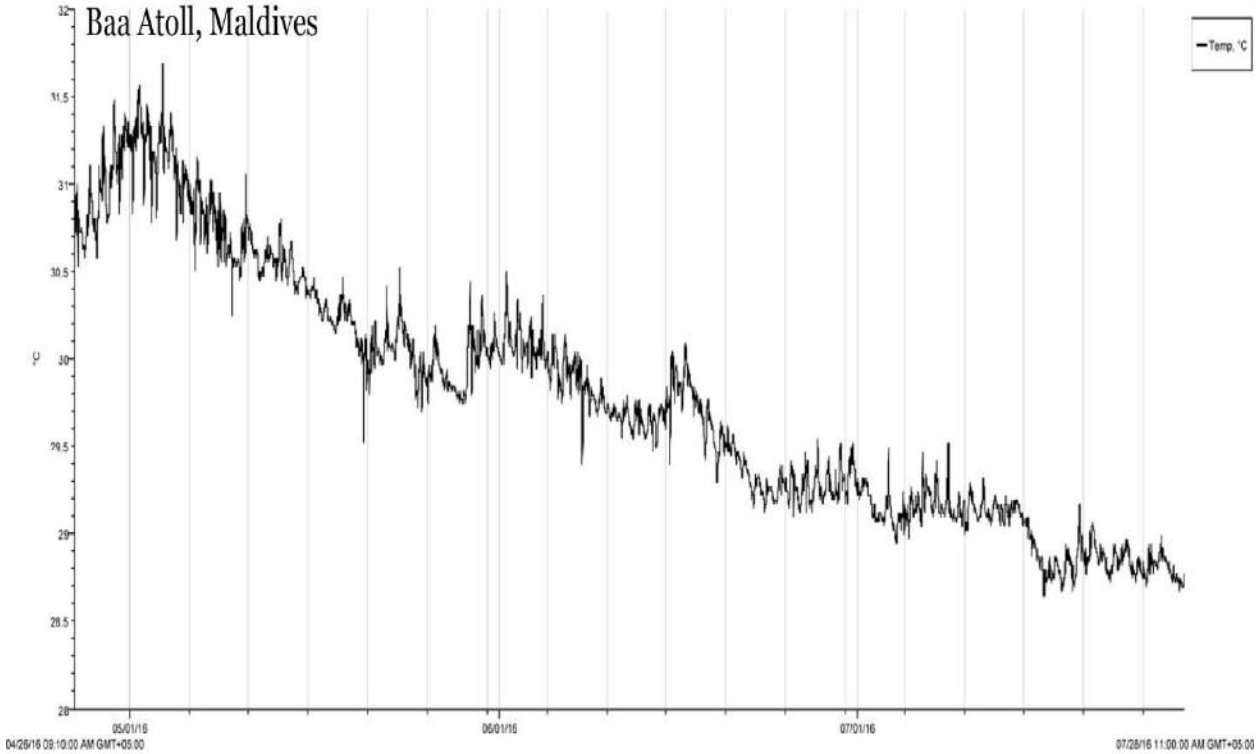

Fig. 5. Temperature profile at Baa Atoll between 4/25/16 and 7/29/16.

Coral Monitoring

A. Kihavah, Baa Atoll

We completed our monitoring of our five permanent sites; with point intercept transects (4-6 per reef) at 2-3 m on the reef terrace, 7 m at the top of the slope and 10-15 m on the deeper section of the slope. We also re-photographed all of our permanent transects and monitored the survival of our tagged corals.

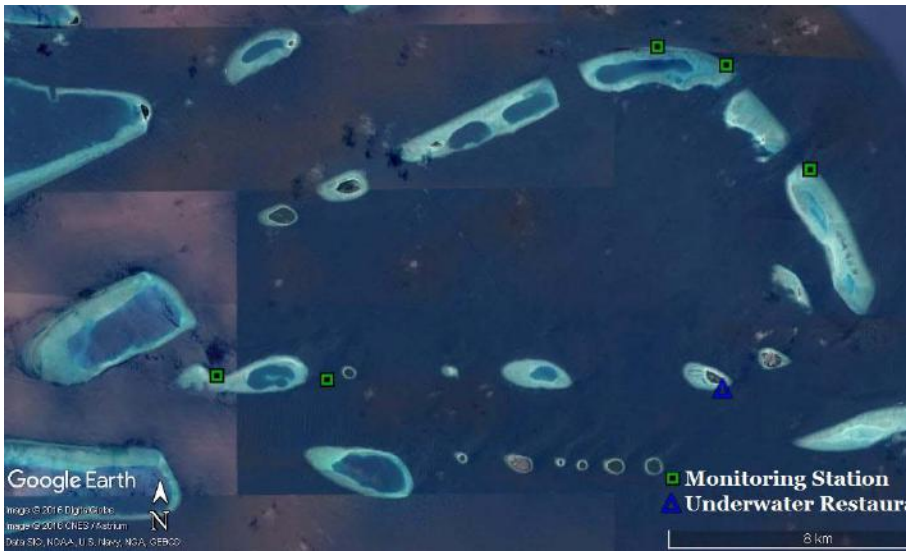

Fig. 6. Location of permanent monitoring sites on Baa Atoll.

The inner reefs were formerly dominated by large colonies of tabular acroporids and branching and digitate corals on the reef platform (2-5 m depth) and a mix of table, branching, digitate, foliaceous, plating and massive corals on the slope. The tops of the reef are largely dead, with near total loss of the Acroporids, including all of the larger table corals and large stands of staghorn coral. On the reef slope there were many more survivors, with losses of branching corals estimated at 20-50%.

Fig. 7. All shallow reef communities within the lagoon at Kihavah lost nearly 100% of the tabular acroporids and branching species. Skeletons remain in place, but are covered with algae.

Fig. 8. One of our sites on Baa Atoll had unusual old-growth fields of foliaceous *Echinopora*. This coral sustained over 95% mortality.

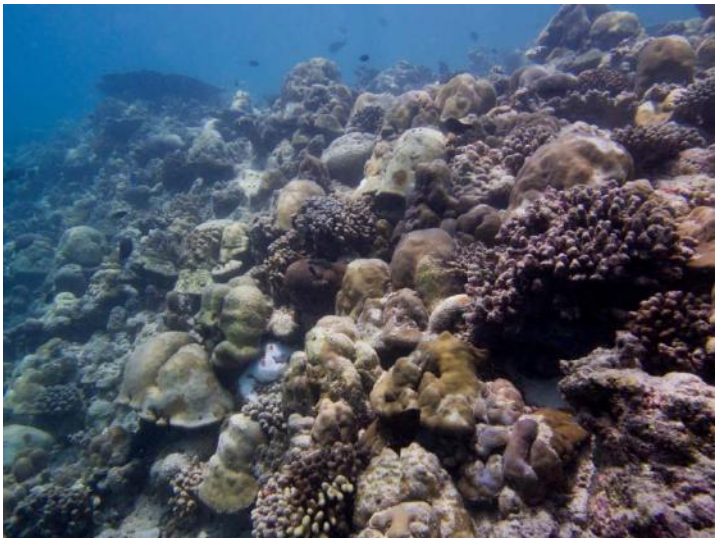

Fig. 9. An outer reef at Baa Atoll where most of the *Porites* colonies survived while all the branching corals died. There were, however, a large percent (30-50%) of massive boulder corals that experienced partial mortality and dead patches were now covered in turf algae. Many of these types of corals were also still bleached, pale or fluorescently colored.

Fig. 10. On some reefs, large parts of colonies have died, while some areas remain live but are fully bleached. The white branches of staghorn coral shown here are still alive, while the rest of the skeleton is covered in algae.

The three outer sites have a different coral composition, with fewer branching and tabular corals and a dominance of massive, boulder corals. The dominant coral is *Porites lobata*, with most colonies estimated at 10-50 year of age (roughly 20-50 cm diameter). There are also high numbers of massive faviids (especially *Platygyra* and *Goniastrea*) along with other boulder corals and more plating corals on the deeper slope. These reefs had much less mortality overall, with <10% of the boulder corals sustaining complete mortality.

Fig. 11. Colony of *Porites lobata* with a considerable amount of partial mortality (white areas). Skeletal areas colonized by algae (light yellow).

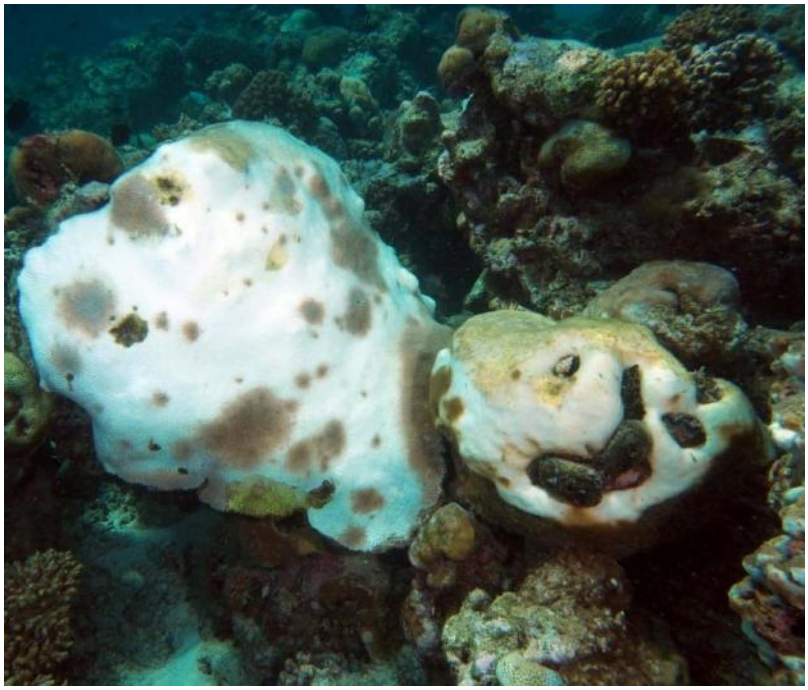

Fig. 12. A massive colony of *Hydnophora* that bleached, but is starting to recover (brown blotches). A portion of the colony (top surface) on the right has died and is covered in fine filamentous green and brown algae.

B. Dhigu, South Malé Atoll

Permanent monitoring sites include two fore reef locations (Stage and Maafushi), one channel reef (Veli) and two lagoonal patch reefs (Raaebundi and Sand Bank).

Shallow reef communities at Stage and Maafushi (reef platform, from 2-8 m depth) sustained near total mortality of branching and tabular corals (*Acropor*a and *Pocillopora*), with some surviving massive boulder corals. Many of the survivors were still partially or fully bleached and they had lost portions of their tissue.

Fig. 13. Maafushi reef at 9 m depth near the reef slope. All of the acroporids and pocilloporids are dead. A few large Porites are visible that are still partially bleached.

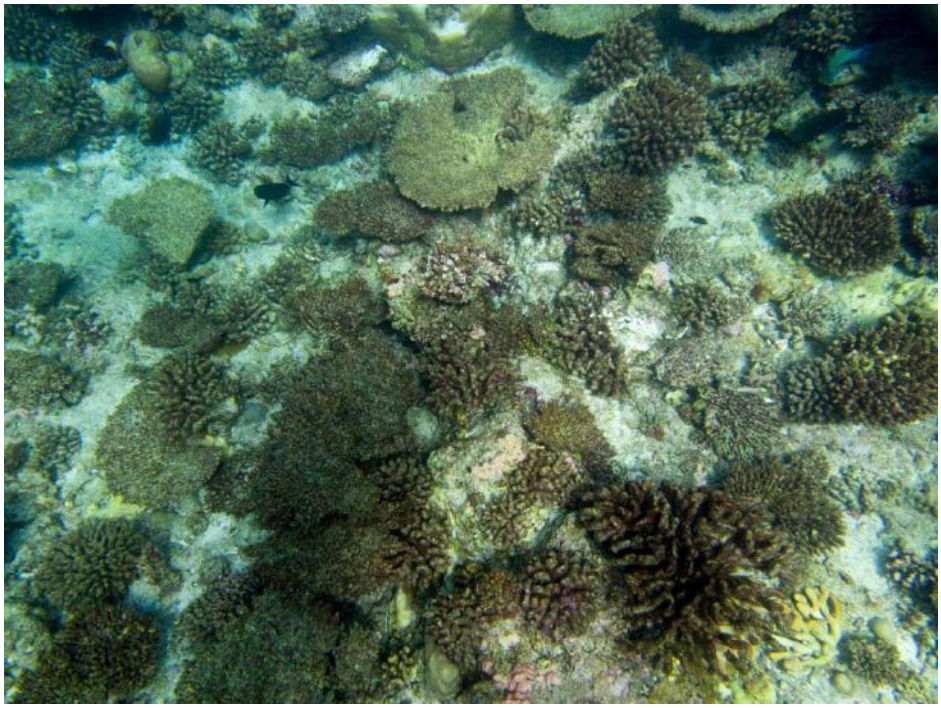

Fig. 14. A view looking down onto the shallow reef terrace at Stage Reef, 8 m depth. There was a near total loss of table acroporids, Pocillopora and other branching corals.

Raaebundi has very little surviving coral. The reef platform is 99.5% dead, and the shallow slope also lost more than 99% of the branching corals. On the deeper slope there are some remaining *Porites rus, Porites lobata, Goniastrea, Pachyseris* and a few other isolated corals, although many of these were still pale, with lots of partial mortality and recent tissue loss from a reemergence of crown of thorns starfish.

Fig. 15. Raaebundi sustained the highest levels of mortality with a 99% loss of all staghorn thickets, table corals, and branching corals, as well as most massive boulder corals on the reef terrace and shallow slope. The only surviving corals are on the deeper reef; these are predominantly those taxa that are not preferred food sources for COTS. Raaebundi is also the only ref where we saw a complete absence of coral recruits and juveniles.

Sand Bank lost most of the coral on the reef platform. There was much more survival on the reef slope from 5-15 m depth. Many surviving acroporids, pocilloporids as well as small massive and plating corals were seen. In addition there were a high number of surviving juveniles and recruits.

Fig. 16. A boulder at Small Sand Bank with surviving juvenile acroporids.

The shallow reef terrace at Veli lost most of the table corals and branching corals, with some surviving massive boulder corals. On the reef slope a portion of the branching acroporids were still living, and there were high numbers of surviving coral fragments, juveniles and recruits.

Fig. 17. A high number of surviving recruits, juveniles and fragments of branching acroporids were found on the reef slope. Many of these were being targeted by coral-eating snails

Fig. 18. There was a dramatic increase in coral diseases in July/August as colonies began to recover from bleaching. Black band disease was documented on both massive and plating corals.

Veli Lagoon:

The coral thickets surrounding the water villas at Veli were formerly flourishing, consisting predominantly of one species of staghorn coral with colonies that were 1-2 tall and occurred in dense stands on both sides of the villas. These sustained near total mortality during the bleaching event. Isolated survivors of staghorn coral were found under a single villa. These were shaded and were at the margin of the stand. A few other branch ends also survived but all of the survivors were still pale and they were being rapidly consumed by coral-eating snails. Unusually, 10 very healthy branches that did not bleach were found within territories of damselfish. These survivors were surrounded by dense algal lawns created by the farming damselfish (*Stegastes punctatus*). These were photographed and will be followed over time to evaluate their growth. In addition a few other corals, of different species, that had attached to the pilings were still alive

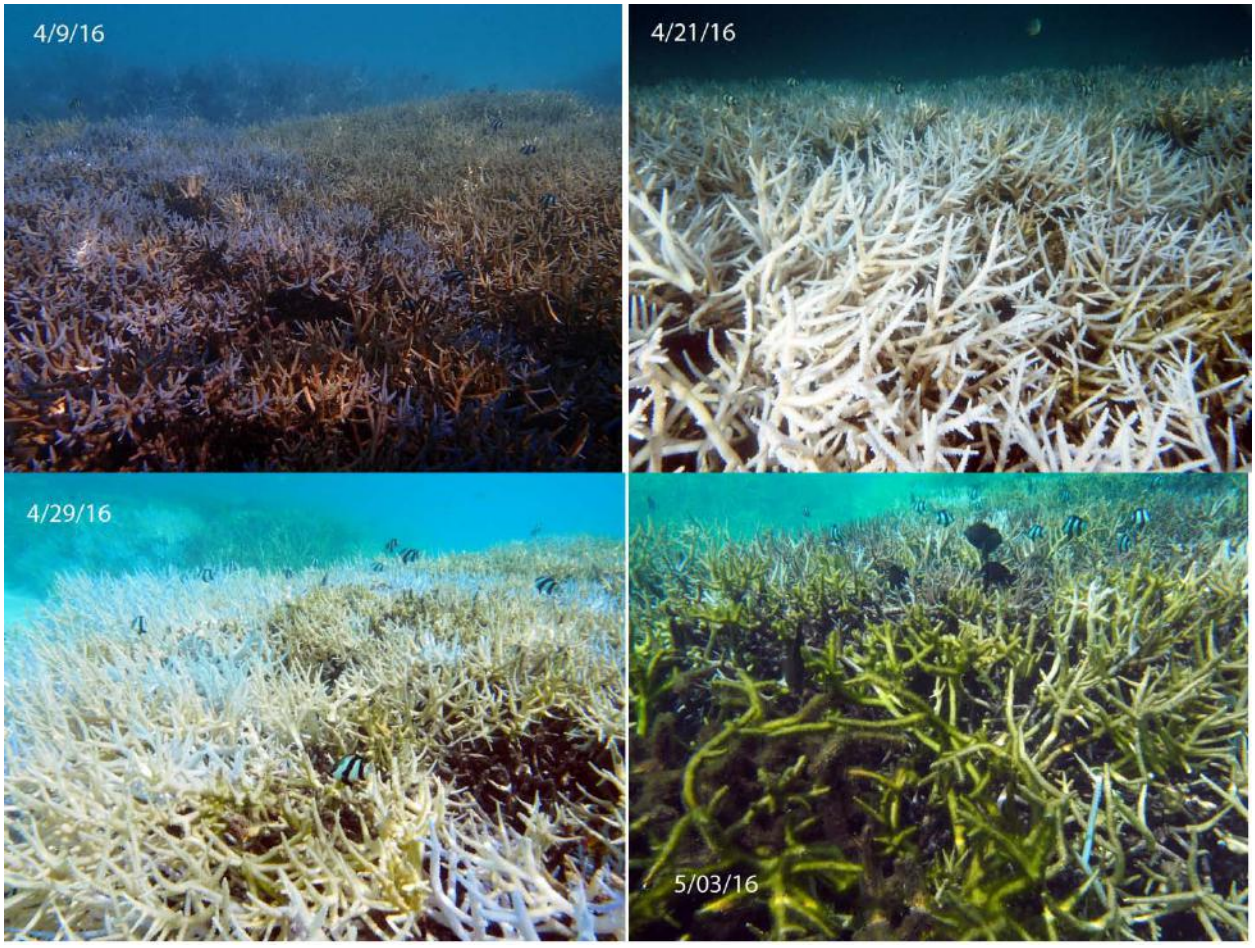

Fig. 19. Sequence of mortality of the staghorn coral stands near the water villas. By May, 2016 more than 98% of the corals had died.

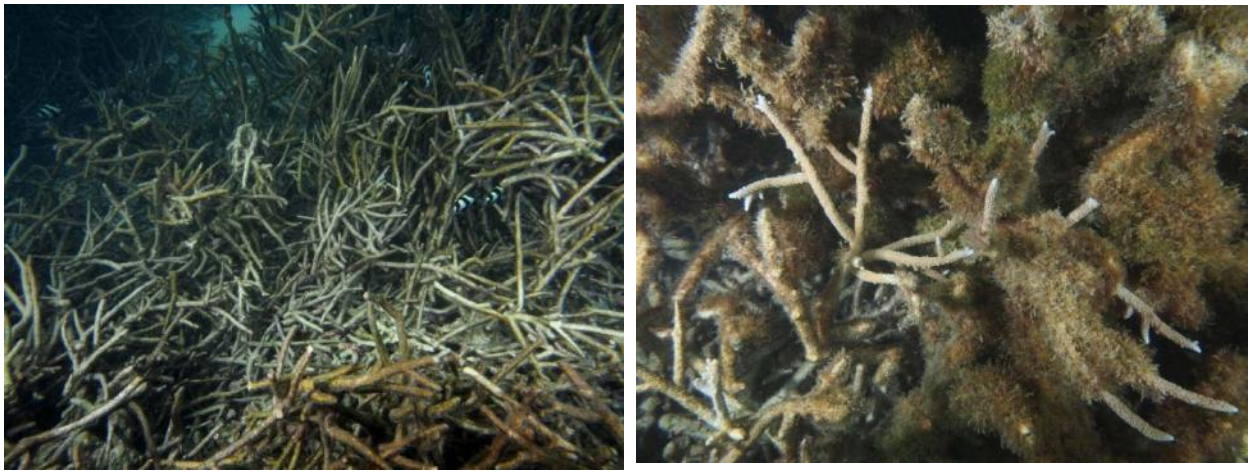

Fig. 20. Condition of staghorn coral populations at Veli water villas in August 2016. The general appearance of the stand is shown on the left. More than 99.8% of the population died. Many of the branches are still upright, in growth position but they are covered in algae and beginning to collapse. There was a notable increase in mat-forming cyanobacteria. There were also many areas where turtles and other animals had broken the coral skeletons apart in search of food. The right image shows living staghorn coral amongst a dense damselfish algal lawn.

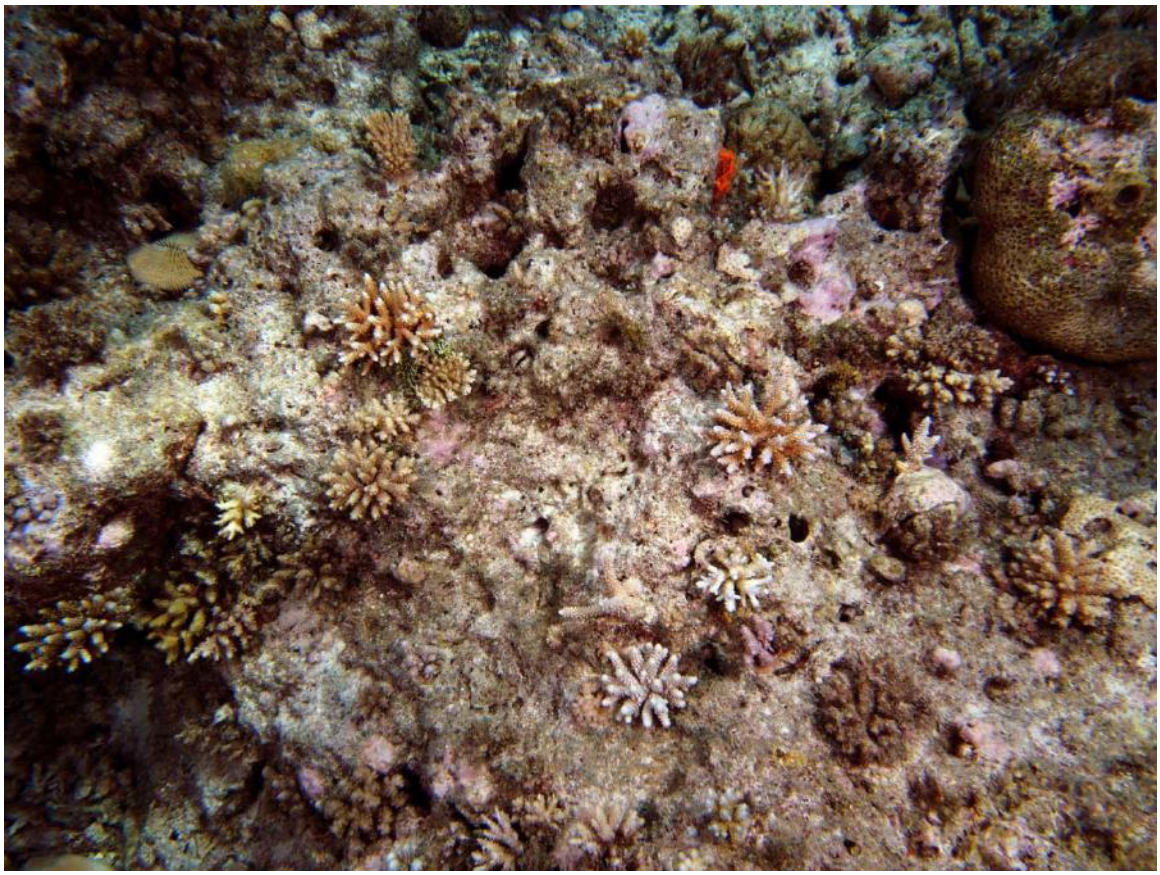

Fig. 21. One of the most unexpected surprises was the high number of surviving juvenile corals and recruits from 2015. This is a shallow reef terrace at Kuda Giri.

Coral reef clean-up

Crown of thorns starfish (COTS), which were rarely observed in April, 2016, reemerged as the water temperature cooled. The highest numbers of starfish were seen on the fore reef at Stage and in the lagoonal patch reef, Raaebundi. At Stage, over 90% of the P*ocillopora* and *Acropora* corals died, and the COTS were feeding primarily on surviving boulder corals such as *Hydnophora*, *Goniastrea* and *Platygyra*. On Raaebundi, 99% of the coral on the reef top and shallow slope was either consumed by COTS or died during the bleaching. On the deeper slope some remaining *Porites lobata, Porites rus, Pachyseris* and a few faviids remained; although these are not preferred food items, COTS were feeding on these taxa. Low numbers of COTS were also seen at Veli fore reef. These were primarily feeding on the shallow slope on the surviving pocilloporids and acroporids. Unusually four COTS were also collected from Veli lagoonal reef near the water villas and one was found on the sand at Dhigu near Aquafanatics.

Fig 22. Crown of thorns starfish feeding on *Pachyseris* at Raaebundi.

Two dives each were undertaken at Stage and Raaebundi to collect COTS. In total, 120 were removed from Stage and 135 from Raaebundi. COTS remain at both locations. Every COTS that occurred on Veli fore reef was removed.

Fig. 23. Crown of thorns starfish (COTS) removal. Kathryn Bimson removing COTS (top left). Kathryn is armed with a collection device (PVC bar) and goody bag containing COTS (bottom left). Kittipan is removing a COTS from under a boulder (center right). Very few preferred corals remained on reefs infested with COTS. Starfish were often seen feeding on the long-lived massive boulder corals such as *Porites* (bottom right).

On all reefs examined at Dhigu an abnormally high concentration of coral eating snails (*Drupella*) were seen on remaining branching, digitate and tabular corals (primarily *Acropora* and *Pocillopora*), with up to 150 snails seen on individual corals. While the total population of snails is unlikely to have increased, these snails are being concentrated on the few surviving corals as their food source has become limited. This is of major concern, as they are targeting those corals that did not bleach (the "super corals") and they are likely to have a major impact given the small number of survivors of these species. Snails were removed (1,928 total) in the vicinity of the coral nursery tables, mainly because it is likely that snails will seek out and kill the fragments we are propagating.

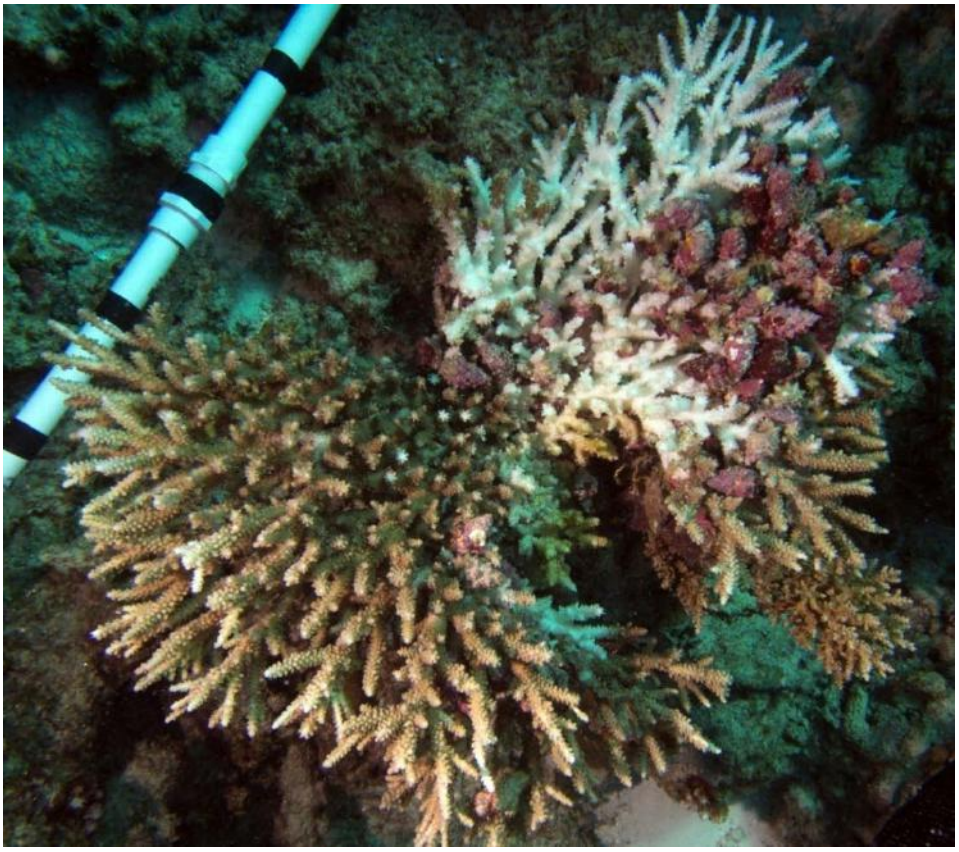

Fig. 24. A dense aggregation of coral eating snails on a tabular acroporid. The colony on the left is still alive; nearly 70% of the colony on the right has been eaten. Scale between black tape is 10 cm.

Fig. 25. A collection of snails removed from a single (20 cm diameter) colony of table coral (*Acropora hyacynthis*). Scale bar is 15 cm.

Coral Nurseries

Fig. 26. Location of monitoring stations and coral nursery sites. Five monitoring stations, five nurseries and one restoration site (Gulhifushi) have been established. Entire area is shown in top map and close-up of sites around Anantara are in the bottom map.

Our coral gardening efforts focused on four aspects: 1) evaluation of survival of fragments attached to "adopt a coral" rebar frames; 2) creation of coral restoration plot; 3) attachment of coral fragments to nursery tables in five locations; and 4) attachment of fragments to ropes suspended between pilings.

1. "Adopt a coral" frames

Over 99% of the corals that had been previously attached to rebar frames at both Kihavah and Dhigu died during the April/May bleaching event. At Kihavah, a few (<5%) surviving Pocillopora and Acropora colonies were seen on frames placed near Yellow Wall, adjacent to the dock and 1-2% of the Pocillopora colonies near the underwater restaurant *Sea* were still alive. Other corals all died.

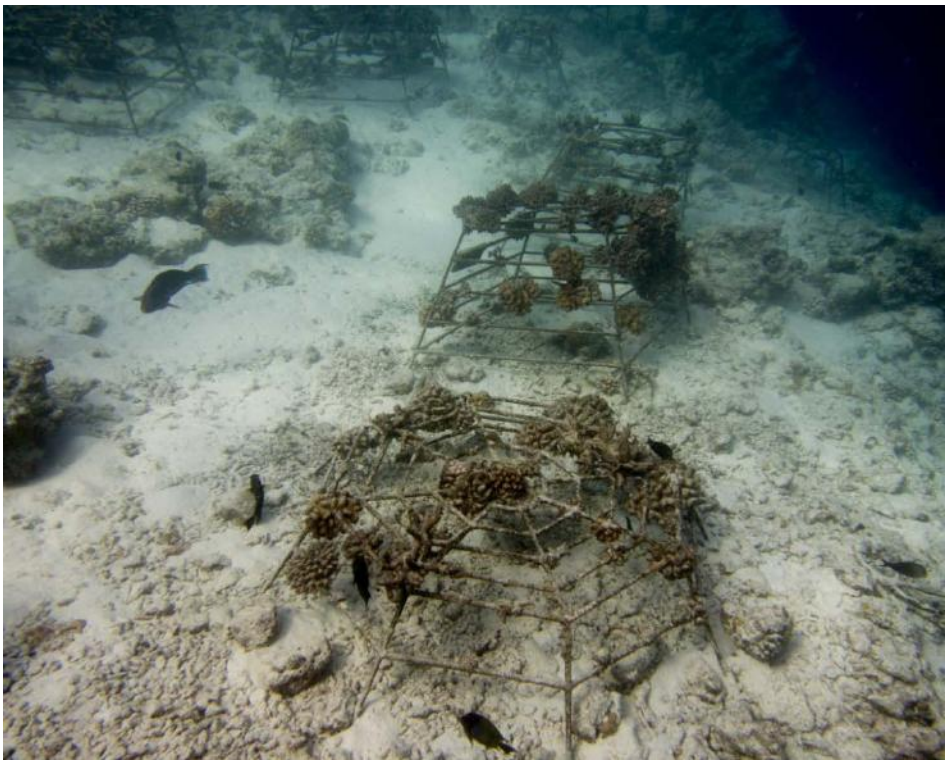

Fig. 27. A few *Pocillopora* colonies at Sea (underwater restaurant) survived the bleaching event. The frame in the foreground has 3 living corals and the rest are dead, algal covered skeletons.

Fig. 28. “Adopt a coral” frame deployed at Veli near the water villas. All of the corals placed onto frames at this site died.

One frame was established in July 2016 as a guest adoption program using broken, detached fragments of *Acropora* collected from the reef slope. These were reexamined on August 8, approximately 2 weeks after deployment. One fragment died from snail predation. Others were still living and had begun to attach to the metal frame. However, rust was noted and coral tissue adjacent to the rusted areas had died. Corals were also pale, possibly because these were collected at depths of 8-15 m and they were placed at 3-4 m depth.

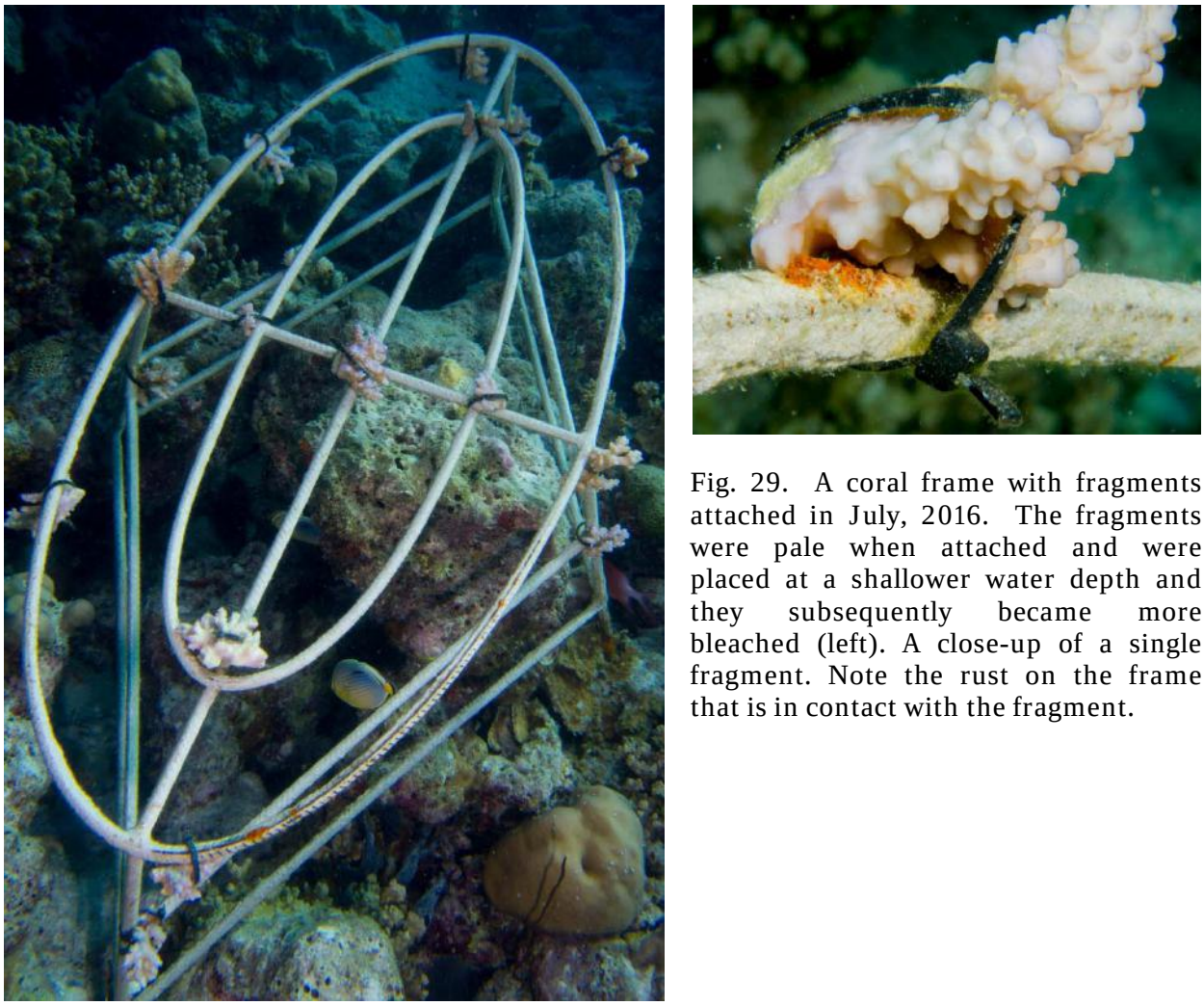

Fig. 29. A coral frame with fragments attached in July, 2016. The fragments were pale when attached and were placed at a shallower water depth and they subsequently became more bleached (left). A close-up of a single fragment. Note the rust on the frame that is in contact with the fragment.

In April, four "adopt a coral" frames with attached coral fragments were deployed at Guhlifushi (Snorkel Island) to determine survivorship of fragments during the peak water temperature. The fragments on three of the frames were attached by guest volunteers and one of the frames by reporters as a demonstration project. Fragments of two taxa (*Pocillopora* and *Acropora*) were collected from the surrounding reef terrace. All fragments had been broken by recreational snorkelers and were detached. The frames were separated into four different health categories: 1 containing fully bleached, 1 with pale yellow, one with fluorescent blue and 1 with light brown fragments. All of the light brown fragments survived, all bleached fragments died and 30-60% of the yellow/blue fragments survived.

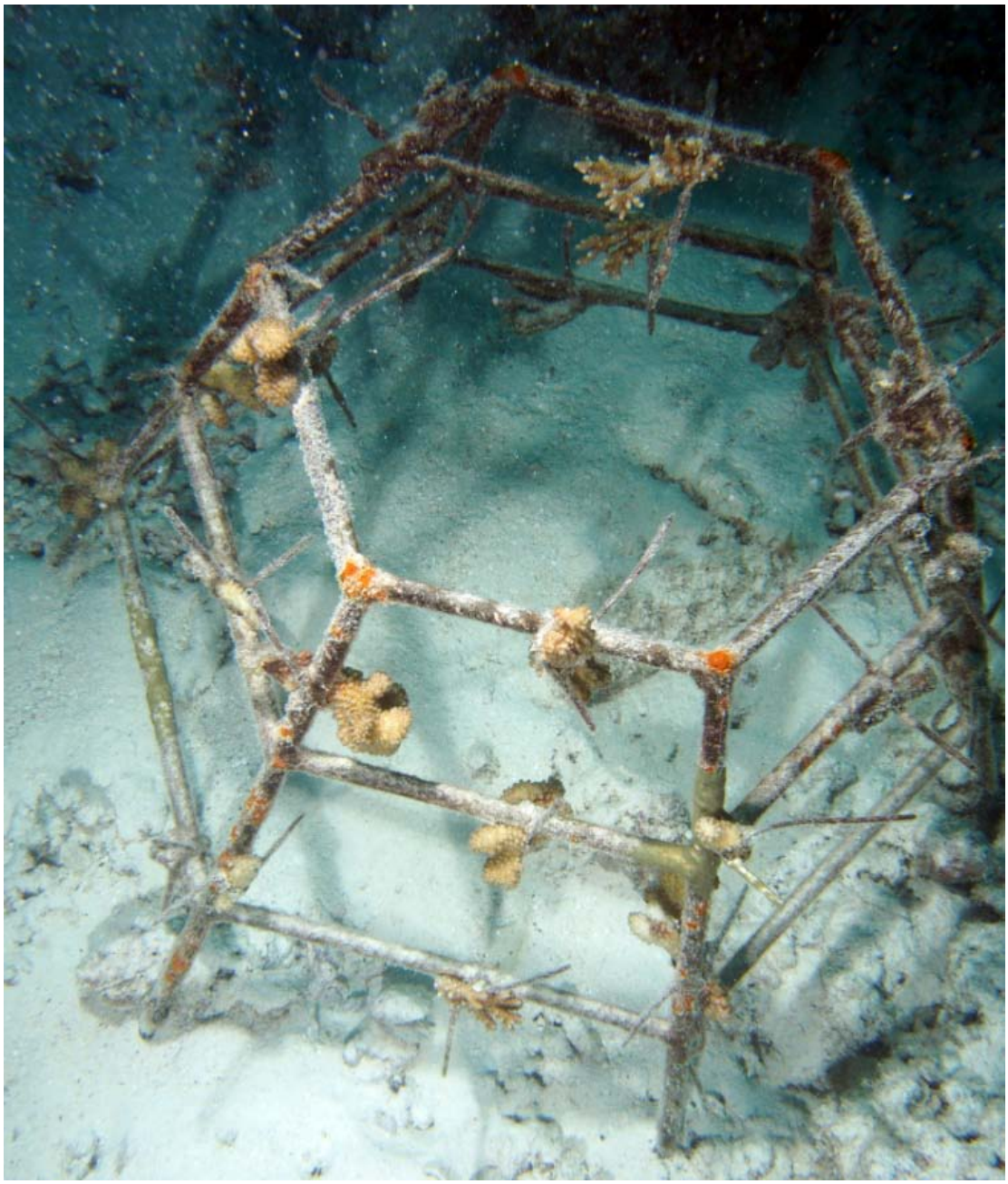

Fig. 30. “Adopt a coral” frame deployed at Gulhifushi on April 22, 2016. The coral are surviving, but each of the attachment points of the rebar is now rusting.

2. Restoration plots

A single 1 m x 1 m restoration plot was established with 25 fragments of staghorn coral at Gulhifushi adjacent to the edge of the slope. The fragments were attached to cement nails using cable ties. The nails were inserted into a large, dead coral head. All of the fragments were collected from three detached colonies that were found at the base of the reef slope. Fragments were pale when collected. The fragments were placed in much shallower water than where they were collected from.

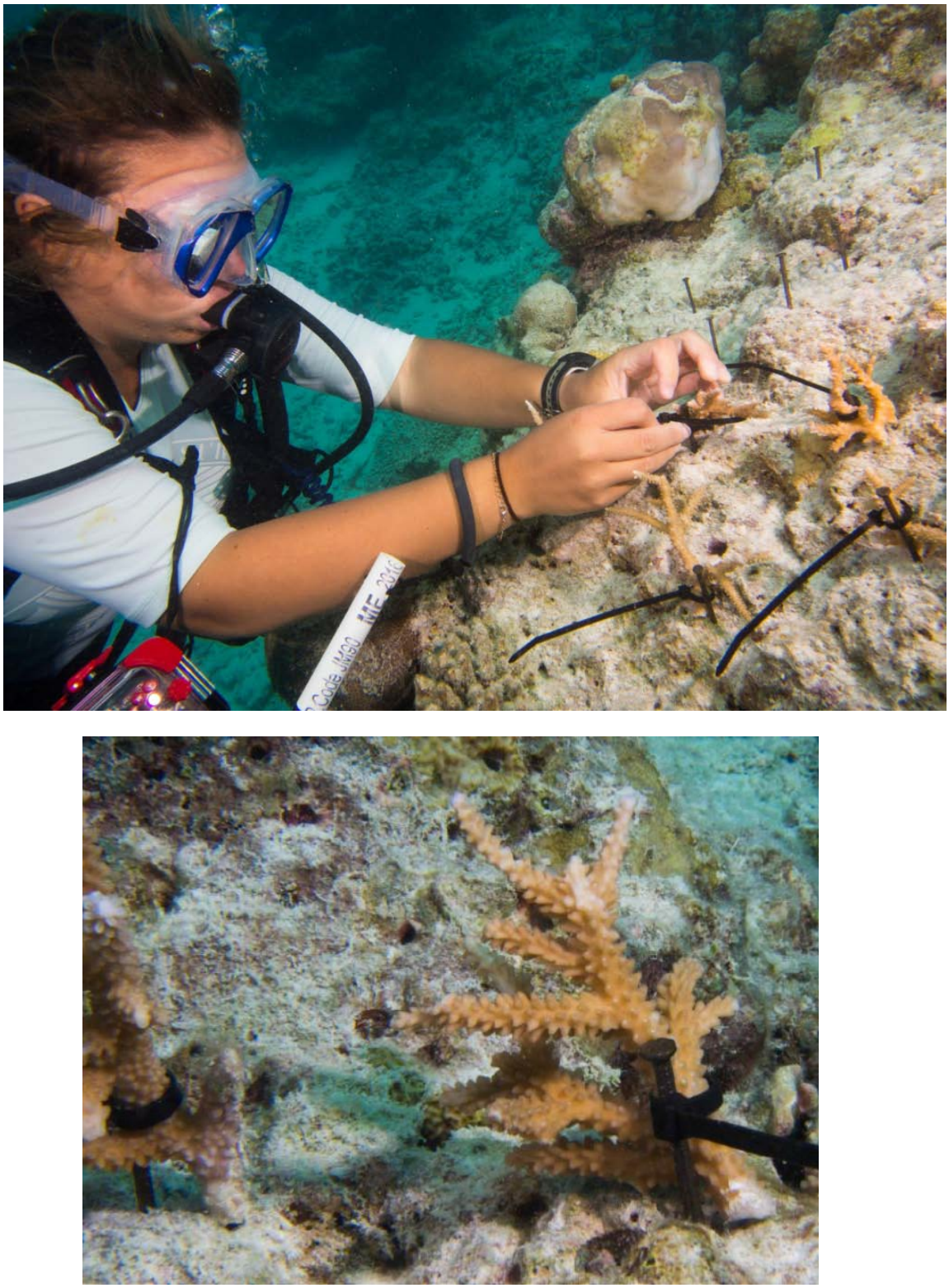

Fig. 31. Attaching fragments of staghorn coral to a denuded section of reef using cement nails and cable ties. Close-up of a single fragment.

3. Nursery tables

Nursery tables (two per site) were established at Veli fore reef (7 m depth), Naladhu/Marina fore reef (8 m depth), Dhigu house reef (6 m depth), and Kuda Giri. Approximately 100 fragments were attached to each frame. A single genera (*Acropora*) consisting of multiple species was used in each location. The fragments also include a very high genetic diversity as a maximum of 2-5 genetically identical fragments were attached. All corals were collected on the reef slope (depths that were deeper than the frames), except at Dhigu house reef. They consisted of colonies that had been broken and were unattached to the bottom. Many of these had patches of partial mortality due to sediment, algae and predation by coral-eating snails, but all were light brown or fully pigmented. Branches for use on the nursery tables were selected using coral clippers. We attempted to remove dead, exposed skeleton and all snails. Fragments were 2-8 cm in diameter when attached.

Fig. 32. A coral nursery table at Dhigu house reef with 100 coral fragments.

4. Coral ropes

We began efforts to rehabilitate the coral population near Veli water villas that sustained extremely high losses during the bleaching event. Our efforts were very limited because there were very few surviving corals. Nevertheless, we established 7 ropes with very small coral fragments (3-5 cm). Each rope contains 5-10 fragments depending on its length. Ropes were secured to pilings beneath the water villas, with one placed near the jetty. We also deployed two nursery tables, one near the jetty and a second adjacent to the villas on the north side, near the artificial island. These have 100 fragments on one, and 50 on the second table.

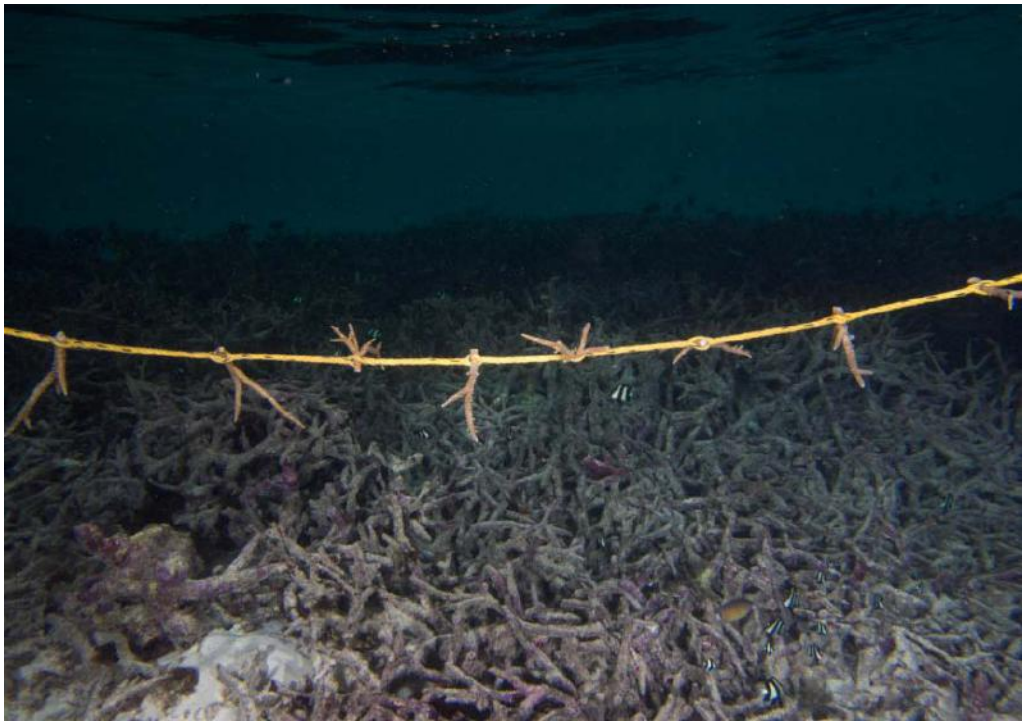

Fig. 33. Coral ropes. The top image shows a rope placed between the pilings above the dead staghorn coral thicket. The bottom image is a close-up of two fragments. Fragments were inserted into the rope by separating the braid.

Education and outreach

We conducted an interactive session in Malé City where approximately 85 high school students and 15 teachers from five schools attended. This session incorporated the importance of reefs, their uses, their threats (both natural and anthropogenic) and how they can be protected. Students were encouraged to answer questions throughout the seminar. This enabled us to gauge the level of knowledge amongst the students and areas where understanding is more limited. We were impressed by the level of awareness of reefs and their uses, however were surprised that approximately 80% of children had never seen a coral reef.

Several students and teachers expressed interest in participating in field-based conservation training. We aim to bring 8-10 students to Dhigu to assist in coral mariculture.

Fig. 34. At the end of our high school seminar, the environmental club unveiled their new logo in honor of Coral Reef CPR Director, Dr Andrew Bruckner.

During our research trip, two guest presentations were held in Dhigu where the HARP Program's goals, findings to date and future plans were discussed. Guests were encouraged to ask questions. We attended two guest cocktail evenings (1 at each resort) to promote the

partnership between Coral Reef CPR and Anantara Resorts, and the HARP Program. A staff presentation was held at Anantara Dhigu, where members from most resort departments attended, and a presentation specifically for villa hosts at Kihavah. It is important that resort staff are aware of the coral conservation efforts being undertaken at the resorts, as guests are likely to ask questions on the changing conditions of the surrounding reefs.

Table. 1 Presentation type, resort and number of people reached	
Presentation	**Audience reached**
High school students in Malé City	85 children; 10 teachers (5 schools)
Anantara Dhigu/Veli staff	30
Anantara Kihavah Villa Hosts	9
Anantara Dhigu guests (presentations and cocktail evening)	100
Anantara Kihavah guests (cocktail evening)	30

Recommendations

1. A large-scale effort to remove crown of thorns starfish from South Malé Atoll reefs is essential as these are feeding on the few remaining branching corals and they are now eating the long-lived massive corals. This could delay or prevent recovery of these reefs.

2. Increased efforts by resort/dive center staff and scientists to remove coral eating snails from branching corals. The snails are aggregating on the remaining branching corals that did not bleach. These are the most valuable corals for these reefs, as they are genetically superior and could provide offspring that can resist future El Niño and climate change-associated temperature perturbations.

3. Expansion of coral nurseries, with emphasis on coral ropes and tables using nylon and plastic ropes. Metal frames have drawbacks because they rust, and it is not possible to remove corals for use in reef restoration. Fragments used in nurseries should be those that are naturally broken, broken by diver/snorkeler contact and corals removed from areas where development, land reclamation or where dredging projects are undertaken. Promotion of this by Aquafanatics and Elements to guests to promote Anantara's conservation efforts, and to obtain guest adoptions of ropes etc.

4. A dedicated staff member is needed to maintain nurseries, including removal of snails and crown of thorns starfish from frames/corals, cleaning sediment from corals and removing algae. Nurseries need weekly maintenance to survive and thrive.