Post bleaching surveys of the northern and central atolls of the Maldives

Field Report

November 2016

Andrew Bruckner
Georgia Coward

CORAL REEF CPR
CONSERVATION · PROTECTION · RESTORATION

Section 1: Background

Coral Reef CPR has partnered with Carpe Diem Maldives Fleet to promote conservation of coral reefs in the Maldives in several different ways. First, we provide seminars and workshops to guests on board the safari vessels focusing on coral reef ecology, health threats and conservation options. The guests gain a new insight on the reef, understand what they are witnessing when diving, and are able to participate in the in water conservation actions.

Fig. 1. The Carpe Vita live-aboard boat

Our participation provides us with the opportunity to assess reef systems in remote parts of the country, where scientific data are lacking. Much of the vast coral reef system of the Maldives is yet to be scientifically assessed. Difficulties in reaching these disparate atolls have limited scientists, and as a result there are still no true estimates of coral, fish and other organism diversity, and the impact of the 2016 coral bleaching event is relatively unreported and understood.

Over two live-aboard trips to the northern and central atolls on the Carpe Vita (left), the Coral Reef CPR team have completed rapid assessments of nearly fifty reefs. The key to the future of the Maldives is that we also are able to undertake low-tech but highly meaningful actions to protect the reefs. Since 2013, many of the reefs in the Maldives have been badly damaged by a voracious coral predator, the crown of thorns starfish (COTS). When we encounter these animals, we remove them from the reef, maximizing the numbers that can be collected in a single dive with assistance of the Carpe Diem dive instructors and the visiting recreational divers. We are also able to assess impacts from the devastating 2016 mass coral bleaching event, identifying bleaching refuges and processes that enhance the recovery of the reefs.

Section 2: State of reefs – big and the small

Our main efforts target the coral community, as healthy corals are the keystone to the reefs and the organisms they support. They provide habitat, nursery areas, breeding refuge, feeding areas and shelter for motile invertebrates, reef fishes and turtles and many of the megafauna such as mantas, whale sharks, and reef sharks (juveniles), and they are visited by large pelagic fishes. During August, the summer monsoon

was in full swing, with winds, currents and waves bringing in nutrients that fuelled the growth of plankton, providing food for the manta rays and whale sharks. As a result, visibility was lower on the west side of the atolls, but this also brought in hundreds of manta rays and whale sharks.

Fig. 2. A reef manta ray gliding over a cleaning station in North Malé Atoll

The November trip took place during the calm period just before the winter monsoon, where winds, currents and waves come from the opposite direction, creating similar conditions on the east side of the atolls. During this period, we had spectacular viewing of manta cleaning stations on the west side of the country, as well as additional opportunities in other locations that are frequented by these majestic creatures during winter months.

Many of the reefs we examined are submerged pinnacles and thilas, some located within channels and others within the lagoon of an atoll. These deeper areas offer ideal viewing opportunities for reef sharks and rays, especially grey reef sharks, black tip sharks, and eagle rays.

Fig. 3 Thila at Rasdhoo Atoll

These sharks and rays were seen, often in very high numbers, on the side of the reef with the strongest currents, which was also where the largest schools of planktivorous fishes and pelagic species were found.

Fig. 4. A marbled ray (*Taeniurops meyeni*) sits on the seabed of a deep thila.

During November, we also had up-close experiences with leopard sharks, sting rays, white tip sharks and nurse sharks. Eagle rays and sting rays feed largely on small invertebrates, especially molluscs and crustaceans found on the bottom and in the sand.

Fig. 5. A common day octopus moving between rock crevices.

Nurse sharks and leopard sharks are bottom dwelling species and also eat invertebrates from the seabed, and some small fish. The nurse shark favours octopus, which were frequently seen moving across the reef, dramatically changing colour to camouflage into their environment.

The Maldives also has an unusually large population of hawksbill turtles. We observed feeding behaviour of these animals on multiple occasions. On some reefs they consume predominantly cnidarians - especially false corals (colonial corals without a hard skeleton) and zoanthids, while sponges are their preferred foods in other locations. We also dived one reef inhabited by dozens of green turtles and affectionately referred to as 'Turtle Airport'; most of these turtles were sleeping under ledges and in caves. These tend to rest on reefs that are adjacent to seagrass beds, which is their primary diet.

Fig. 6. Hawksbill turtle being cleaned (left) and a close-up of a green turtle (right).

Section 3: Atoll by atoll

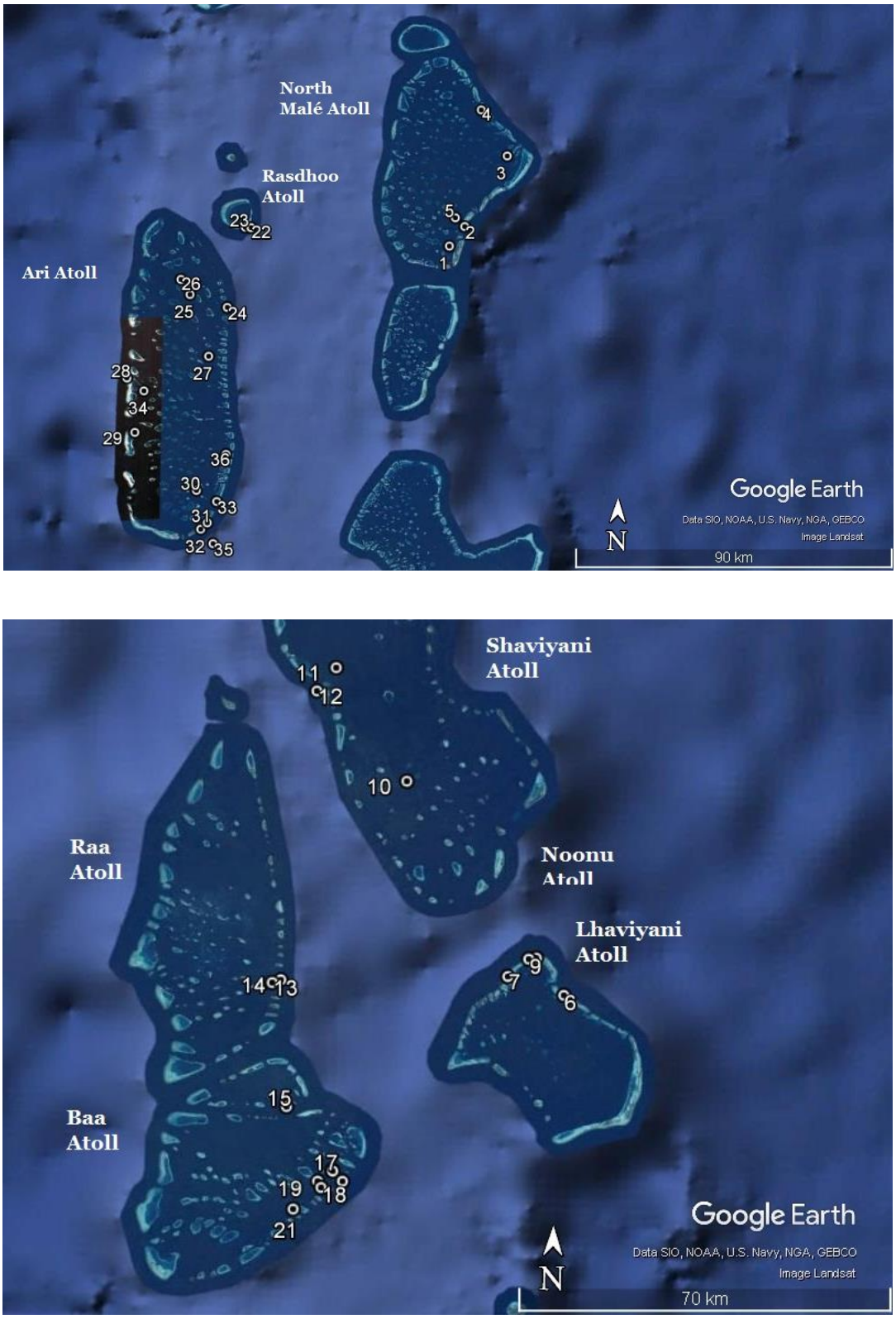

Fig. 7. Maps indicating the reefs dived by the Coral Reef CPR team. Top: Central Atolls. Bottom: Northern Atolls. Numbers correspond with the table.

Table 1. Dive site numbers, atoll and reef name for the 36 reefs scientifically assessed aboard Carpe Vita. Site number corresponds with maps in figure 4. Note additional reefs were dived but either co-ordinates could not be obtained or sites were not assessed.

Reef Name	Atoll Name	Site Number
Kurumba Faru	North Malé	1
Lankan Faru	North Malé	2
Asdhoo Rock	North Malé	3
Trixie Caves	North Malé	4
Sunlight Thila	North Malé	5
Fushi Faru Thila	Lhaviyani	6
Kalhi Fushi Kandu	Lhaviyani	7
Kuredhoo Express	Lhaviyani	8
Turtle Caves	Lhaviyani	9
Orimas Thila	Noonu	10
Komandhoo Thila	Shaviyani	11
Keekimini Out	Shaviyani	12
Kottefaru Thila	Raa	13
Kottefaru Wall	Raa	14
Yellow Wall	Baa	15
Kihaadhoo Faru	Baa	16
Kakaa Thila	Baa	17
Dharavandhoo Thila	Baa	18
Dhonfanu Thila	Baa	19
Hanifaru Beyru	Baa	20
Nelivaru Thila	Baa	21
Rasdhoo Blue	Rasdhoo	22
Rasdhoo Madivaru	Rasdhoo	23
Kan Thila	North Ari	24
Maaya Thila	North Ari	25
Hafsa Thila	North Ari	26
Fish Head	North Ari	27
Moofushi Rock	South Ari	28
Bulhaa Cave	South Ari	29
Machafushi Wreck	South Ari	30
Dhigu Beyru	South Ari	31
Lux Beyru	South Ari	32
Five Rocks	South Ari	33
Dhega Thila	South Ari	34
Dhigga Thila	South Ari	35
Camel Rock	South Ari	36

North Malé

Reefs examined on North Malé Atoll varied considerably in condition, depending on the severity of bleaching and whether they had been impacted by COTS. Most reefs have lost most of the branching and table corals, although scattered cauliflower corals (*Pocillopora*) and a few isolated patches of staghorn coral still remained, especially on Kurumba. Most notable were the high numbers of coral eating snails (*Drupella*) on the surviving acroporids and *Pocillopora* colonies. In general, boulder coral communities (*Porites*) were still in good shape, a positive sign as these are the longer living and slower living species. These included high cover areas at the edge of the reef flat and top of the reef slope (6-10 m depth), with some very large boulders and flattened thick shingle-like plates at the base of reefs, especially around manta ray cleaning stations.

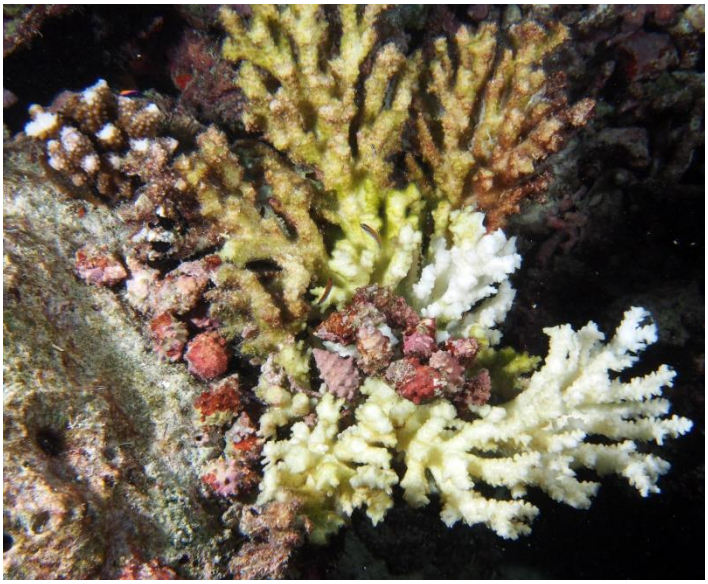

Fig. 8. Coral-eating snails (*Drupella*) *infest a branching acroporid.*

Many of the steeper slopes and vertical areas in high current locations had numerous large green tube coral "trees" (*Tubastrea*), along with black coral and soft corals.

Fig.9. A *Tubastrea micrantha* colony feeding at a site on North Malé Atoll.

Asdhoo Rock was very severely damaged, with 99% of the large boulder corals, all table corals, branching corals and most other species having been killed by crown of

thorns starfish. The only remaining corals on this reef were boulders and plates of *Goniopora lobata*, a sediment tolerant taxa that is not a preferred food source of COTS. A moderate density of COTS still occurred on this reef, with divers collecting over 50 starfish in August and November. The COTS were found feeding on *Goniopora lobata*.

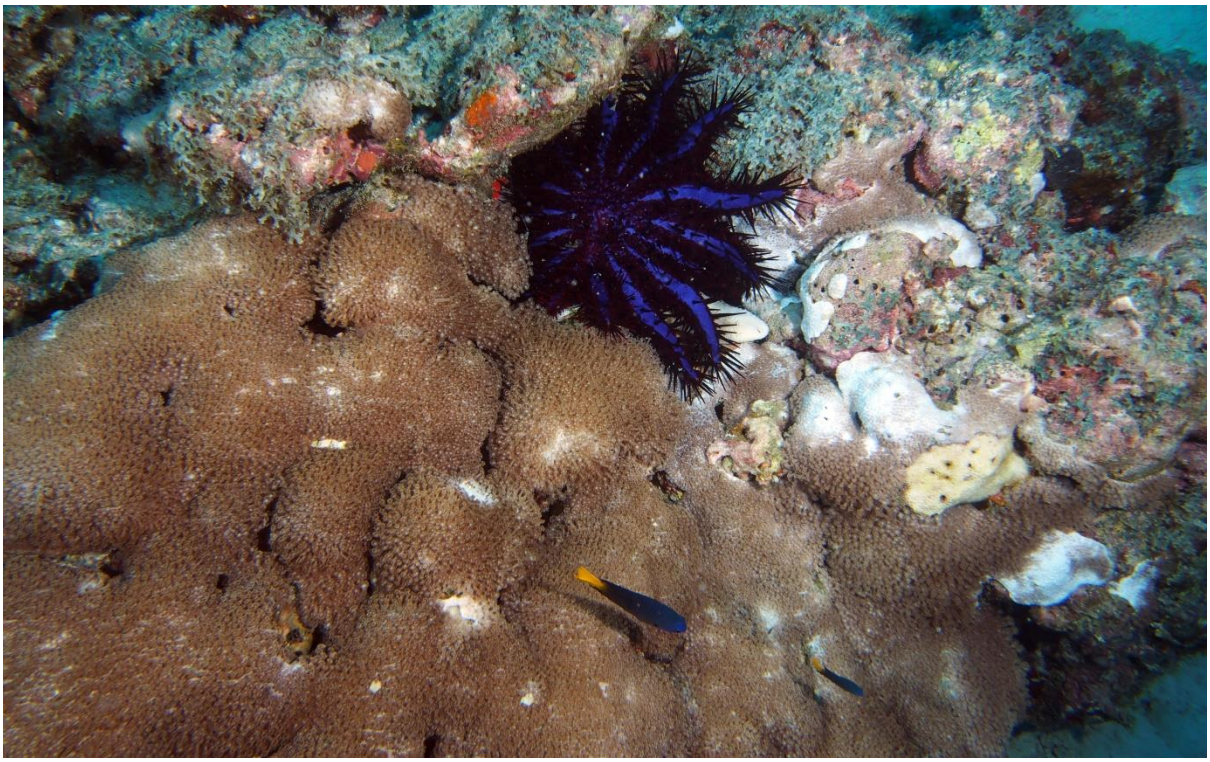

Fig.10. A large crown of thorns starfish (COTS) feeding on *Goniopora lobata* at Asdhoo Rock.

Lhaviyani

Both Kuredu Express and Kuredu Caves had a prominent community of small boulder corals, with some larger colonies, at the seaward edge of the reef terrace and top of the reef slope and a large number of *Tubastrea* colonies, soft corals, black coral, and patches of plating and encrusting corals on vertical surfaces, steep parts of the slope and overhangs. Very few branching and table corals had survived. Interspersed among the coral were numerous patches of rubble. Very few coral recruits were seen. The slope and top of the reef also had a high amount of filamentous and fleshy algae, as well as large populations of chubs, both of which suggest high nutrient input from the resort.

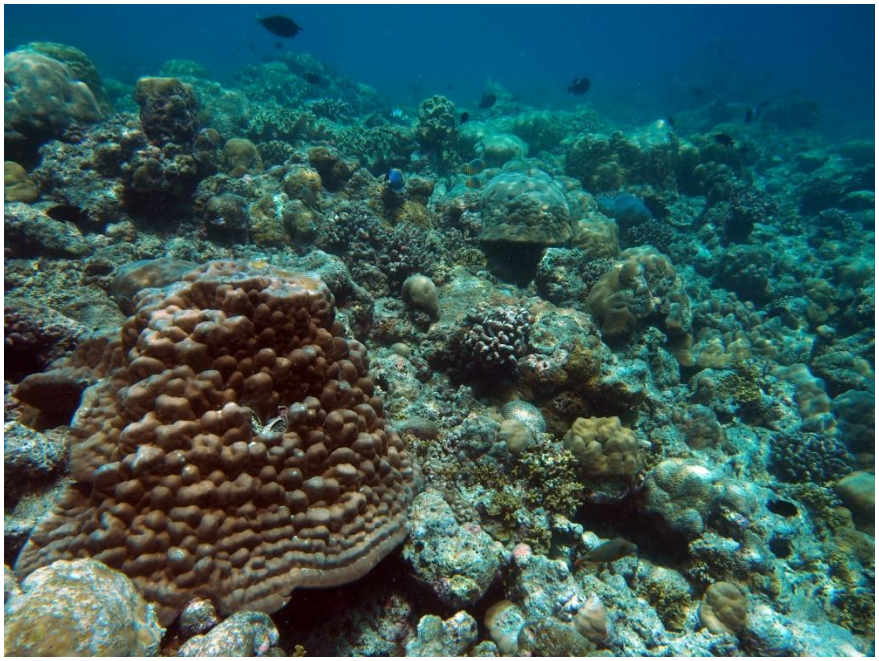

Fig. 11. Boulder corals (*Porites lobata*) at edge of slope

Both sites had healthy populations of green turtles that use these areas as a resting ground. An extensive seagrass bed is nearby, on the opposite side of the resort.

Noonu

We dove a single location in Noonu, Orimas Thila. This deeper patch reef had a relatively flat top, only a few meters above the surrounding sand terrace. The high current side had a prominent pelagic fish community with trevallies, snappers, and high numbers of grey reef shark, eagle rays, sting rays and leopard sharks, along with large schools of planktivorous fusiliers and anthias.

Fig. 12. A large grey reef shark at the cleaning station of Orimas Thila.

Most surviving corals were massive, submassive and plating species, with a lot of rubble and very little surviving Acropora. The site had high numbers of sea cucumbers, including an unusual translucent species (*Euapta*), mantis shrimp, octopus and sea urchins.

Shaviyani

Two sites were surveyed in Shaviyani, Komandhoo Thila and Keekimini Out. Neither of these reefs had very much living coral in shallow water. There was a considerable amount of coral rubble, interspersed among the few remaining boulder corals (*Porites*) at the edge of reef slope. The deeper part of the reef slope had much more surviving coral, most of which were small colonies. These included Acropora, *Pocillopora*, as well as many more unusual taxa including bubble coral (*Plerogyra* and *Physogyra*), anchor coral (*Euphyllia*), *Galaxea*, and volcano coral (*Hydnophora*). The slope also had some dense patches of black coral, sea fans, anemones and soft corals. The slope also had a fairly healthy population of new recruits (baby corals) and juvenile corals, suggesting it is undergoing recovery.

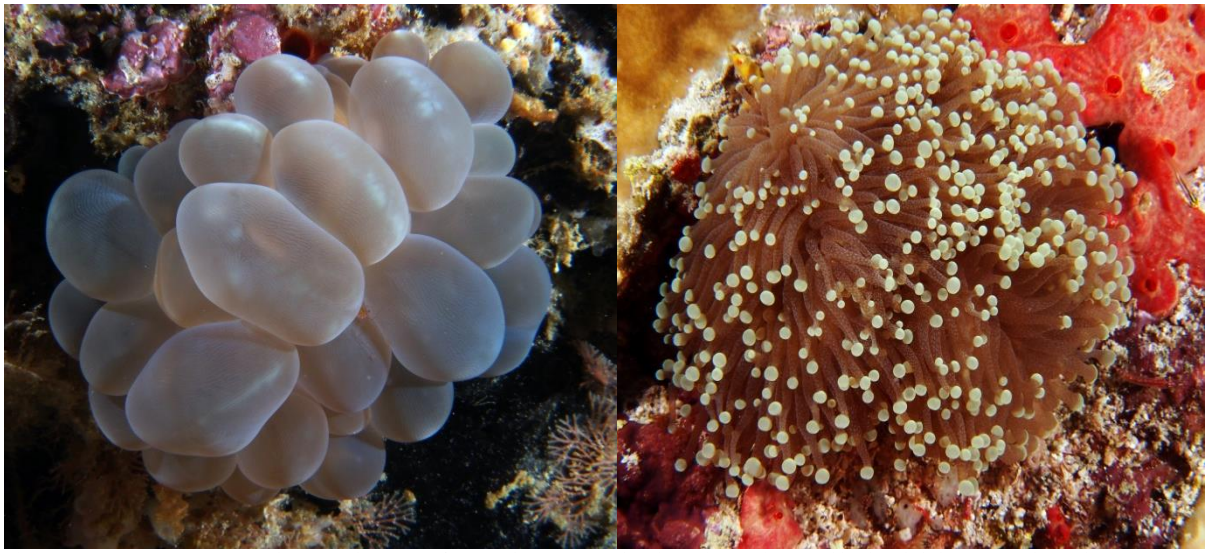

Fig. 13. Two unusual coral taxa found around Shaviyani Atoll- bubble coral (*Plerogyra sinuosa*; left) and anchor coral (*Euphyllia glabrescens*; right).

Raa

Two reefs near Kottefaru were examined, a wall and a submerged thila. These had prominent remaining stands of boulder corals and other massive corals on the reef terrace, but many of them had lost large patches of tissue and were now covered in algae. There were virtually no branching or table corals remaining. Coral quickly declined on the slope, becoming a hard bottom terrace with occasional gorgonians and tube coral trees with a lot of algae.

Fig. 14. Recovery of the reefs in the Maldives is dependent on large populations of herbivores to control the algae, such as the convict tangs.

Baa

Baa Atoll is a biosphere reserve that was established to protect large populations of manta rays that feed in the vicinity. Known best for Hanifaru Bay, this site is a shallow sandy lagoon frequented by 100s of mantas during certain periods. Mantas can also be seen on adjacent reefs when not feeding, as their cleaning stations are located throughout the surrounding area.

Most of the reefs in Baa Atoll now have very little branching and table corals, as these died in April/May. However, outer sites still have flourishing boulder coral communities (primarily *Porites*). Of note is Yellow Wall, near Anantara Kihavah Resort. This wall has a very dense population of soft corals (*Dendronepthya*) including the largest population of the yellow soft coral found in the Maldives. There are also many other species of anemones, sponges, orange tube coral, and small encrusting and branching stony corals on the wall. The base of the reef also provided refuge from bleaching and still contains numerous branching and table acroporids.

Fig. 15. The vibrant yellow soft coral, *Dendronepthya* spp. that gives 'Yellow Wall' its name.

Another unusual submerged thila, Nemo City, is named for the hundreds of sea anemones (only a few have anemonefish) on the top of the terrace. These were completely bleached in August but have now recovered. Interspersed among these were large table corals, some 3-4 m diameter. Most died during the bleaching event, and the remaining colonies were diseased and being preyed on by large numbers of Drupella. The edge of the terrace, and the top part of the slope still had very high coral cover dominated by small branching and table corals (*Acropora*), most in good shape. This area also had very high numbers of newly settled corals.

Fig. 16. An endemic Maldivian anemonefish.

Rasdhoo

Rasdhoo Madivaru is a double reef system located at the western end of the atoll, near the channel. This reef system has a diverse and abundant reef fish community with large numbers of pelagic species, reef sharks, eagle rays and other megafauna.

The shallow reef top has dense, healthy stands of boulder coral (*Porites*) and a very diverse reef slope with surviving stands of staghorn coral, foliaceous corals, digitate corals and branching corals. The strong currents, tidal flow near the channel, and nutrient rich waters transported dot the reef during the summer monsoon kept the area cooler during the 2016 El Niño, enhancing survival of the corals.

Ari

While many reefs have been badly damaged by COTS, this region exhibits unusually high resilience, having resisted full impacts of the 2016 bleaching event. It is one of the few locations where flourishing stands of acroporids remain. These corals, formerly the dominant species on Maldivian reefs, sustained 80-98% mortality in other locations.

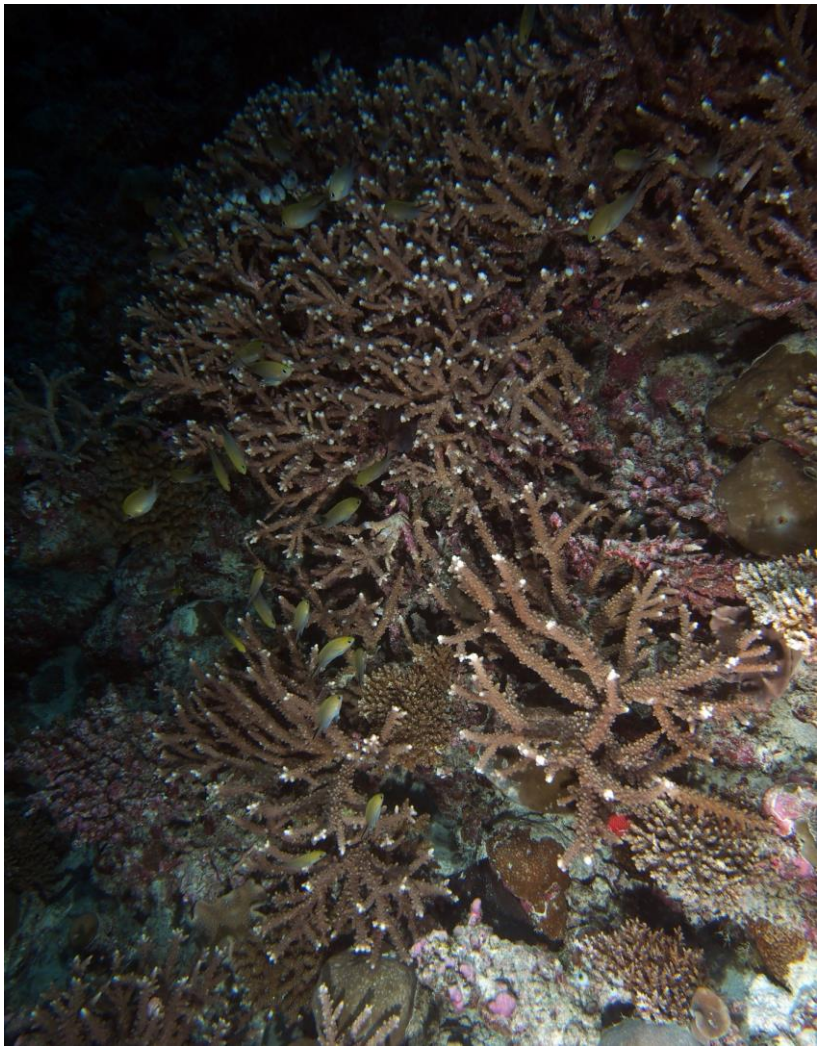

Fig. 17. An example of a flourishing stand of branching acroporids found throughout Ari Atoll.

Dhigu Beyru and Lux Beyru, located on the eastern end of South Ari in an area frequented by whale sharks, form part of a long barrier reef system on the outside of the atoll that is exposed to strong currents and nutrient input during the summer monsoons. This site was an important bleaching refuge with some of the best survival of branching and table acroporids in the region. While much of the coral on the reef terrace died from the 2016 bleaching, numerous large tables, staghorn coral thickets and digitate acroporids were surviving on the reef slope. These corals were intermixed with a very high diversity of boulder corals, encrusting and plating corals and other branching coral species.

Section 4: Crown of thorns starfish removals

Crown of thorns starfish (COTS) are a normal inhabitant of reefs in the Indian Ocean, Pacific Ocean and Red Sea, but they typically occur at very low densities. Beginning in 2013, these starfish underwent a population explosion, with tens of thousands emerging on reefs on the west side of North Malé Atoll, near Reethi Rah Island. They slowly radiated outward, and by May 2015 outbreaks were reported throughout North Malé Atoll and Ari Atoll. Over the last year and a half, they have continued to expand their range as food became scarce, and now have been reported throughout South Malé, Lhaviyani, Shaviyani and Dhaalu Atolls, amongst others. Since the beginning of the outbreak, several hundred thousand animals have been removed from the Maldives, but they are still a severe threat and this threat needs to be combated.

COTS consume a large amount of coral. Each animal will consume an entire coral each day and 6-10 m^2 of reef per year. This is more of a concern now, as much of the coral throughout the country died during May due to the devastating mass bleaching event, and the few corals that remain are the strongest colonies that are key to the recovery of Maldivian reefs.

Fig. 18. A COTS feeding on two *Acropora* colonies.

During each dive, we remove any COTS we find. These are placed into mesh goody bags, brought onto the dive vessel and transported to shore, where they are buried. We identified small outbreaks of COTS on three reefs during the November trip, removing 199 starfish in total.

Fig. 19. One of the divers aboard Carpe Vita assisting us in a big COTS removal

Section 5: Education on board

Every day the Coral Reef CPR team conducted a seminar for the guests on a new marine topic. We taught this enthusiastic audience a wide range of subjects; from coral ecology, to the reef's smallest critters, to coral bleaching to manta rays. There was always plenty of time for questions and discussion amongst the divers. These educational sessions left the guests with a new perspective and understanding on coral reefs, their importance, their inhabitants and conservation actions. At the end of the trip we held a fun, interactive quiz that covered the different topics. Everyone joined in and it was amazing how much these divers had retained over the course of the live-aboard.

Section 6: Next steps

Our team will continue to join Carpe Diem live-aboard trips throughout the Maldives over the course of 2017. These trips are invaluable to us from both a research perspective, but also at teaching an audience with an avid interest in the ocean and coral reefs. We thank the team at Carpe Diem Maldives Fleet, in particular Agnes van Linden for their support and incredible partnership with us.

In May 2017, we are planning a week long live-aboard to conduct a wide scale crown of thorns starfish removal effort throughout the Maldives. We are aiming to target atolls and reefs with a high density of COTS, and to remove these localised outbreaks. You can join this trip and help us to protect Maldivian reefs- find out more by visiting www.carpediemmaldives.com

For more information on the conservation efforts of Coral Reef CPR please visit www.coralreefcpr.org and follow us on Facebook (Coral Reef CPR).