# Short Communication

## The present status of the shallow reef patches at the Bar Reef Marine Sanctuary, Sri Lanka

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## Abstract

The Bar Reef Marine Sanctuary (BRMS) has been subjected to various natural and anthropogenic stressors for decades and notable fluctuations in Live Coral (LC) cover has been observed over the years. In order to assess the current status, a preliminary survey was conducted at the shallow reef patches of BRMS in February 2021 to investigate the diversity and abundance of existing coral species. Line Intercept Transects (LITs) were deployed between the depths of 1.5 m to 4.0 m and subsequent LC, Coral Rubble (CR), and Dead Coral (DC) covers were recorded. Total mortality in LC species (0% live coral cover) was observed during the preliminary survey, and it was also evident that the structural integrity of the DCs was severely depleted, creating extensive unconsolidated CR fields in the vicinity. A negligible proportion of new coral recruits (less than 1%) of *Acropora* sp. was observed at the study site. Moreover, an abundant overgrowth of seaweed *Stoechospermum polypodioides* was visible in all sampling sites whereas, the occasional occurrence of *Halimida opuntia* and *Halimida macroloba* were also present in small numbers. Even after the 1998 mass bleaching event, the shallow reef patches of BRMS had recovered from nearly 0% to 40% within a five-year period. Yet the situation is quite different after 2016 bleaching event, where no recovery was observed after five years. Hence the reef should receive immediate attention and restoration measures should be implemented to enhance the reef recovery and promote restoration.

**Keywords:** BAR Reef Marine Sanctuary (BRMS), live coral cover, mass bleaching events, Line Intercept Transect (LIT), reef recovery

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## Introduction

Bar Reef Marine Sanctuary (BRMS), located in the Northwestern coastal zone of Sri Lanka is one of the largest Marine Protected Areas (MPAs) in Sri Lanka covering an area of 306 $km^2$. The reef consists of patchy reef areas at variable depths ranging from 1 to 20 m. Thus, based on the depth profile, the reef can be partitioned into two; Shallow Reef Patches (SRP) and Deep Reef (DR). The SRP (1 - 10 m) were reported to have a dominant cover of branching *Acropora* species and *Echinopora lamellosa* that surpassed 50% of the Live Coral (LC) cover during the late ’90s (Rajasuriya and White, 1995). Rajasuriya *et al*., (1997) assessed the average LC cover of the shallow reef flats of BRMS as (83.95%); Acropora sp. (73.37%), and *E. lamellosa* (8.58%).

The mass bleaching event that occurred in 1998 resulted in nearly a total mortality (less than 1%) of *Acropora* and *Echinopora* corals in the SRF and the coral species that survived the event were found to be limited to the deeper areas below 10 m (Rajasuriya, 2002; Rajasuriya and Karunarathne, 2000). After the bleaching event, total Dead Coral (DC) cover was recorded as 87.5% with the remaining 12.5% represented by Soft Corals (SC) and other bottom habitat types (Rajasuriya, 2005). According to post-bleaching surveys conducted in 1998 and 1999, an overgrowth of two filamentous algae species (*Bryopsis* sp.) was observed growing on the dead reef areas of the reef. *E. lamellosa*, *Galaxea fascicularis*, *Favia* sp., *Favites* sp., *Pavona varians*, *Pocillopora verrucosa* and *Acropora* sp. were observed to be the remaining species that had survived in the shallow reef areas during the bleaching event (Rajasuriya and Karunarathne, 2000). Moreover, the reduction of corallivorous butterflyfish abundance was also notable during the post-bleaching period and it provided clear evidence on the reduction of Scleractinian coral cover.

The survey conducted by Rajasuriya (2002) revealed that the shallowest reef patches, previously considered totally degraded, had retained their coral cover through the re-emergence of *Pocillopora damicornis* and many branching and tabulate *Acropora* colonies. Compared to the SR patches, a high percentage of LC cover was recorded at the depths of 7–8 m where the presence of many hermatypic corals species (*Acropora* sp., *Montipora* sp., *Favites* sp., *Favia* sp., *G. fascicularis*, *Pavona* sp., *Cyphastrea* sp., *Hydnophora microconos*, and *Podabacea crustacea*) were recorded. The estimated LC cover was 14% of which 3% was branching *Acropora* species whilst 0.3% was tabulate *Acropora* species. Other substrate types; Coral Rubble (CR), DC with algae, and small sandy patches consisting of about 80% cover.

Another survey carried out in 2005 revealed that the BRMS was not affected by the tsunami and the LC cover was recorded as 18.64% in 2003 and 40.76% in the last quarter of 2004 (Rajasuriya, 2005). The same trend, which indicates an increase in LC cover was observed in subsequent years as the LC cover increased from 40% in 2004 to about 70% in early 2007. The rapid growth of *Acropora cytherea* which constituted 75% of LC in 2007 had remained the governing factor for the rapid expansion of LC cover in the BRMS. A peak LC cover of 90% was observed during the year 2011 and thereafter a gradual decline in LC cover was observed (UNDP-GEF-DWC, 2019). Two independent surveys that were carried out in 2017 to assess the status of the Bar-reef, post-2016 coral bleaching event indicated massive coral mortality with LC cover on the reef crests of the two shallower reef sections to be less than 2% of substrates. These areas were the sections of the reef that survived and recovered post-1998 bleaching event and are believed to have the highest chance of future recovery.

As stated above, it is well evident that the SRP of the BRMS has continuously been subjected to changes with respect to LC cover and sequential monitoring is essential to early identify and implement management actions. Therefore, our study was focused on accessing the benthic cover in the SRP to understand the degree of recovery for the past five years time from the bleaching event in 2016.

## Materials and Methods

An underwater survey was conducted at the shallow reef flats of BRMS in February, 2021 to investigate the diversity and the abundance of existing corals species. Survey sites were selected from reef sites monitored previously by NARA. Five sampling locations were selected to conduct underwater visual surveys between the depths of 1.5 and 6 m. Line Intercept Transect (LIT) methodology was adopted for the underwater survey (Hill and Wilkinson, 2004).

### Key observations

Total mortality of hard coral species was observed during the present survey (Figure. 1a). No visible LC cover was observed within the transects. A negligible proportion of new coral recruits (less than 1%) of *Acropora* sp. was present at the study site where the average cover was estimated to be around 24% (Figure.1b). An abundant overgrowth of seaweed *Stoechospermum polypodioides* was visible in all the sampling sites (Figure. 1c). The occasional occurrence of *Halimida* sp. was also evident in small numbers (Figure. 1d). Occasional sightings of corallivorous butterflyfish species: *Chaetadon collare* and *C. octofasciatus* were also recorded during the survey.

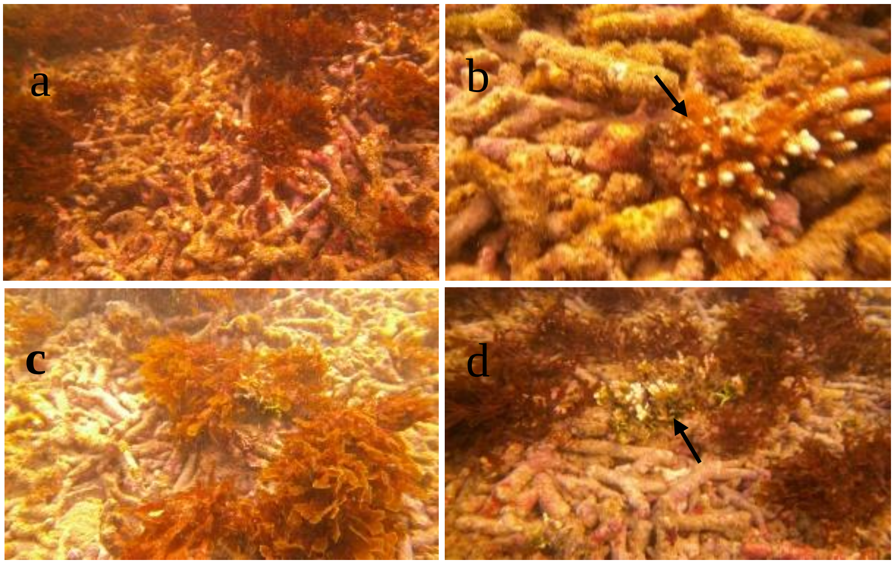


Figure 1: a) Abundant coral rubble substrate at the sampling sites, b) new recruitment of *Acropora* sp. (marked by an arrowhead), c) *S. polypodioides* d) *Halimida* sp. (marked by an arrowhead)

## Discussion

The only instance where the LC cover of the shallow reef flats of the BRMS reached nearly 0% is the mass bleaching events that occurred in 1998 and 2016 (Figure 2). However, a steady increase in the LC cover was observed up until 2011 and after that, it was evident that the degradation of existing coral cover had accelerated remarkably (UNDP-GEF-DWC, 2019). Even after the 1998 mass bleaching event, the shallow reef flats of BRMS recovered from 0% to 40% within five years time.  Yet the present status is quite different where no recovery was observed for the subsequent five-year period after 2016 bleaching event. Most notably, the structural integrity of the reef has been completely depleted and as a result, vast areas of unconsolidated CR beds were observed during the survey.

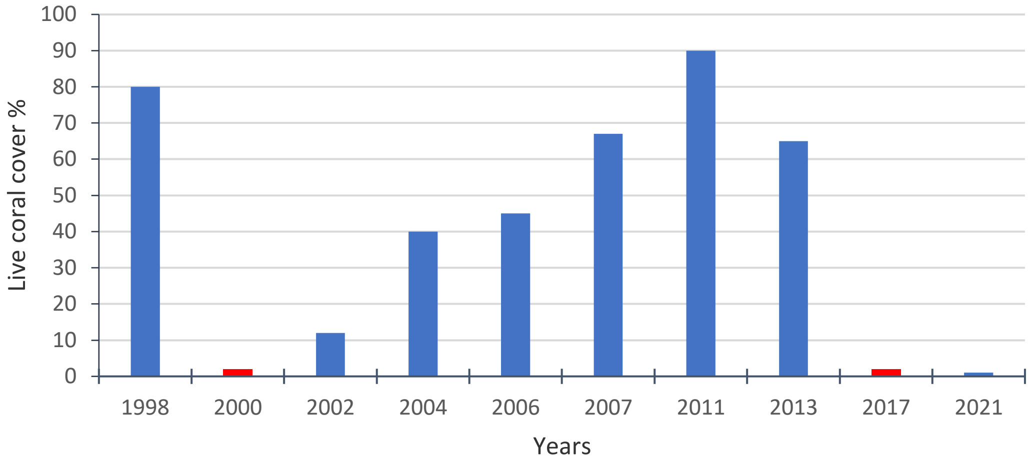


Figure 2: Changes in the LC cover of BRMS from 1998 to 2021. The bars highlighted in red represent the post-bleaching reef surveys (Derived from Bar Reef Management Plan by UNDP-GEF-DWC, 2019).

It is well established that the unconsolidated CR hinders the attachment of new coral recruits when the natural consolidation rates are impaired by the high rates of rubble generation (Ceccaralli *et al*., 2020). Hence, the management and restoration plan for BRMS should consider either rubble removal or substrate stabilization techniques to promote natural reef recovery. The coral areas (mostly deeper areas) that have survived may serve as a viable reproductive source for the regeneration of the degraded reef area following disturbances (Bongaerts *et al*., 2010). Yet for the past five years, SRP has been unable to recover highlighting that other stressors may act as limiting factors for the natural recovery.

The low abundance of corallivorous butterflyfish species at the BMRS is a clear bio-indicator of reef health depletion in the SRP (Van Quan and Vinh, 2009). Similarly, the rapid overgrowth of macroalgae can be subjected to land-based nutrient enrichment or the lack of competition imposed by corals for the substrate. Hence more research is needed on the behavior of different bio-indicators of reef health in the vicinity of BMRS to have a proper insight into possible correlations. Nutrient enrichment and sedimentation are admitted to have adverse primary and secondary interactions with corals that lead to coral mortality, decreased reproductive success, alterations in skeletal density and calcification rates, increase disease susceptibility, macroalgal overgrowths, sediment smothering, and so forth (Dunn *et al*., 2012; Fabricius, 2005; Nugues and Roberts, 2003). Conversely, Sri Lanka being the 2$^{nd}$ largest fertilizer consumer in the South-Asian region: 297.8 kilograms per hectare of arable land, almost tallying with Bangladesh (320.9 kg/ha), has raised major concerns on nutrient loading into the coastal waters (World Bank, 2022). Hence it is imperative to study the effects of nutrient enrichment and sedimentation on coral reefs not limited to the BRMS but along the entire coastal area to in cooperate some level of control on these manageable stress factors

## Future implications

To account for the variable change in LC cover and reef health it is recommended to conduct annual monitoring in both SRP and deep reef areas of the BRMS. Similarly, long-term monitoring is recommended to investigate the changes in bioindicators of reef health; macroalgae, micro and meiobenthic, corallivorous fish, Foram Stress Index (FSI) (Dimiza *et al*., 2016), etc. and ultimately predict the trend in reef health at the BRMS. Moreover, *in situ* coral restoration programs should be implemented with a proper scientific background to enhance and facilitate the reef's recovery.

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