The Bertarelli Programme in Marine Science

Expedition Report

Coral Reef #1

March 2018

The *Bertarelli Programme in Marine Science* is a collaborative programme bringing together scientists from all around the world to work in the British Indian Ocean Territory (BIOT). Each brings their own expertise to the research programmes and, with the support of the Bertarelli Foundation, tackles some of the most important and challenging questions in ocean science.

This large, remote, near pristine, no-take MPA presents an incredible opportunity to take an integrated and interdisciplinary approach to understanding the role of these complex ecosystems for mobile species such as tunas, sharks, turtles, and seabirds. As BIOT was negatively impacted by the 2015-2016 global coral bleaching event, it also provides an important study area to explore the resilience that large marine reserves offer in the absence of fishing and other anthropogenic pressures.

Between 2017 and 2021 the *Bertarelli Programme in Marine Science* will transform our understanding of the benefits of the BIOT MPA for terrestrial, reef-dwelling and pelagic species.

The Bertarelli Programme in Marine Science Reef 1 Expedition 2018

The Bertarelli Programme in Marine Science Reef 1 Expedition 2018 aimed to undertake a survey of reef condition and especially reef recovery across the archipelago following the 2015-2016 warming events which had caused severe bleaching and mortality. In addition, instruments were deployed to build a more detailed picture of changes in environmental parameters affecting the reefs over time.

The expedition worked its way from Peros Banhos, Salomon and Blenheim atolls, and then to Nelson's Island, The Three Brothers, Eagle Island and Danger island on the Great Chagos Bank, before a brief visit to Egmont atoll and Diego Garcia between March 27th and April 16th aboard the BIOT patrol vessel, *Grampian Frontier* (Figure 1).

Figure 1. The Grampian Frontier provided the perfect platform for the BPMS Reef 1 Expedition (Image from drone, Rob Dunbar)

Expedition members drawn from BPMS Projects 6 and 9 worked collaboratively and included Professor John Turner (Expedition Lead), Dr Ronan Roche and Dr Gareth Williams (Bangor University, UK), Professor Charles Sheppard and Anne Sheppard, Dr Andrew Mogg and Daniel Bayley (SAMS/UCL, UK), Dr Catherine Head and April Burt (Oxford University, UK) and Professor Robert Dunbar, Dr Hans Dejong and David Mucciarone (Stanford University USA), accompanied by Dr Katie Sellens (Medical Doctor) and Simon Browning (BIOT Senior Fisheries Protection Officer). The team were extremely well supported by *Grampian Frontier* Captain and crew, and BIOT staff on Diego Garcia. Unfortunately our Mauritian PhD student Jyodee Sannassy Pilly was unable to join her first Chagos expedition due to being unable to obtain a visa to transit through Bahrain.

Over 400 hours were spent underwater, working at 29 permanent monitoring sites on seaward, leeward and lagoon patch reefs of the 6 atolls of the Archipelago across 200 km of latitude. This provided a comprehensive understanding of the state of the reefs now, compared with measurements recorded at the same sites in 2015 (pre warming), and those of the northern atolls in 2017.

Figure 2: Reef survey, Isle Anglaise, Salomon.

The team used both visual and video techniques to record coral and other life-form cover on the reefs between 25 and 5 m depth (Fig 2). An important aspect of this work was to assess the number of coral juveniles, using both visual census and fluorescence photography (Fig 3 and 4). Three dimensional reef structure was assessed on the reef terraces using photogrammetric methods to build high resolution images of 200 m^2 areas at each site, which will be compared with models built from data collected in 2016 and 2017. Temperature loggers were successfully downloaded and redeployed, and the Stanford team put in 35 new instruments to collect seasonal data on dissolved oxygen, salinity, irradiance, water flow and coral reef boundary layer dynamics. At three sites, the team deployed BEAMS (Benthic Ecosystem and Acidification Monitoring System) array (Fig 5) for periods ranging from 1.5 to 3 days to provide measurements of primary production rates and calcification. ARMS (Autonomous Reef Monitoring Structures) of the same modular design as those used at reef sites globally (Fig 6) were placed on 3 reefs, allowing for progressive sampling over the next 3 years to assess the early stages of biodiversity colonisation and succession of reef cryptofauna. Further, coral samples of *Acropora tenuis*, *Acropora cytherea*, and *Porites lutae* were collected for genetic analysis to assess reef connectivity, and water samples were collected from within and over reefs to assess the often neglected micro-organism community of reefs using metagenomics sequencing to identify their diversity and contribution to reef productivity.

Figure 3 and 4: Visual and Fluorescence techniques were used to assess coral recruits with cross calibration

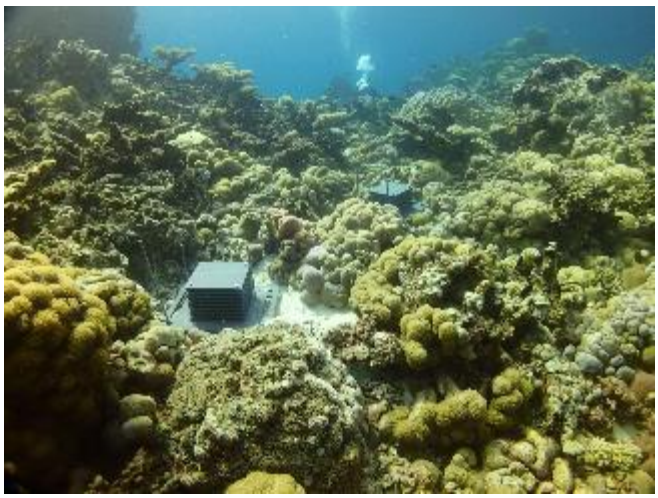

Figure 5 and 6: Deployment of BEAMS (Benthic Ecosystem and Acidification Monitoring System) and ARMS (Autonomous Reef Monitoring Structures). (Fig 5 Rob Dunbar)

The impacts of warming events on reefs are now regularly reported as are the status of those reefs after a decade or more, but what is poorly understood are the early processes that follow a warming event leading to the recovery of reef communities, especially on reefs unaffected by direct anthropogenic impacts. By revisiting those sites previously assessed, our projects are investigating the processes underpinning the recovery of the reefs.

A general pattern emerged, although there were exceptions at some sites. At depths below 15 m, the reefs were generally in good health with most showing a high diversity of hard coral, soft coral, sponge and calcareous green and red algae (Fig 7), while others have remained characteristically dominated by a single species of coral (eg. *Pachyseris* in Horsburgh Bay, Diego Garcia (Fig 8).

Figure 7: High diversity below 15m on seaward reef of Peros Banhos and Figure 8: Monospecific stands of Pachyseris below 15m at Horsburgh Bay, Diego Garcia

Although not observed in 2017, the Chagos brain coral, *Ctenalla chagius* evidently survived the mass mortality events at mid to deep sites (Fig 9) at Isle de la Passe, Salomon and Moresby, Peros Banhos, and most of the *Porites* colonies had recovered their colour (Fig 10) and therefore their symbionts, having appeared very pale in 2017.

Figure 9: Ctenella chagius at Moresby, and Figure 10: Large Porites colony at Diamont, Peros Banhos

Shallow reefs with a terrace of tabular *Acropora* had faired least well (Fig 11), but provided an insight into regenerative reef processes that are now underway. In exposed locations such as at North West Egmont, water movement channelled coral rubble off the reef terrace and down the reef slope (Fig 12), thereby providing a clean and stable surface for calcareous coralline algae such as *Porolithon* spp. which favour coral colonisation (Fig 13). In more sheltered locations, such as within lagoons, calcareous algae and bioeroding sponges had colonised the corals, beginning to break down their structure (Fig 14).

Figure 11: Dead standing tabular Acropora tables on the reef terrace at Danger Island

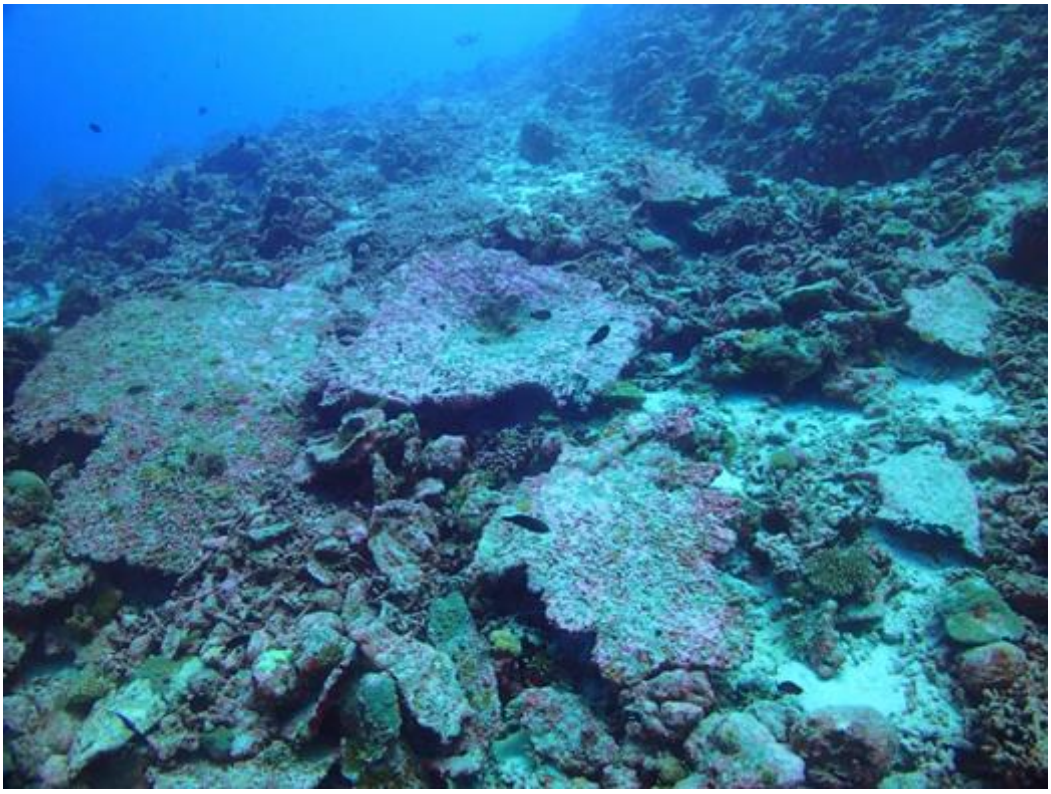

Figure 12: Dead coral colonies at base of reef on Egmont North West, having been cleaned off the reef terrace by water movement.

F*igures 13 and 14: New coral colonies on clean reef terrace at Egmont North West, and bioerosion weakening and collapsing coral colonies at Bernard's Shoal, in the Peros Banhos atoll lagoon.*

Crustose coralline algae is now growing on most collapsed structures, helping stabilise the material, and in many cases, providing a surface for coral recruitment (Fig 15).

Figure 15: A variety of coral recruits on stabilised coral and coralline algal covered substrate, Moresby.

At 8 sites shallower than 15m, a fungal disease was observed causing death of the coralline algal tissues. This is the first observation of coralline fungal disease in the Indian Ocean, and a full description has been accepted for publication in the journal Coral Reefs 'Reef Sites' (Williams et al., in press), prompting more detailed study on reef processes such as accretion and coral recruitment next year.

Deep patch reefs at 20m in Salomon still showed little recovery from the warm saline event of 2013 Fig 16), but patches close to passes and in areas of stronger water movement were dominated by a spectacular show of *Goniopora* (Fig 17).

Figure 16: Deep patch reef at Salomon has yet to recover from the dense warm water that caused mortality in 2013. Figure 17: Patch reefs close to passes have well developed colonies of Goniopora

The most damaged sites were those previously impacted by the Crown of Thorns starfish, such as at Danger Island lagoon, Great Chagos Bank, which is now reduced to an urchin barren above 10 m depth with mostly coral rubble (Fig 18), and with no coral remaining at deeper depths. The urchin *Diadema* grazes coralline algae and prevents coral larval settlement.

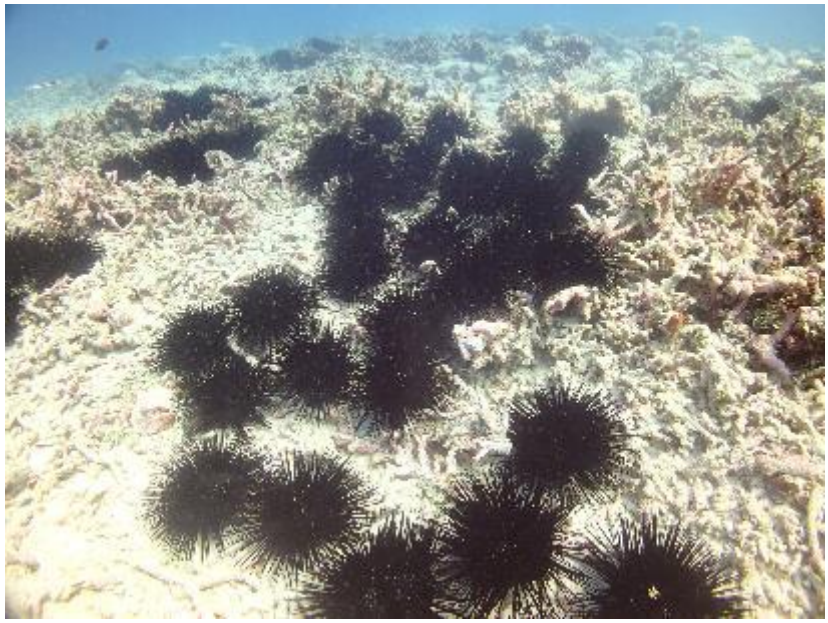

Figure 18: An urchin barren at Danger Island lagoon side, Great Chagos Bank

Although the shallow areas of the reefs appear to have entered a period of negative accretion (to be confirmed by Project 6 team member Chris Perry on the Reef 2 Expedition), Reef Team 1 were heartened by high coral cover and diversity on deep reef slopes, and high levels of coral recruitment. Fish life remained abundant at sites of high topography such as Barton Point, Diego Garcia (Fig 19), and nursery areas on lagoon knolls (Fig 20).

Figure 19: Barton Point, Diego Garcia

Fig 20: Diamont leeward reef, Peros Banhos

We thank the British Indian Ocean Territory (BIOT) for granting access to the Chagos Archipelago and the crew of the *Grampian Frontier* for logistical support. Funding was provided by the Bertarelli Foundation. A full Expedition Report will follow once preliminary results have been analysed.

Professor John Turner, Reef 1 Expedition Lead, May 2018.

Reference

Williams, GJ*, Roche, RC, Turner JR (*accepted for publication*). First record of coralline fungal disease (CFD) in the Indian Ocean. *Coral Reefs*.