

**Rescue a Reef  
*Culcita* Removal Trip**

**Field Report  
Oct 20-29, 2017**



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## ACKNOWLEDGEMENTS

This trip would not have been possible without the dedication and hard work from all of the recreational divers that participated. We are extremely grateful for their time, effort, enthusiasm and endless amounts of fun during the expedition. A special thank you to the repeat divers –we are so appreciative and excited that you were able to join us for another ‘Rescue a Reef’ mission. We would also like to offer a huge thank you to the hard-working team aboard Carpe Vita. Thank you to the Ministry of Fisheries and Marine Research Centre for their ongoing support. Finally, thank you to Carpe Diem Pvt. Ltd., for their support.



## EXECUTIVE SUMMARY

Coral Reef CPR, in partnership with Carpe Diem Maldives Pvt. conducted a “Rescue a Reef” Program on board the Carpe Vita which focused on the removal of *Culcita schmideliana* (cushion starfish, *kashi boa*) sea stars from heavily infested reefs. With the assistance of 13 recreational divers from around the world, and four dive instructors we collected 2,678 *Culcita* from six different reef systems in Raa and Baa Atolls. We searched for starfish over a total area of 48,500 m<sup>2</sup>, extending from the reef flat to 25 m depth. Over the week long mission, we covered the entire Huruvalhi Reef System, including the reef flat, reef crest and reef slope (total area = 36.9 HA).

Most cushion starfish removed during the trip were from Huruvalhi Island, Raa Atoll (n=2209). Cushion stars occurred throughout all habitats at a mean density of 5.9 starfish per 100 m<sup>2</sup>, with the highest density ( $11.2 \pm 1.3$  per 100 m<sup>2</sup>; mean  $\pm$  SE) on the seaward edge of the reef flat and the reef crest (1-5 m depth). In previous studies, normal densities have been reported to range from 0-5-2 starfish per 500 m<sup>2</sup>. Numbers observed here were 20-30 x higher.

Interestingly over 99% of the starfish were represented by a single age class, with maximum diameters of 15-18 cm (78%). The smallest cushion star collected was 12.5 cm and the largest was 20.8 cm.

Most (65%) *Culcita* were observed actively feeding on coral or adjacent to a recently killed coral. They fed on 14 genera, most of which were small (1-8 cm diameter) and low relief, with the greatest preference for *Pocillopora* (44%) and *Acropora* (24.4%). They also ate larger corals, but because they are unable to wrap their bodies around these corals they tend to feed on branches located on the colony margin. The preferred taxa consumed by these starfish are the same corals that sustained the highest mortality during the 2016 mass coral bleaching, and large colonies of these species are currently rare. A low number of coral larvae (5-10 per 30 m<sup>2</sup>) had settled in shallow habitats and these were starting to show prominent growth, but a high proportion of them were being eaten. Given the abnormal number of cushion starfish, the high numbers of juvenile corals they eat on a daily basis and the relative scarcity of newly settled corals it is likely that chronic predation by *Culcita* could delay the recovery of Maldivian reefs damaged by bleaching in 2016.

The successful removal effort undertaken during the “Dive with a Purpose –Cushion Starfish Removal Week” could never have been accomplished without the assistance of the team of recreational divers. As the starfish are more spread out than crown of thorns, it was critical to have a large team to allow us to cover different depths throughout the same reef system. One key lesson from this effort, however, is that a thorough removal requires a second swim through an area, as the cushion stars are cryptic and easily missed. In the three weeks following the team effort, we have continued searching for the starfish and have so far removed another 350 cushion starfish from this reef system and hundreds remain on the shallow reef flat.

## BACKGROUND

*Culcita* spp. sea stars are influential corallivores that may affect the abundance and community structure of corals on Indo-Pacific reefs. *Culcita* have a preference for small, low-relief scleractinian corals, although they also feed on sponges, tunicates, algae and other encrusting organisms. Like *Acanthaster*, the starfish climb on top of corals and evert their stomachs over the corals, releasing digestive enzymes to dissolve the coral tissue. Because they lack long prehensile arms and have smaller stomachs than *Acanthaster*, they are unable to consume large corals.

In Hawaii, individual *Culcita* consumed up to 1 m<sup>2</sup> coral per year (28 cm<sup>2</sup> day<sup>-1</sup>). Their preference for small colonies (3-8 cm) of *Pocillopora* and *Acropora* suggests they may have a significant selective impact on coral composition.

Although densities of *Culcita* tend to be fairly low ( $\leq 1$  per 200 m<sup>2</sup>), their populations have been reported to fluctuate (Quinn and Kojis 2003; Pratchett et al. 2011). Populations are generally controlled during their early life phases, especially while in the plankton, due to the high number of planktivorous fishes. In contrast, there are few animals that will feed on adult *Culcita*, due to their tough calcified skeleton and presence of spicules and small spines. Certain generalist echinoderm feeders, such as triggerfish and trumpet triton gastropods will eat adults, but these eat too few animals to control populations.



**Fig. 1. A trumpet triton (*Charonia*) eating a cushion star.**

In the Maldives, we have observed heavily infested reefs, at densities that have not been previously reported. The abundances we found are not natural. While this density of starfish would not be a concern if the reefs were healthy, with high living cover as observed prior to the 2016 bleaching event, they are of serious concern given the current state of the reef.

As one component of Coral Reef CPRs work to halt the degradation of reefs in the Maldives and facilitate recovery from bleaching, we are removing coral predators from reefs where they are at an unnatural abundance. The three key predators affecting reefs here are crown of thorns starfish (*Acanthaster* spp.), coral eating snails (*Drupella* spp.), and cushion starfish (*Culcita* spp.). To date, we have removed over 600 starfish from a single reef system in Baa Atoll, and have observed a substantial increase in survival of newly settled and juvenile acroporid and pocilloporid corals. However, due to the considerable amount of time required to effectively control these species, we have never been able to conduct a complete removal from a reef system. The current effort was undertaken to determine whether the use of recreational divers could facilitate the removal, and whether it is possible to completely eradicate these destructive animals from a site experiencing an outbreak.



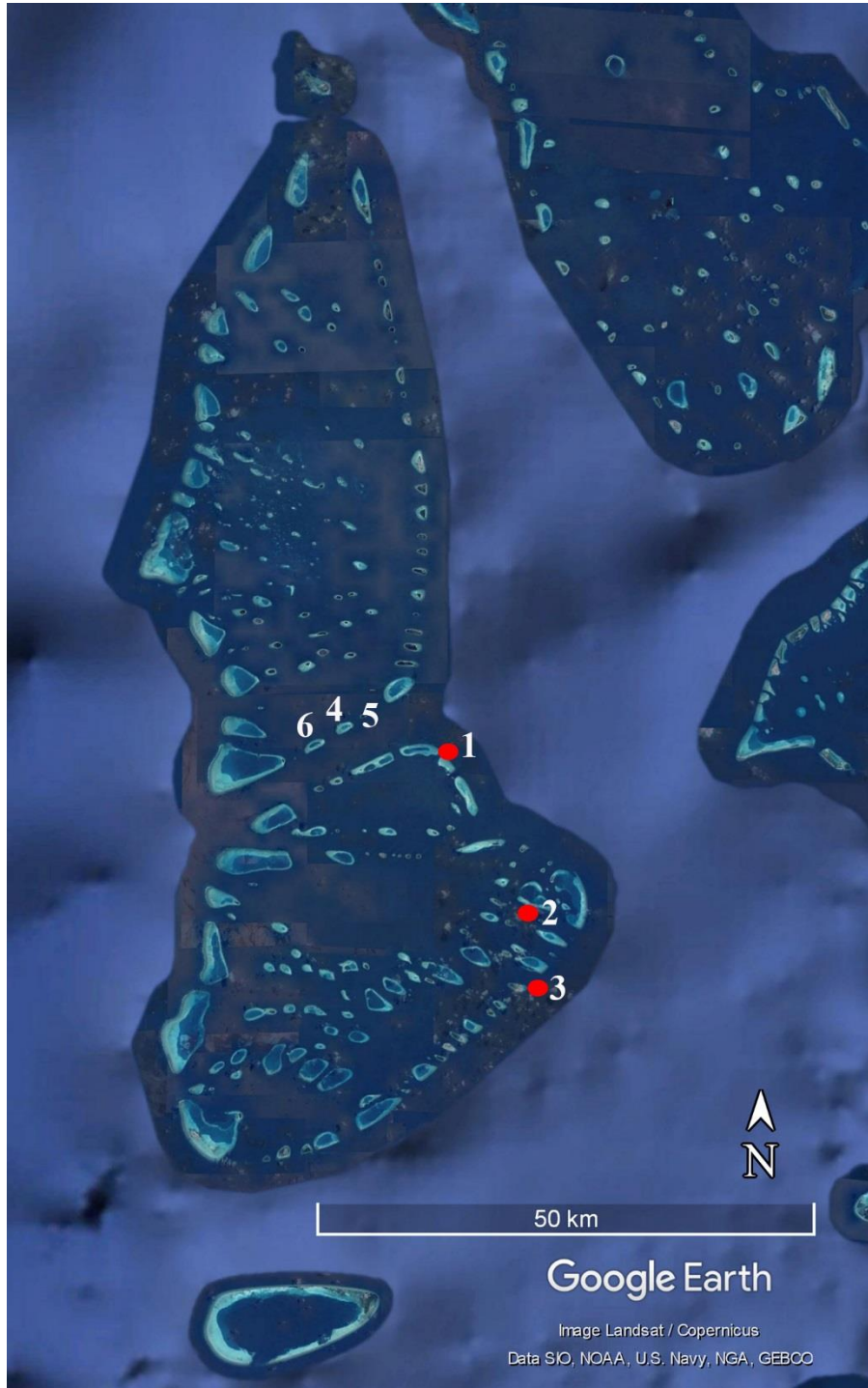
**Fig 2. Oral side of a cushion star that was feeding on the Pocillopora to the right. Although they lack typical legs seen in other starfish, they have a pentamorous (five part) symmetry characteristic of echinoderms. Within each of the grooves are rows of tube feet used for locomotion and attachment to substrates.**

## METHODS

All removal efforts were conducted from the Carpe Vita *dhoni* using SCUBA and snorkeling. Each buddy team was responsible for a specific depth range, with teams distributed from the reef flat to the base of the reef at 25-30 m. A higher number of divers worked the shallow areas, as this was considerably wider and contained more starfish. Each buddy team carried one to two large green mesh bag as they swam along

the reef carefully searching for cushion starfish. Each bag was filled with 25-40 starfish, carried back to the *dhoni*, emptied, counted and measured.

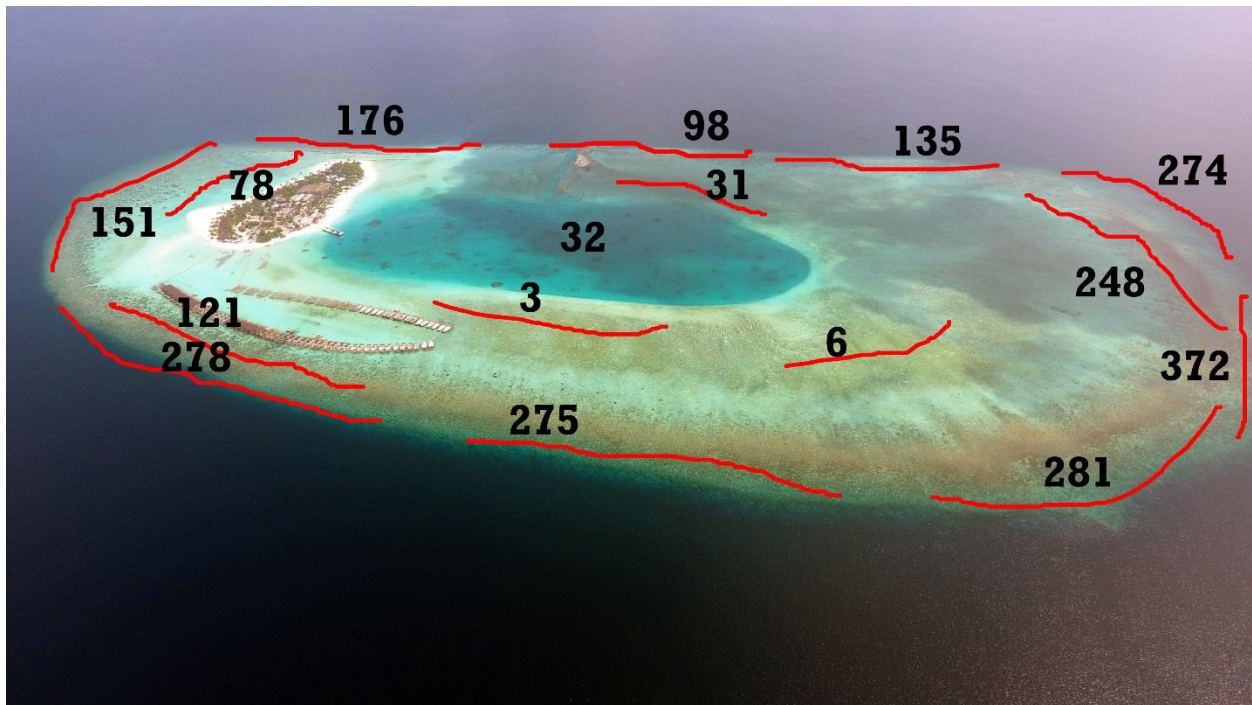
Six different reef systems were examined, including three in Baa Atoll and three neighboring reefs on Raa Atoll. In five of the six locations a single dive was undertaken. Five full days was spent collecting cushion stars from Huruvalhi Island, with surveys undertaken over the entire reef system.



**Fig 3. Locations targeted by the *Rescue a Reef-Cushion Star Removal Team* during October 2017.**

## Findings

We recorded the number of *Culcita* collected per unit area, separating our collection effort into specific depths/zones of the reef. Starfish were found in all habitats and depths, to 30 m depth. They occurred in rubble flats, sandy areas and coral dominated habitats. In general, the highest densities were found at the seaward edge of the reef flat and reef slope from 1-5 m depth (up to 19 per 100 square meters), with densities decreasing with depth. The densities also were highest in low relief rubble and hardground areas with the highest number of juvenile corals, with fewer starfish in high relief *Porites* dominated areas.



**Fig 4.** Number of *Culcita* collected from different sections of the Huruvalhi reef system.



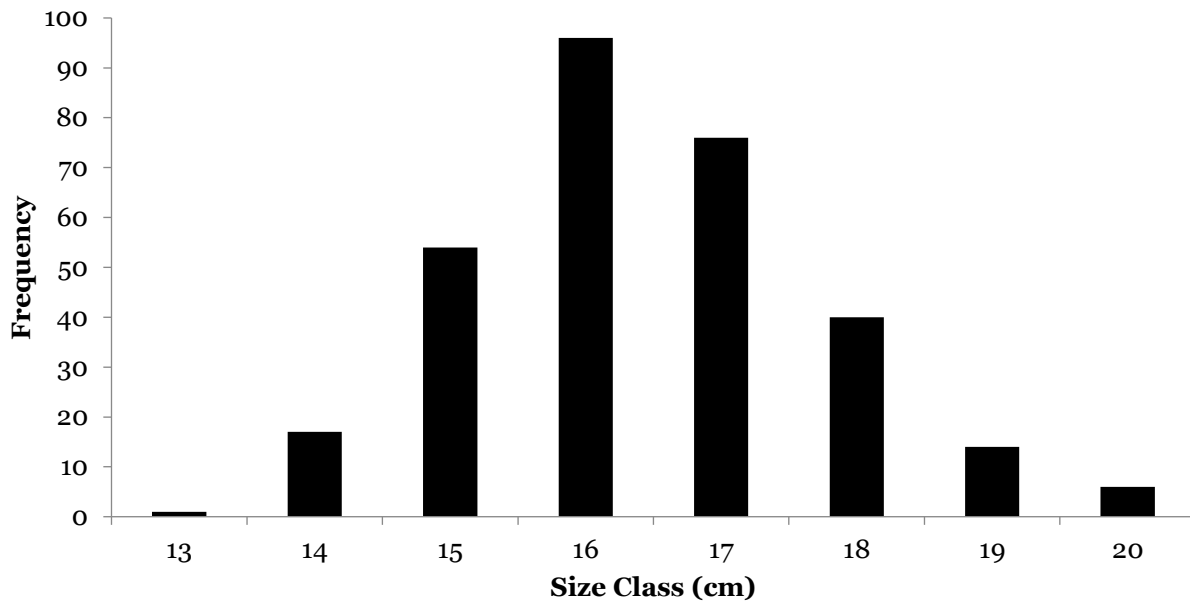
**Fig 5. A typical pile of starfish collected on a single dive.**

The sizes of starfish were very uniform, with most between 15-18 cm. Juvenile *Culcita* were not found, even during a night dive. The uniform size class suggests that these are all the same age, having recruited to the reef during a single event.





**Fig 6. Three different sized *Culcita*. The cushion starfish on the left is 19 cm. The smallest starfish found on Raa Atoll was 13 cm (middle starfish) and the smallest starfish collected to date (from Baa Atoll, right) was 9 cm.**



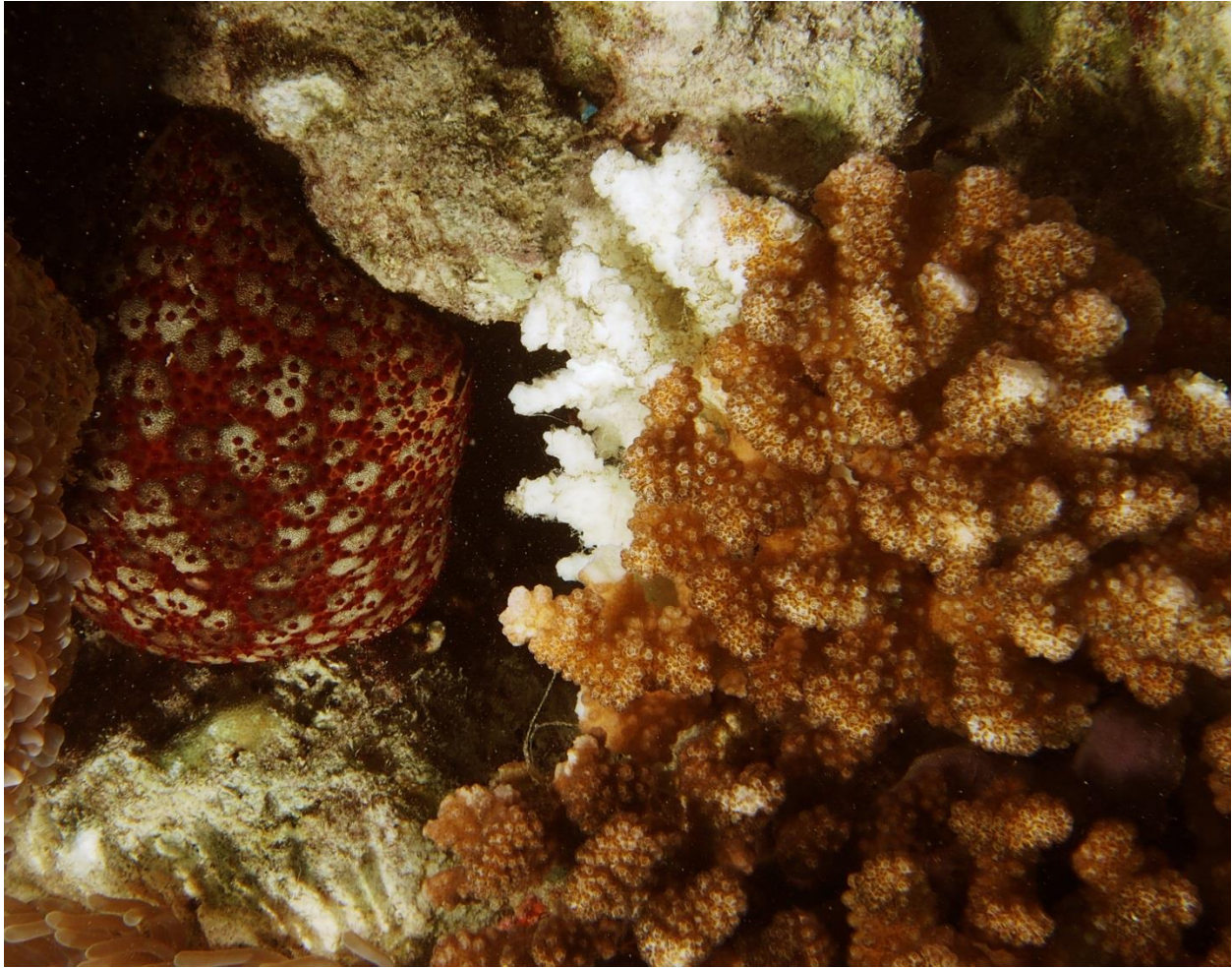
**Fig 7. Size structure of *Culcita* collected from Raa Atoll.**

Most starfish were located by finding white, recently eaten corals and only a small percentage were actively feeding when collected. In general, the starfish were within one meter of a recently eaten coral, and there was often a track of white skeletons, indicating the corals that they had eaten on previous days. They fed most frequently on low-relief corals, less than 10 cm diameter.



**Fig 8. A single *Culcita* and three corals it consumed, a *Favites*, *Pocillopora* and digitate *Acropora***

They also ate larger corals (mostly *Pocillopora*), but they tended to eat only the branches at the perimeter of the coral. The starfish would crawl up onto large coral heads, including colonies that were several meters tall, to consume the newly settled and juvenile corals that had settled on patches of dead skeleton.



**Fig 9. A large *Pocillopora* that has been partially eaten by *Culcita* (the white is recently eaten coral).**

They were also seen on vertical surfaces and under coral, and often were wedged into crevices and under ledges. In rubble fields they were also found feeding on coralline algae and *Palythoa* colonial anemones.



**Fig. 10. *Culcita* were seen in sandy areas and rubble fields at Huruvalhi.**



**Fig 11. A cushion star hidden in a crevice on the reef slope.**

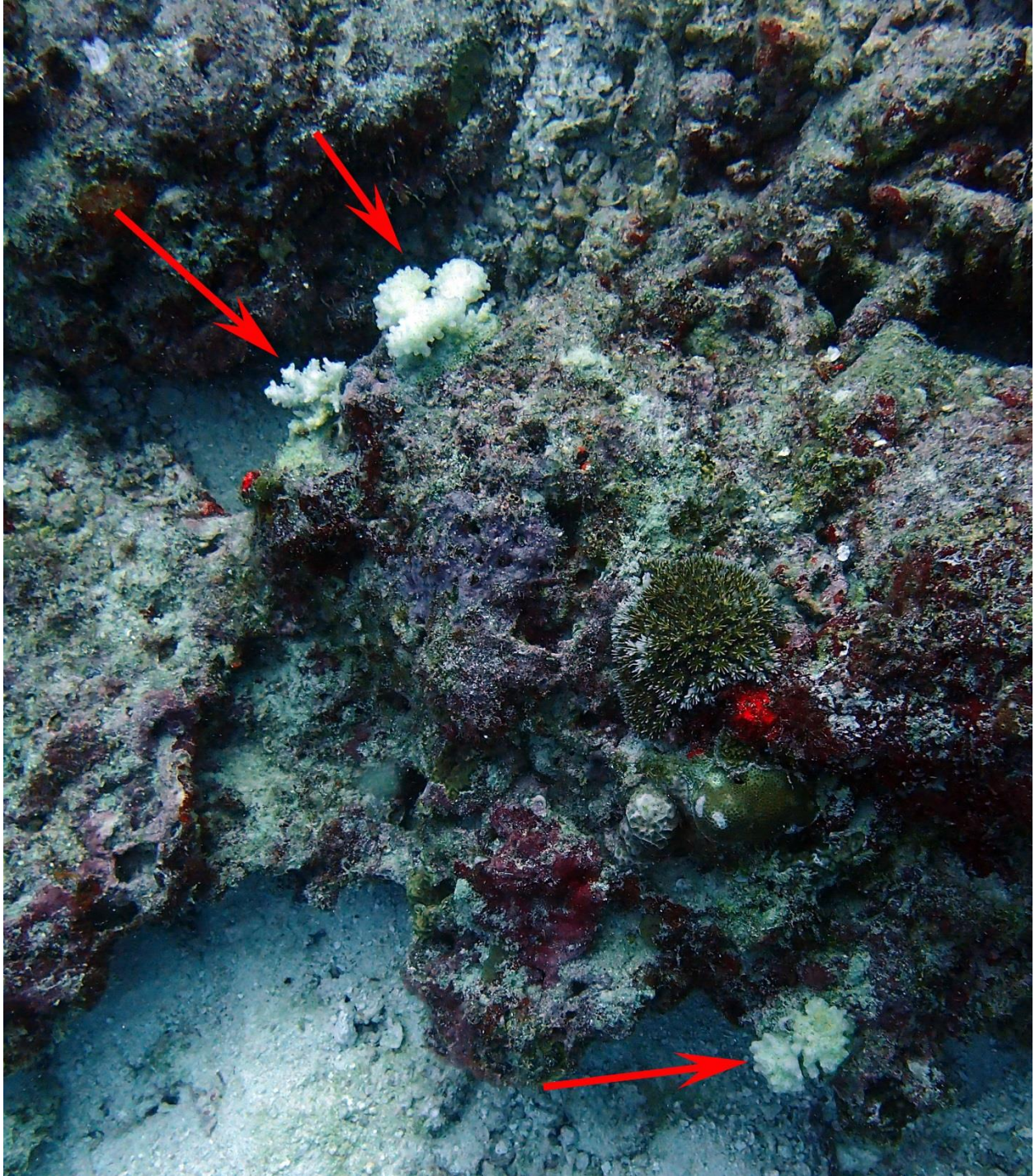
Their preferred food was *Pocillopora* (44% of all recently eaten colonies that were observed on these reefs) and *Acropora* (24.4%) but they also ate 9 other genera.

**Table 1. Percent of observations for preferred food choice by *Culcita*.**

Coral	Percent of observations
<i>Pocillopora</i>	44
<i>Acropora</i>	24
<i>Montipora</i>	7.1
<i>Pavona varians</i>	5.6
<i>Favia</i>	4.3
<i>Porites</i>	4.3
<i>Goniastrea</i>	3.4
<i>Favites</i>	2.1
<i>Fungia</i>	1.7
<i>Hydnophora</i>	0.9
<i>Leptastrea</i>	0.9
<i>Lobophyllia</i>	0.4
<i>Pocillopora damicornis</i>	0.4
<i>Galaxea</i>	0.4
<i>Leptoceris</i>	0.3



**Fig 12. A cushion star feeding on a mushroom coral (*Fungia*). The everted stomach is visible.**



**Fig 13.** Three juvenile corals eaten by a single *Culcita* within the last two days. These were 2-5 cm diameter and included a juvenile *Acropora* and two *Pocillopora*. There are no surviving juveniles of this species in this photo.

## Appendix 1. Participant list

Participant	Country	Role
Agnes van Linden	Maldives, Carpe Diem	Asst. Managing Director Carpe Diem Maldives
Andrew Bruckner	USA, Coral Reef CPR	Lead Scientist
Georgia Coward	UK, Coral Reef CPR	Program Manager/Coral Reef Ecologist
Karin Anne-Marie Blomfeldt	Sweden	Diver
Lars Richard Erik Blomfeldt	Sweden	Diver
Sarah Blomfeldt	Sweden	Diver
Tracey Hansen	USA	Diver
Dyann Donahue	USA	Diver
Naoko Machida	Japan	Diver
Rajlakshmi Saikia	India	Diver
Kevin Merton	UK	Diver
David Brown	UK	Diver
Graham Austin	Canada	Diver
Norbert Walter	Germany	Diver
Igor Višnjar	Slovenia	Diver
Ana Višnjar	Slovenia	Diver
Ibbe Abdulla	Maldives	Carpe Vita Crew
Nathig Ibrahim (“Natti”)	Maldives	Carpe Vita Crew
Shaifan Shareef	Maldives	Carpe Vita Crew
Chakku Hussein	Maldives	Carpe Vita Crew
Captain Adam	Maldives	Carpe Vita Crew
Mohamed	Maldives	Carpe Vita Crew

