British Indian Ocean Territory (BIOT) Ecosystem Action Plan

SHALLOW CORAL REEFS

Summary

Description:

BIOT covers approximately 650,000 km^2, in the central Indian Ocean, with a central core approximately 400 x 300 km across which contains five islanded atolls and numerous submerged atolls and banks. These are all built of limestone and rest on a limestone platform mostly 0.5 to 2 km thick, overlying a volcanic substrate. The shallow areas relevant to this BAP therefore are composed entirely of biogenic limestone reefs, mainly of coral and algal origin. This biogenic limestone is a relatively soft rock, whose continued creation to offset natural erosion is essential for maintenance of the reefs and of the islands supported by them.

In terms of biodiversity, this is a rich site in Indian Ocean terms for several groups of benthic biota, with over 300 coral species and with fish counts exceeding 800 species, although seagrasses show an impoverished biodiversity. However, all this is based on older data, and there has been a recent, substantial decline in the condition of shallow water habitats since the surveys were carried out. At present, any biodiversity assessments are in a state of flux; there have been several multi-annual rises and falls in condition but a multi-decadal decline since at least the 1970s.

Threats:

Threats are predominantly from ocean warming which is severely affecting the reef-building corals and hence endangering the main shallow structures of the archipelago, including islands. Warming episodes are now being called 'marine heatwaves'.[1] In addition to an important background rise in

Citation: Sheppard, C. 2020. British Indian Ocean Territory Ecosystem Action Plan: Shallow Coral Reefs. Prepared by Bangor University for the BIOT Administration, FCO, King Charles Street, London.

seawater temperature measured in the archipelago of nearly half a degree over the last decade, there are warming pulses that are significantly greater which last for several months, usually between March to May. These marine heatwaves cause bleaching and then usually mortality not only of the reef building corals but of all benthic biota dependent on an algal symbiosis such as soft corals and "false" corals that occupy a substantial proportion of the reef. Other threats exist, but all are minor in comparison over most of this uninhabited archipelago. Biodiversity is supported by corals and soft corals, and the vast range of fauna and flora they support, feed and shelter, and loss of this habitat negatively impacts associated biodiversity. These large losses are relatively recent, so to date there has been little quantitative study of their magnitude, though some extinctions and functional extinctions have been recorded.

2. Distribution

This shallow reef habitat is spread across five islanded atolls and numerous submerged atolls and banks in the central part of BIOT. Within this area there are 3,000 km^2 of shallow substrate < 20 m depth, which is the depth with the greatest biodiversity of corals, and 13,000 km^2 of substrate to 60 m depth around the atolls and banks, where coral cover can still be high.[2] The proportion of this which supports coral reefs and that which supports associated soft substrates that are generated by the reefs is not known.

3. Habitat characteristics

Physical

Whatever the dominant flora and fauna, all shallow substrate is limestone, the islands and banks being constructed by coral reef over millions of years such that there is now a plateau a couple of km thick on the volcanic base.[3] An essential though commonly overlooked component of the greater coral reef system are the extensive banks of sand and other graded sediments, though the biodiversity within these soft substrates is largely unresearched in BIOT.

Biological

The relative proportions of the shallow (<60m) category that are dominated by coral, seagrass beds, sand and bare soft substrate is not known. Vast seagrass beds have been recently discovered between 10–30 m depth which suggests that while corals dominate around islands, seagrass may occupy a far greater area further offshore.

Biodiversity of the coral dominated proportion reaches peak values at 20 m depth on ocean reefs due to the very clear waters around the archipelago.[4] This is a depth two to four times greater than is usual for reefs of the world.[5] By 60 m depth, coral diversity is reduced again, with a largely different suite of species, until it tapers off at greater depths still where soft substrates dominate. Cover by benthic biota does not necessarily follow the same pattern as diversity. Before the marine heatwaves cover, or abundance, used to be highest in the shallowest water, on breaks in the reef shelf or slope, while in many parts of lagoons below 25 m cover was near total. In 2019, this pattern has changed; in most ocean-facing reefs the warming has killed shallowest species to the greatest extent, while in lagoons the patchy nature of water circulation for example has resulted in greater fluctuations in cover over relatively small distances.[6]

4. Status

The status of the coral dominated habitat at present is in a state of rapid and substantial change and decline.[7] Massive mortality has taken place following the 2015–2016 marine heatwaves. This has taken place subsequent to earlier mortalities resulting from a heatwaves in 1998 and probably earlier also[8] which themselves caused substantial reduction of the corals to 40 m depth and much bioerosion.[9] At present, coral cover is low at around 10% on average, and there is, consequently, greatly reduced recruitment of juvenile corals.

Patches of greater coral cover exist, with no obvious distributional patterns other than commonly being located near major passes, being likely caused by vagaries of cool water flow, and by upwelling, cool water on ocean-facing reefs.[10] Whereas there tend to be greater patches of surviving live coral in lagoons, there are also vast areas of dead corals on e.g. the floor of lagoons, including near total mortality on many lagoon knolls.[11]

Sand beds are an integral component of a coral reef system, commonly overlooked, and indeed their study in this archipelago has been severely limited, other than observations that the main species *Thalassodendron ciliatum*, which is important most notably for housing a large and separate infauna and for being an important turtle feeding and foraging area, is thriving over extensive areas.[12]

4. Threats

A trend of ocean warming, and especially the occasional marine heatwaves that superimpose on the rising trajectory, provide the main threat to the coral reef substrates because of coral bleaching that is followed by mortality. Warming, as measured by a series of loggers that have been emplaced at different depths since 2006, has shown rises (linear regression) in water temperature of between about 0.2 and 0.5 ^{o} C per decade, depending on location and degree of ponding etc. However, superimposed on this have been warm pulses that raise the temperature to 30–31 ^{o} C for several weeks. These raised temperatures are observed to at least 25 m depth. These cause severe and widespread bleaching of all groups that show symbiosis with algae (corals, soft corals, false corals such as Millepora), reducing the total cover of substrate that these groups occupy from being dominant on the reef sometimes to zero, with an average cover immediately post-warming of around 10%. During these episodes, and for several years following, reef functions such as calcification and reef maintenance, provision of three-dimensional habitat and productivity etc., essentially disappear or are hugely reduced.

Biodiversity loss of corals may be significant and is likely to become more so. No specific work has focussed primarily on this aspect to date but, from work done on other aspects, it is clear that one formerly important lagoon reef builder *Diploastrea heliopora* disappeared completely following the warming in 1998, and several more species such as the major shallow water, energy-breaking species *Isopora palifera* have been reduced by over 90%. As observed in numerous countries, several Pocilloporiids including the genera *Seriatopora, Pocillopora, Stylophora* and several finger form species of *Acropora* have likewise temporarily disappeared, or almost so, but may recover as was the case after their disappearance following 1998. Regarding the near-endemic 'Chagos brain coral' *Ctenella chagius*, it was initially thought to have become extinct also after the 2015 warming event, but a few colonies have subsequently been found with small remaining live portions. With several of the heavily reduced populations, the zones where they dominated have now become devoid of most corals, and these zones include the main high energy, wave breaking zones that protect the islands.

Unfortunately, global climate projections suggest mean sea surface temperatures will increase by 1.5 – 2.6 °C by the end of the 21st century, potentially coupled with more pronounced marine heatwaves.[13]

Sea level rise is taking place, but while this is crucial in low lying islands,[14] it is not important to shallow habitats. Acidification of seawater is also relatively minor at present, given its tropical location. However, although not measured in BIOT, suspended sediments are clearly increasing, reducing the amount of light energy that reaches the benthos, following the disintegration of dead coral skeletons; the floor at 25 m in Salomon lagoon for example today commonly has water visibility of only 3–4 m, whereas 20–25 m was normal prior to extreme warming events..

Locally derived threats are relatively minor given the uninhabited nature of most islands, and because most human induced degradation has been avoided since BIOT's creation about 40 years ago. However, impacts are commonly synergistic in their consequences[15] which means their management must be taken at least as seriously. Indeed, because management of such effects can take place, unlike global effects such as warming, it is important that control of localised events continues to be afforded a high priority.

Fishing has not been permitted since 2010 except for recreational fishing in Diego Garcia. Poaching is, by its nature, largely of unknown extent but best estimates are that it has been marked for holothurians in probably all northern atolls, and shark poaching has been significant throughout the archipelago. A survey in 2006 found that there were no introductions of marine species.[16] Anchoring by visiting recreation vessels is significant only in very circumscribed areas in two northern atolls where, however, its effects have been locally very destructive. Anchoring in Diego Garcia's military facility has been problematic in past years though today appears to have been resolved. And it has been found that elimination of invasive rats on islands which permits birds to exist also enhances the condition of the shallow coral reefs that lie close to shore. [17] These are enumerated in the table of Threats and Actions later.

In the event of resettlement, additional threats will emerge, including issues concerning shoreline construction and sewage disposal. However, such an event is by no means certain due to cost. Unfortunately, cost cutting itself, were construction to occur, generally tends to lead to later environmental problems.

Plastic litter and microplastic contamination is a topical subject; the former is unsightly and may be harmful to e.g. nesting turtles, while microplastic degradation products enter food chains involving filter-feeding species. Litter from Asian and shipping sources is substantial on beaches throughout all atolls. However, it has been noted that in Diego Garcia where litter clean-ups take place, the abundance of microplastics in sediments is significantly lower.[18] Thus beach clean-ups can be an important and effective means of reducing this source of pollution.

Diego Garcia

Diego Garcia is a special case, being the only permanently inhabited atoll at present, with a military facility and a few thousand inhabitants. While all atolls have been greatly disturbed on land as a result of the earlier coconut plantations,[19] Diego Garcia is the only one that has experienced substantial marine change. This has come initially from removal in the 1970s of numerous 'bommies' in the lagoon for shipping, and subsequently from ship anchoring and sewage discharges.

This is a very enclosed atoll, with extremely restricted water exchange that is required for healthy coral and reef growth. Substantial sedimentation takes place at the southern end, along with erosion of the northern lagoon shore where much infrastructure exists. Extensive and costly shoreline armouring already takes place to counter the erosion. The only way to avoid this, now that anchoring on the northern reefs has been halted, could be to markedly increase water exchange and encourage coral growth.

To achieve this, a breach in the south-eastern land rim would greatly increase water exchange, flush the more turbid lagoon water out and improve growing conditions and temperatures for coral growth and reef maintenance. It is recommended therefore that an environmental assessment be conducted to assess options for making and locating a breach. Such water exchange increases have been successful in other atolls, but one in Diego Garcia must avoid faunistically important sites such as 'Turtle Cove'. It can be argued that such drastic interference to an atoll should be avoided on principle, but dozens of interferences have already taken place in this one, none of which have helped the natural history, so performing one that does could well be justified and be hugely cost saving.

Recreational fishing is permitted in Diego Garcia. While it is partially limited and controlled, it still has a marked effect on the remaining fish composition,[20] which is unsurprising considering some species are targeted and others are protected. Therefore, regular monitoring of the surviving fish stocks and composition is needed to ensure the integrity of the reef fish populations.

5. Existing measures

Numerous local measures and laws exist to protect aspects of the environment, including and often particularly focussing on marine habitats and species. A concise set of environment objectives relevant to biodiversity are contained in the latest management plan, presently being drafted concurrently with the Biodiversity Action Plans.[21]

- To conserve or enhance marine and terrestrial biodiversity and ecosystems including, where practicable, restoration of damaged or degraded habitats;
- To sustainably manage recreational fishing activities and effectively monitor and prevent illegal fishing using methodologies;
- To manage and where possible eradicate invasive non-native species through active programmes of control; and prevent the introduction of new invasive non-native species through effective biosecurity measures;
- To ensure that permitted human activities within the Territory are undertaken to the highest possible environmental standards;
- To better understand the effects of climate change in the Territory through a programme of monitoring and research;
- To communicate widely the unique value of the Territory as one of the last marine wildernesses and foster its status a reference site for global conservation efforts through sharing of experiences and knowledge;

- To encourage and support high quality scientific work, both in support of our management and strategic objectives and to enhance our knowledge of the natural environment, and work with UK, regional and international organisations to promote research and collaboration.

ACTION NEEDED

There is essentially no 'management' that can be done of shallow marine habitats themselves, especially ones as vast, complex and rich as coral reefs since the overwhelming impact upon those of BIOT is coming from global climate changes acting from outside its boundaries. But there can be management of people and their impacts upon the habitats.

The present, extensive restrictions on use of the archipelago have in the past have meant that its shallow marine habitats have been those in best condition in the Indian Ocean. But it has been predicted in numerous studies that warming, already very damaging, will increase in severity in terms of both temperature and of increasing frequency of marine heatwaves, so that the fate of these highly biodiverse shallow reef habitats ultimately lies outside any management that can be done from within the archipelago. It is of course important that any possible greenhouse gas reduction measure be maintained on the inhabited island of Diego Garcia. However, given the fact that impacts are commonly synergistic in their effects, of key importance is to maintain existing restrictions on activities that would add to the stresses on the shallow reefs that already exist from climate change. Doing so, such that the only significant impact comes from warming, is likely to mean that the life of these reefs will be extended.

Actions. Table of key issues relating to shallow water biodiversity and measures required to enhance biodiversity and habitat functioning.

Activity	Priority
All atolls	
Commercial fishing. Maintain the present ban.	High
Recreational fishing. Maintain or increase the current restrictions.	High
Shoreline development, northern atolls. In the event of any development of these atolls, impose strict, professional and binding restrictions on what activities can be done	High
Beach clean-up of plastic litter	High
Diego Garcia	

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Shoreline development in Diego Garcia. Improve the present EIA mechanism.	High
Recreational fishing. Maintain or increase the current restrictions. Perform regular assessments to determine adverse effects of the fishing.	
Improve water exchange. Perform exploratory EIA on breaching the south-eastern rim with a view to increasing flushing and water exchange.	High

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