

Bertarelli Programme in Marine Science (BPMS) Reef0 Expedition (1st-12th March 2020)

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Reef0 Expedition Team (L-R): Margaux Steyaert, Vivian Cumbo and Bryan Wilson.

Overview: The Reef0 Expedition (a joint venture between the University of Oxford and the Zoological Society of London) was borne out of a desire to assess the feasibility of using Diego Garcia (DG) as an ecologically-relevant base for British Indian Ocean Territory (BIOT) research. The BIOT Patrol Vessel (BPV) Grampian Frontier and its crew is an extraordinarily valuable resource for the ongoing BPMS and likely the only current practical means by which scientific investigations may be conducted throughout the entire archipelago. However, the boat-based expeditionary model is not without its limitations, several of which have been highlighted over recent weeks as a result of the challenges posed by the global COVID-19 pandemic. The predominant and fundamental restriction is the lack of year-round access to BIOT, the changeable nature of open sea conditions limiting scientific endeavours to defined periods of the year, and with the BPV otherwise understandably engaged in its primary and essential role of fisheries patrol of the expansive marine-protected area. As much of biology accedes to a regular and annual periodicity, the constraints of limited entry to the region have necessarily meant there are huge gaps in our basic ecology knowledge here. Indeed, two of the defining areas of global coral biology research in recent decades - spawning and bleaching events - have been historically difficult to observe *in situ* in the archipelago. It is indeed unfortunate that our contemporary knowledge of the biology of reefs in BIOT is lacking in even these basic facts that are staple to other coastal regions of the world and so the Reef0 Expedition was formulated to appraise how the BPMS might potentially address these issues.

In the weeks preceding the Reef0 Expedition, the COVID-19 outbreak was seemingly prevalent in South-East Asia only and with no UK Foreign & Commonwealth Office (FCO) travel restrictions in place at the time, our schedule appeared to be unaffected. However, mere days before our departure

date, an outbreak in Iran meant that the Kingdom of Bahrain dutifully closed its borders to flights (and returning pilgrims) from Dubai and so it was suddenly necessary to reroute via Abu Dhabi in the United Arab Emirates instead. Upon arrival in Bahrain on March 2nd, circumstances continued to escalate with our ongoing military flight to DG on March 3rd cancelled and the alternative Singapore route closed due to an ongoing outbreak. This led to the unfortunate but necessary return home of one of our team members, Diving Safety Officer (DSO) Dominic Andradi-Brown, and so the remainder of the team (supported remotely by Emma, Rachel, Heather and the PIs Adrian and Catherine) made the decision to continue, and flew on instead to Male in the Maldives, where on March 4th we joined the BPV Grampian Frontier sailing to DG. Given the unfortunate delay to the beginning of the expedition and with the Reef1 Team due to arrive the following week, shortening our already brief time in the field, there was discussion of our options with the BPV's Captain, Killian Hickey. In a continuing show of support for the expedition, the Foundation generously approved increasing our speed (and fuel consumption) to arrive at DG a full day earlier than anticipated - and thanks must go to Heather and Damian for their incredibly timely and positive response to our request. As it happened, later that same day, the BPV received intelligence reports of illegal fishing in the waters some sixty miles north-east of DG and so in a serendipitous turn of good fortune, we steamed south at full speed to intercept. There were no signs of any fishing activity upon arrival at the reported site and after several hours' patrolling the immediate area, we returned to our journey to DG, making landfall at midday, Sunday 8th March.

Later that afternoon, the island's currently serving Environment Officer Harri Morrall collected the Reef0 Expedition team from the BPV and brought us to the Moody Brook stores, where we picked up dive cylinders, lead weights and a DAN Emergency Oxygen kit for the boat. With a trademark display of efficiency and prior to our arrival on DG, Rachel had organised for the US Navy Fire Service to fill our diving cylinders, which spared us the time we would otherwise have had to spend setting up and testing the air compressors and for which we were all extraordinarily grateful. With Harri and SFPO John Caddle, I then met with Commander Kay Burbidge and Major Lee Mildener (Brit Rep and XO, respectively), who had unselfishly given over their Sunday afternoon to discuss our expedition plans for the week (comprising four days' diving) ahead, which entailed:

- 1) Assessments of various reef sites in and around the island, in terms of accessibility, scientific interest and general reef health (with particular regard to the predictions of recent widespread bleaching in the region);
- 2) Surveys for the critically endangered and endemic *Ctenella chagius*, with a view to assessing potential measures for its conservation on the island;
- 3) Corroboration of reports (from the Reef1 Expedition in 2019) that coral spawning in the region might occur after the March full moon;
- 4) Feasibility studies for the collection and maintenance of live corals on the island;
- 5) Deployment of the ARMS (Autonomous Reef Monitoring Structures) devices, in addition to Margaux's existing installations around the greater archipelago and in support of her ongoing D. Phil. studies.
- 6) Collection of coral specimens for Catherine's ongoing archipelago-wide population connectivity study

The enthusiasm and support of the Brit Rep and XO for our work was immediately obvious and as keen recreational snorkellers both (and officially prohibited from SCUBA diving), they were eager to learn more of the state of the island's lagoonal and seaward reefs. I was also asked if we might

have time to perform an environmental assessment of two potential reef sites for installation of a new communications cable, and engage in public outreach with members of the serving military, which of course I unreservedly agreed to our doing.

With the unavoidable and unfortunate departure of our original DSO, and our Reef0 team reduced from four to three, boat surface cover and expedition safety suddenly became a major issue, threatening to derail our carefully considered plans. Luckily, the BPV Grampian Frontier yet again came to our assistance and Captain Hickey generously offered us full use of the boat's rigid-hulled Daughter Craft (DC), comprising two of the crew acting as surface cover. All of which meant that we could dive as a more risk-averse threesome and make much more efficient use of our limited diving time, especially given that Vivian had also thankfully stepped up into the recently vacated role of Expedition DSO.

Day 1 (Monday 9th March)

AM: Barton Pass Seaward (Lat 7.13.716, Long 72.25.662)

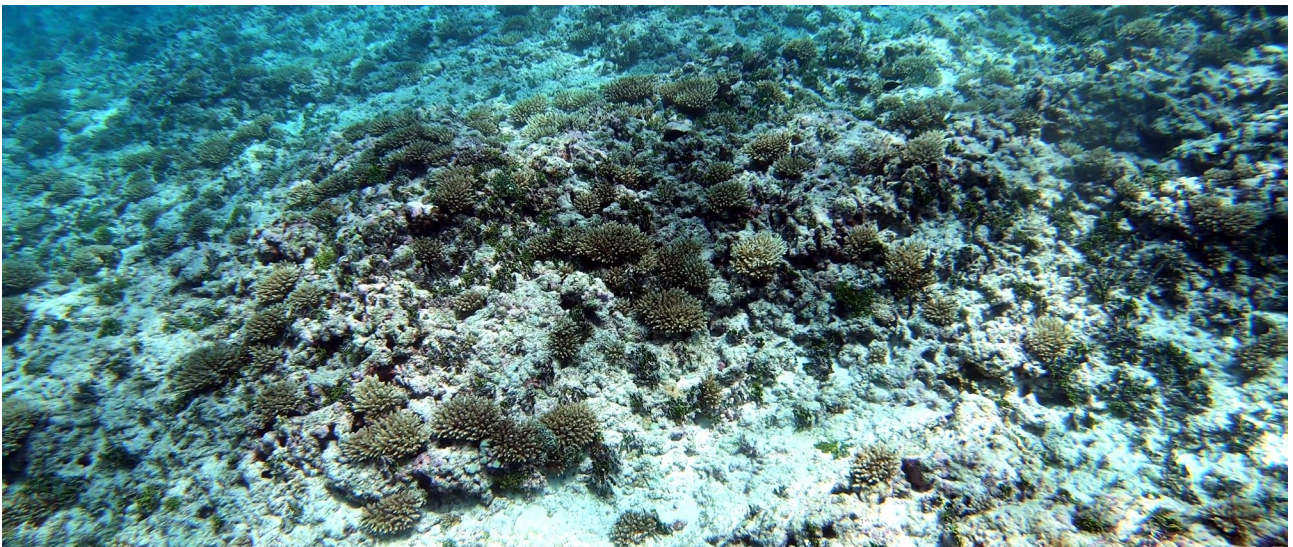
With the area around Barton Point being notably one of high coral cover on the Reef2 Expedition in 2019, we elected to first dive in the exposed channel between East Island and Barton Point and survey from the reef flat to the edge of the drop-off. Reef conditions here were mediocre, with low coral cover and much exposed substrate, as might be expected in the major shipping channel to the lagoon. With a heavy ocean swell and a strong northerly current, diving conditions were far from ideal and we struggled to make headway. Aborting the dive and surfacing, we were collected by the DC and returned to the water to snorkel over the drop-off (with the seafloor at approximately 40m depth). However, with the sudden appearance from the gloom below of ten or more grey reef sharks (>1m in length) with a rapidly increasing interest in us, we decided again to abort and returned to the BPV.



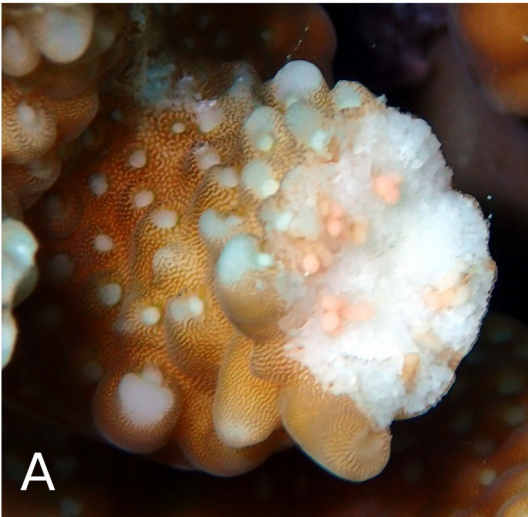
A shiver of grey reef sharks at the seaward drop-off in Barton Pass.

PM: Barton Point Seaward (Lat 7.14.365, Long 72.27.000)

Returning to the site coordinates of last year's Reef2 Expedition, the DC anchored on the reef less than a hundred metres from shore for this dive. Upon submerging, we were immediately surprised to see a wonderful reef in full recovery, replete with healthy juvenile *Acropora* spp. (some >20cm in diameter) which dominated the coral cover, and with no signs of thermal bleaching whatsoever. Anecdotally, overall reef health and coral cover had seemingly improved when compared with the same time the previous year. Vivian cracked open the tips of a number of *Acropora* colonies and revealed the presence of pigmented gamete bundles in approximately ten percent of colonies sampled. The presence of these pigmented gametes indicated that the colonies were gravid and ready to spawn that month. The remaining colonies sampled had no visible gamete bundles (pigmented or pale), indicating that the bulk of the spawning likely occurred in the months before the survey was conducted. With a dearth in coral samples from DG, Margaux also took a number of fragments from *Acropora* spp. to complement Catherine's ongoing population connectivity study. However, the real surprise was the discovery of a single large hemispherical colony of *Ctenella chagiuis* (sited at approximately 8m in depth), approximately forty centimetres in diameter and the largest specimen I've witnessed yet in the region (with the caveat of course, that this was only my second field season in BIOT). As the furthest recently recorded specimen south in the archipelago, I took a small tissue sample from the coral's leading edge for genetic comparisons with samples collected in the northern atolls the previous year. Upon return to the BPV, the tissue sample was immersed in RNALater and stored at -20°C. Three grey reef sharks were also spotted during the dive, one of them almost two metres in length.



Abundant juvenile Acropora spp. at Barton Point Seaward.

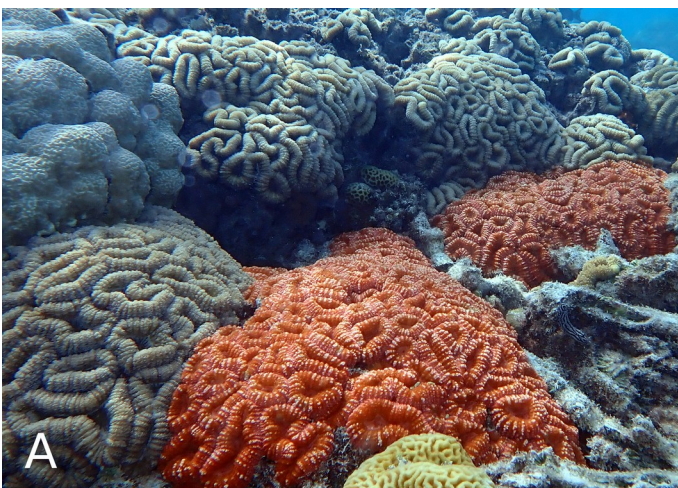


Evidence of gravid *Acropora* spp. (A) and a mature *Ctenella chagius* colony (B) at Barton Point Seaward.

Day 2: (Tuesday 10th March)

AM: Orient Bay Lagoon (Lat 7.14.673, Long 72.26.676)

With a large seagoing swell on the island's outer reefs, the Reef0 team requested that the DC head for the lagoonal reefs inside Barton Point at Orient Bay, where it dropped anchor in the sandy seafloor, providing us with optimal diving conditions in eerily calm waters. The reefs here were absolutely stunning, very shallow (<5m in depth), healthy and diverse but essentially dominated by large and multicoloured colonies of *Lobophyllia* spp. There were also many large (>50cm) tabular *Acropora* spp. and a huge *Porites* spp. (>4m in both height and width). Vivian continued to crack *Acropora* colonies to assess coral fecundity and determined that none of colonies tested on the lagoonal reefs had any visible gametes. Fish populations here were also conspicuously abundant and diverse, and we were later informed that this area of the lagoon is protected from any recreational fishing practices by personnel on the island. However, no sharks were recorded on this particular dive.



An abundance of diverse *Lobophyllia* spp. (A) and large tabular *Acropora* spp. (B) in Orient Bay Lagoon.

PM: East Island Lagoon (Lat 7.13.793, Long 72.25.335)

The team initially headed to the north-western outer edge of the island at Cannon Point but decided against diving here, due to a large north-easterly oceanic swell and strong winds. A brief snorkel survey suggests that the reef is in poor condition, with almost no coral cover and the substrate essentially scoured bare. The DC continued around to Simpsons Point in the belief that the western

coastline of DG would be relatively sheltered from the prevailing north-easterly winds – however, here we observed the beach being pounded by high-energy rollers and again decided against diving. Undaunted, we headed to a site on the lagoonal side of East Island, which was relatively well protected, and the DC anchored there on the sand seafloor. Diving, we swam along the seafloor shorewards to the centre of the island, where we found a mostly degraded reef, with stands of large *Acropora* colonies, none of which had any visible gametes. As we swam towards the eastern end of the island, we found the reefs there to be destroyed, comprising either bare substrate or huge mounds of dead coral rubble, leading to the bare and sandy channel. However, we did spot three sharks (two grey reef and a silvertip) cruising around on those reef flats.



Degraded reef and dead coral rubble at the eastern end of East Island Lagoon.



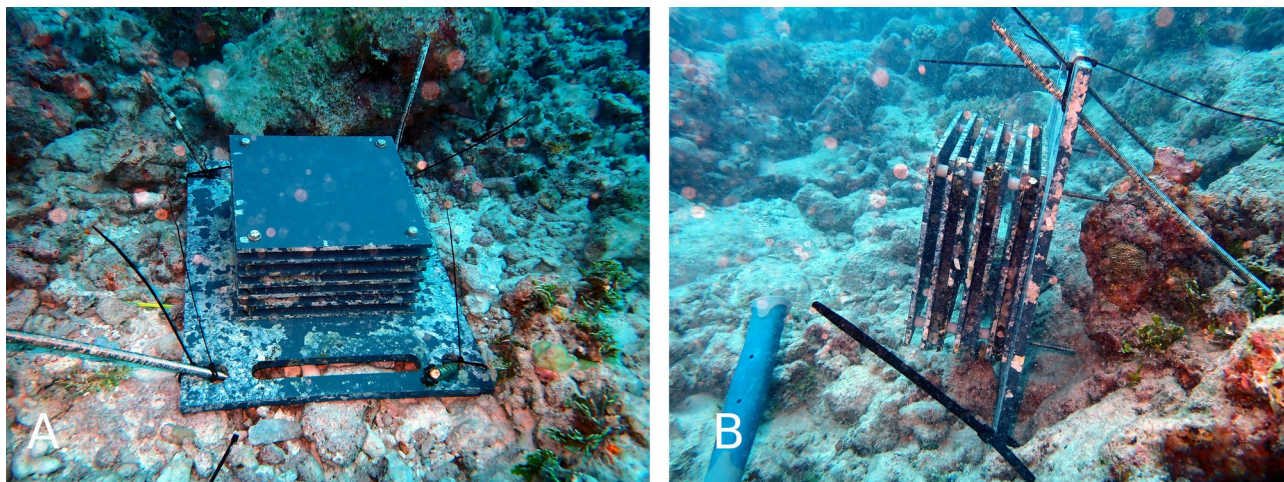
*Healthy stands of *Acropora* spp. at East Island Lagoon.*

Day 3: (Wednesday 11th March)

AM: Barton Point Seaward (Lat 7.14.365, Long 72.27.000)

The team returned to Monday's Reef2 Expedition 2019 location for Margaux and Vivian to deploy four ARMS, the first of their kind to be located on the reefs around DG. Two of the structures were installed in the usual manner (horizontally), whilst two others were placed vertically and perpendicular to the reef, in order to investigate the effects of sediment loading and settlement on the cryptic biodiversity on the tiles. In the meantime, I revisited the large *Ctenella* colony nearby and surveyed the reef around in concentric circles of increasing size for other *Ctenella* colonies, but

unfortunately with no success. Immediately prior to surfacing, a surface marker buoy (SMB) was inflated for the DC surface cover crew to take a precise GPS marker for the single *Ctenella* colony (Lat 7.14.325, Long 72.26.897).



ARMS devices, placed both horizontally (A) and vertically (B) at Barton Point Seaward.

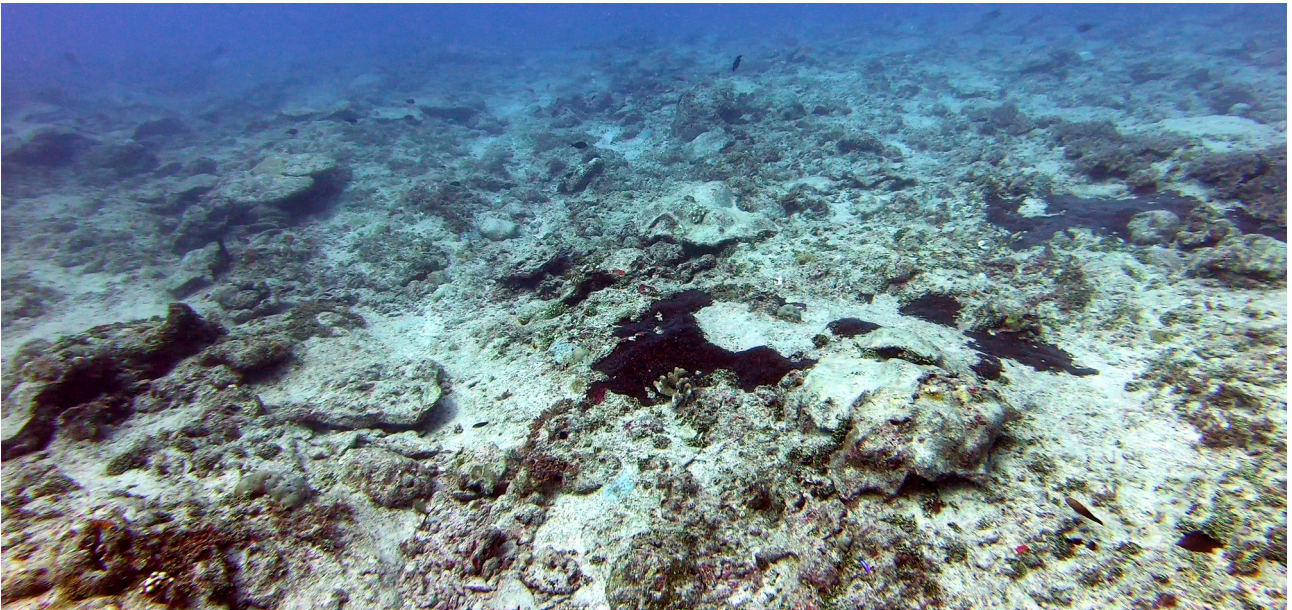
PM: Orient Bay Lagoon (Lat 7.14.456, Long 72.26.970)

The continuing north-easterly swell suggested that both diving conditions and visibility would be poor and an initial snorkel in Eclipse Bay in the north-western corner of the lagoon, just offshore from the Brit Rep's residence, proved that to be the case, with conditions too murky to survey. The DC then proceeded to the lagoonal side of West Island, where we again briefly snorkelled in low visibility conditions over what appeared to be a thoroughly degraded reef. In consultation with the DC crew, we then made the decision to return to Orient Bay and dive further south along the eastern shore of the island. A faulty submersible pressure gauge (SPG) meant that I snorkelled at the surface, whilst Vivian and Margaux surveyed the site together, reporting coral cover similar to before, dominated by *Lobophyllia* spp. and large tabular *Acropora*. And for good measure, there was a fright for us all when a large (>3m) grey nurse shark suddenly emerged from the murky gloom mere metres away...

Day 4: (Thursday 12th March)

AM: "Site C" Western Shore Seaward

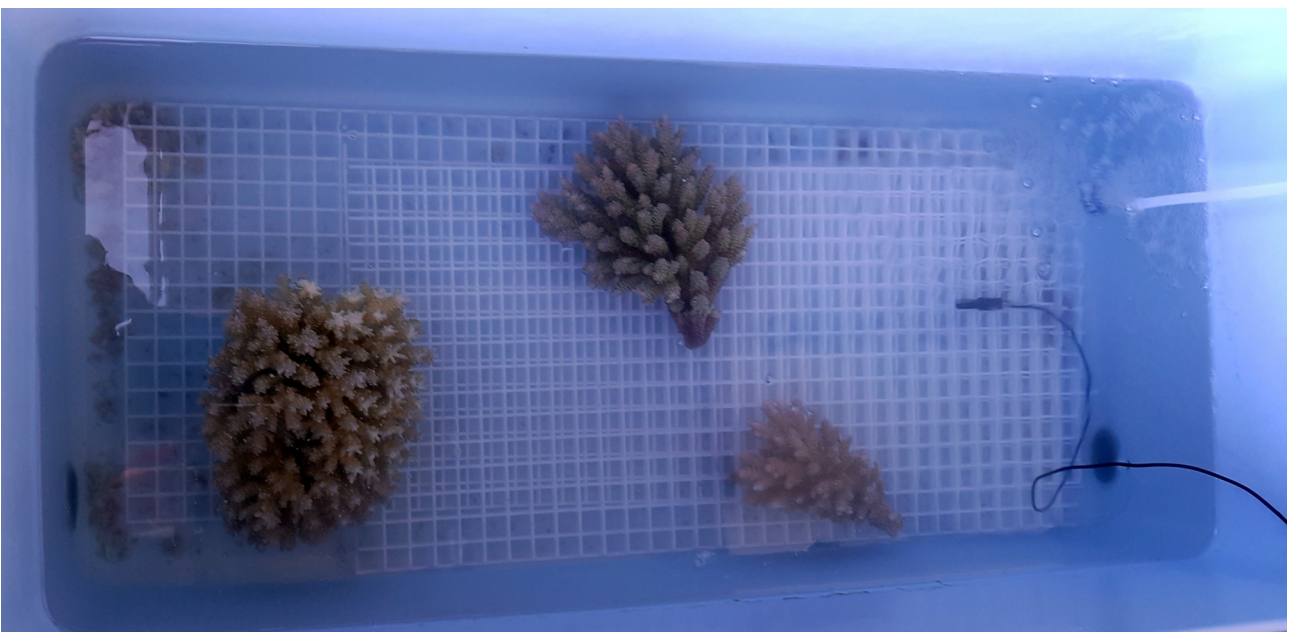
With Vivian departing DG later that evening and therefore unable to SCUBA dive, Margaux and I took the opportunity to perform an ecological assessment of the proposed location for the new undersea communications cable at "Site C". Despite the long lazy oceanic swells rolling in from the south-west, conditions were the best that we had seen on this side of the island and the DC anchored approximately 100m from the beach and at 12m above the seafloor. With a particularly exposed shoreline and with the effects of the swell reaching down into the depths, we descended down the anchor line and began a 50m video transect from the anchor shorewards. The reef condition was extraordinarily poor, very few live corals observed and the seafloor predominantly bare substrate. We provided Harri Morrall (Environmental Officer) with the transect video and recommended that the burial of a cable in the seafloor at this point would have few negative ecological impacts on the reef here, such as it was. On our return to the BPV in the DC, we also briefly snorkelled at "R Site", where an existing cable was placed some years ago. A more sheltered location than "Site C", we were pleased to report that the reef conditions here were significantly better, with an abundance of large *Porites* colonies and this was likewise reported. While Margaux and I were surveying "Site C" and "Site R", Vivian used her time on land to instruct Harri Morrall on the software program Coral Point Count (CPCe), which aids the determination of coral and substrate coverage using random point count methodology. Harri will use this program to determine percentage coral cover from survey sites in BIOT.



Poor reef conditions at proposed location for undersea communications cable at Site "C".

PM: Orient Bay Lagoon (Lat 7.14.673, Long 72.26.676)

On the final dive of Reef0, the team returned to the initial lagoonal site of Orient Bay with Margaux and I diving, whilst Vivian snorkelled overhead. During this dive, a number of samples of *Acropora* spp. and *Porites* spp. were taken to supplement Catherine's population connectivity study. The primary aim of this dive however, was to sample corals for *ex situ* studies in an aquarium and three large fragments of mature *Acropora* colonies were collected and placed in a 70L coolbox containing seawater, on the DC front deck. Upon return to the BPV, the coolbox was transferred to a shaded area on the back deck, and a small battery-operated air bubbler and temperature probe added. As a result of the transport, the corals exhibited some degree of stress, producing excess mucous and this was skimmed from the water's surface, prior to preparation for the arrival of the Reef1 team and seagoing travel. There were some water quality concerns regarding our replenishment of the aquarium with seawater taken from the Small Boat Harbour; however, these were soon dispelled upon observation of a number of seemingly healthy corals growing there.



Ex situ maintenance of Acropora spp. onboard BPV Grampian Frontier.

Summary and Key Observations from the Reef0 Expedition



Site No.	Description
1	Barton Pass Seaward
2	Barton Point Seaward
3	Orient Bay Lagoon
4	Orient Bay Lagoon
5	“R Site”
6	“C Site”
7	East Island Lagoon
8	Eclipse Bay Lagoon
9	West Island Lagoon
10	Cannon Point Seaward
11	Simpsons Point Seaward

Sites surveyed by either snorkel or SCUBA diving during Reef0.

1. The island of Diego Garcia has a diverse range of both seaward and lagoonal reef habitats, with abundant fish (and in particular) shark populations. Our initial (and admittedly brief) observations suggest that the north-east part of the island (Barton Point and Orient Bay) has the healthiest coral reefs, whilst the north (East and Middle Islands) and north-west and west parts (West Island, Eclipse Bay, Cannon Point, Simpsons Point) of the island had generally poor degraded coral cover and diminished reef health. Where live coral cover was observed, recruitment was seemingly high, with abundant and healthy young corals, and no signs of thermal bleaching or coral disease apparent. Should reports of coral bleaching in the region become available, rapid access to DG and its reefs would be extremely beneficial for monitoring the ecology of these outbreaks as a proxy for the greater archipelago.

2. After limited reef surveys, it appears that populations of the *Ctenella chagius* are exceedingly rare in DG. However, it is recommended that further surveys be carried out along the seaward shores of the island. The single mature colony that was found appeared in good health and assumed to be fecund, and therefore might potentially be considered a source of gametes for future conservation measures.

3. Whilst few signs of reefwide spawning were discovered, there were indications of gravid *Acropora* colonies, suggesting that we arrived too late this particular field season, with the mass *Acropora* spawning likely occurring in February around DG (and potentially the wider BIOT region). However, water temperatures in the region were predicted to have been abnormally high in January and February and this may have interrupted this reproductive cycle. Again, exploratory fieldwork from DG in these early months of the year is essential for elucidation of the timing of spawning in the BIOT region, thereby allowing for biogeographical comparison with other global reefs for which these periods are well described.

4. As per the Reef1 report, the *Acropora* corals were maintained in the coolbox aquarium onboard the BPV during transit across the archipelago and remained apparently healthy for twelve days until the experiment was terminated. Collection and maintenance of live corals with limited facilities was therefore proved entirely possible and suggests great potential for both ecological fieldwork and laboratory studies using live coral aquaria in BIOT, both on DG and aboard the BPV. This may have particularly significant ramifications in terms of conservation interventions for the critically endangered *Ctenella chagius*.

5. Several ARMS devices were installed on the reefs in DG which, as the only island in the archipelago with a direct and ongoing anthropogenic influence, will provide a meaningful comparison with existing installations at more remote sites in BIOT.
6. Genomic samples taken from corals in DG will help supplement existing models of population connectivity within and between the islands of the Chagos Archipelago.

Acknowledgements

The decision to assemble an additional expedition team was a late one and as Expedition Leader, I can only begin to offer my heartfelt thanks to Heather, Rachel and Emma for mobilising so quickly and efficiently to make it all possible, despite also having a number of other finalised expeditions to organise - and also for the generous donation of financial support. I'm also incredibly grateful for the boundless enthusiasm and charitable donation from ZSL's Paul Pearce-Kelly and his suggestions regarding our future conservation efforts for *Ctenella chagius*. Thanks of course must also go out to the University of Oxford's manifold administrative staff in the Department of Zoology for also processing my numerous demands so expediently. The actual conception of the Reef0 Expedition came about as a result of first hand reports of the ongoing interest in and support of the BPMS by military personnel at the Naval Support Facility at Diego Garcia and thankfully, these were not exaggerated and so profound thanks must go to the Brit Rep, Commander Kay Burbidge and XO, Major Lee Mildener, for hosting us and showing such a keen interest in our work. Our day-to-day operations on DG were made that much simpler by the wonderful Environment Officer Harri Morrall and also the crew of the US Navy's Fire Service, who helped with filling diving cylinders for us. The logistics of the entire expedition would have been so much more onerous were it not for exemplary and overwhelming assistance of the Senior Fishery Protection Officer John Caddle and the incredible ship's crew of the BPV Grampian Frontier, under the steely and experienced gaze of Captain Killian Hickey. Finally, none of this would have been possible without the prior assistance of our DSO Dominic Andradi-Brown, who unfortunately had to leave the expedition all too soon, Margaux Steyaert and Vivian Cumbo for their scientific professionalism and omniscient camaraderie in the field, and of course PIs Catherine Head and Adrian Smith for their wholehearted support of the venture.

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BPMS Reef Trip 0 Expedition Leader