Research article

Differences in Benthic Cover and Fish Assemblage Inside and Outside Marine Protected Areas

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Abstract Marine protected areas (MPAs) are being used increasingly to manage and protect marine resources. Most studies of MPAs have only focused on either benthic cover or fish assemblage. In this study, the influence of MPA protection on both parameters in two areas at Bohol (Badiang, Anda and Baybayon, Mabini) was investigated. At each MPA, three 50-m transect lines at 10 m interval were permanently established inside and outside at 5-8 m depth. The systematic point intercept method was used in determining the benthic cover and fish visual census method for fish assemblage. In Badiang, the protected area had significantly higher live hard coral cover than the general use area. Dead coral with algae covered the general use area in both Badiang and Baybayon. Fish species richness were significantly different in Baybayon with moderate condition in protected area and poor condition in the general use area. Fish density inside the protected area and general use area were not significantly different but were in moderate condition. The high levels of hard coral cover and fish species richness in the protected areas may be a result of their protection status.

Keywords coral, coral nursery unit, fish assemblage, restoration, management

INTRODUCTION

A part of the world's population lives along the coastal plain comprising the coasts, seas, oceans, rivers and estuaries. Humans deal with the coastal and aquatic ecosystems as food resources and a large proportion of the people in most countries are dependent on aquatic resources to provide their daily needs. Unfortunately, many of these natural ecosystems have been indiscriminately harvested or even devastated due to over fishing, physical and chemical destructions arising from industrial activities, untreated sewage of nearby cities and factories, oil and gas contamination from refineries and passing vessels and oil rigs. All these factors have caused the destruction and/or degradation of marine ecosystems, especially decrease in the population of many kinds of aquatic biota (Azhdari et al., 2012).

One of the solutions being used to address the threats plaguing marine resources is the establishment of marine protected areas (MPAs). They are "clearly defined geographical spaces, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (IUCN definition by Dudley, 2008). This is one of the most achievable modes of protection particularly in the Philippines in relation to Coastal Resource Management (CRM) (White et al., 2002). In the Philippines, MPAs can be categorized into two governance levels: nationally established and locally established MPAs. In general, they take four forms: 1) Marine sanctuary or no take marine reserve, where all forms of

extractive activities are prohibited; 2) Marine reserve, where extractive and non-extractive activities are regulated; 3) Marine parks, where uses are designated into zones; and 4) Protected landscape and seascape, where protection may include non-marine resources (Miclat and Ingles, 2004, White et al., 2014). The most common objectives of MPAs establishment are biodiversity conservation, fisheries sustainability, and tourism and recreation, among others.

In a recent review of 112 independent empirical measurements of 80 different reserves, it was found that average values of all biological measures were strikingly higher inside marine reserves compared to the general use areas (Halpern, 2003). Relative to general use sites, population densities were 91% higher, biomass was 192% higher, and average organism size and diversity were 20–30% higher in reserves. Furthermore, these values were independent of reserve size, indicating that even small reserves can produce high values.

There are only a few reports that determine the biological response of the reserve protection in Bohol (Pollnac et al., 2001). Thus, this study investigated the benthic characteristics condition of the general use and protected area as well as reef fish status based on the diversity and density of fishes. In addition, we tried to determine if there is a significant difference between these parameters in the general use and protected areas.

METHODOLOGY

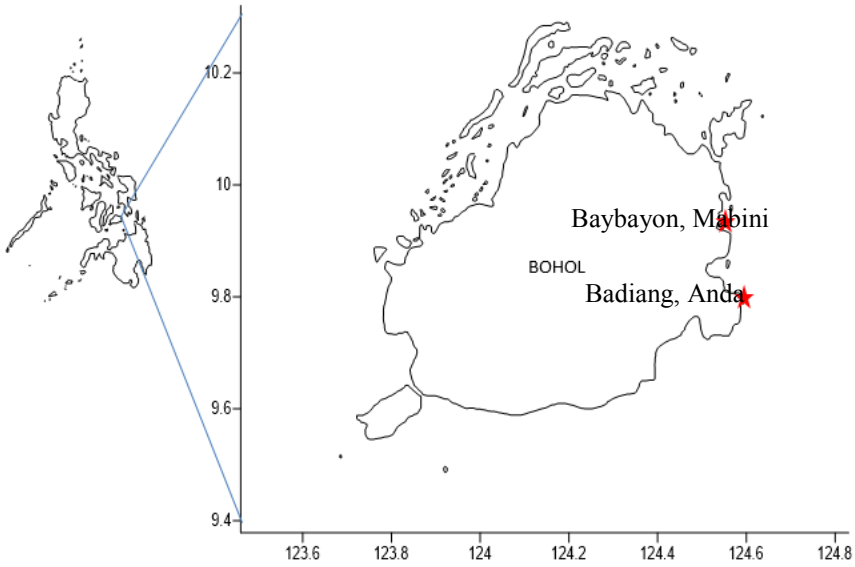

Fig. 1 Map showing the locations of the two MPAs in Bohol as survey sites

Site Selection

This study was conducted in the MPAs at Badiang, Anda, and Baybayon, Mabini, located in the eastern part of Bohol (Fig 1). Badiang, Anda MPA known as Badiang Fish Sanctuary was established in 2003 with a total area of 0.701 km^2 while Baybayon, Mabini known as Lumayag Islet Marine Park was established in 1995 with a total area of 0.265 km^2.The river water quality was monitored at 37 sampling points located on the main stream (nos. 1-17) and each tributary (A-T) of the Tokachi River basin in June, either August or September and October from 2007 to 2011 under base flow conditions. Water samples were analysed for pH, BOD, SS and EC.

Benthic Survey Technique

The benthic cover at each location along three randomly established transect lines at 5 m depth (during highest high tide) were assessed using the systematic point intercept method. Each transect was 50 m in length. Photographs were taken using an underwater camera at .25 m intervals and at a height of .50 m above the substrate of each transect. To examine the condition of the coral reef, we grouped the coral cover into 16 categories: branching, table, digitate, encrusting, foliose, mushroom, massive, sub-massive, soft, macroalgae, seagrass, other fauna, dead coral, rubble, hard rock, and sand. Coral reef status were categorized using the criteria of Gomez et al. (1994).

Fish Species Richness and Density

Divers recorded the density and diversity of fish in 250 m^2 area demarcated by a 50 m transect line (laid during the benthic survey) an hour after the benthic survey. The number of individuals per species was noted. The families surveyed are those that are diurnal only. Reef fish status was determined based on fish density (individuals/1,000 m^2) and diversity (mean number of fish species/250 m^2), using the categories by Hilomen et al. (2000).

Statistical Analysis

The data were arcsine transformed to pass the assumptions. T-tests were used to determine if there is a significant different between each biological component measured in the general use and protected areas.

RESULTS AND DISCUSSION

Living structures excluding dead corals covered an average of 51% and 33% of the substrate in the protected areas of Badiang and Baybayon, respectively, and 10% and 29% in the general use areas (Fig. 2). Live hard coral, rubble, and sand and silt were among the benthic categories which have high percentage cover in both protected areas of the study sites. Dead coral with algae, sand and silt, and rubble were among those which have high percentage in the general use areas. Soft corals, sponges, and fleshy algae combine contributed less than 3% to total benthic cover in both protected and general use. In Badiang, the protected area had significantly higher live hard coral cover compared to the general use area ($p < 0.05$). Its live hard coral, which had the highest coral percentage cover observed, was classified as 'good'. The general use in Badiang was 'poor' while the coral status in Baybayon in both general and protected areas was 'fair'.

The 1950's were typically regarded as the start of the demise with the introduction of dynamite fishing during the Second World War and other illegal practices in the subsequent decades, such as cyanide fishing and trawling (Marcus et al., 2007). Green et al. (2002) conducted a survey on illegal fishing in Bohol Province and they found out that out of 11 out-lawed fishing gears and activities, dynamite was the most widely used. Though the areas examined in this study are not listed as dynamite and cyanide hotspots in Bohol by Green et al. (2002), we suggest that the use of cyanide, and local plant poisons such as *tubli* and *lagtang* were the most likely reason for the high percentage cover of dead coral with algae in the general use areas since this kind of destructive fishing practices do not directly result in physical breakage of hard corals (McManus et al., 1997). The presence of rubble in the protected and general areas also indicates incidence of dynamite fishing.

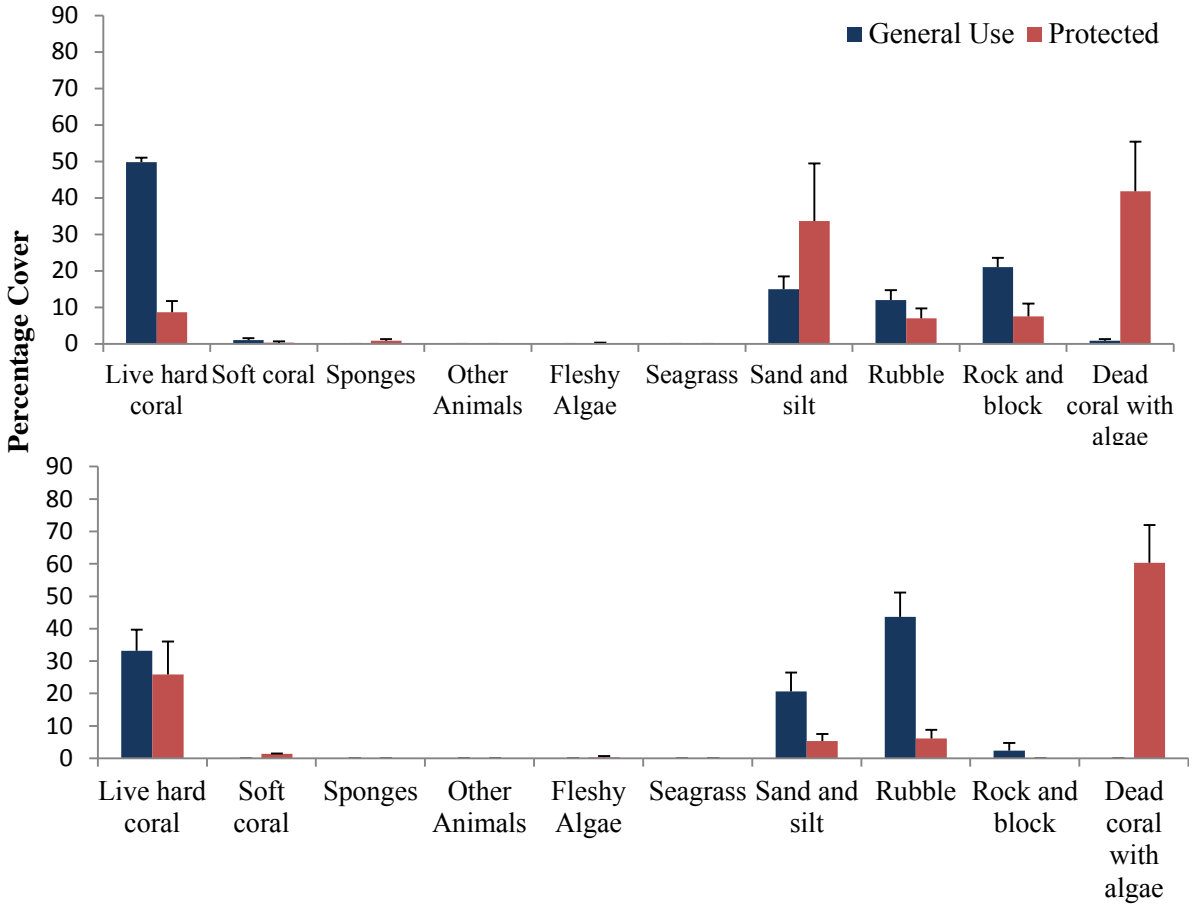

Fig. 2 Benthic composition in the general and protected areas at Badiang and Baybayon

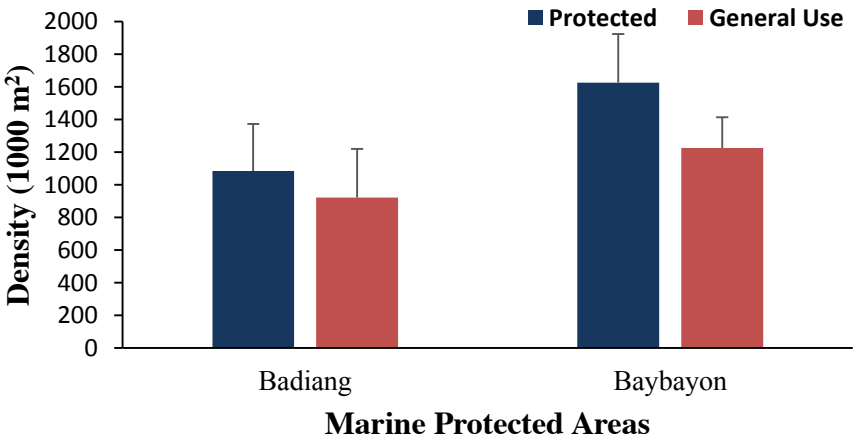

Fig. 3 Fish density in the two marine protected areas

Fish diversity were significantly different in Baybayon with a moderate condition in protected area and poor condition in the general use area (Table 1). However, fish density in the protected and general use areas of both Badiang and Baybayon showed no significant difference (Fig. 3). This is an indication that they were under more or less of the same condition. Based on the classification of

Hilomen (2000), the density of fishes in all study areas were in moderate condition. The most dominant families in both Badiang and Baybayon came from Pomacentridae and Pomacanthidae. Higher density of these species was probably due to the lack of top predators which declined following intense fishing pressure (Corrales et al., 2015).

Table 1 Species richness in the marine protected areas at Badiang and Baybayon

Family	Badiang		Baybayon	
	Protected	General Use	Protected	General Use
Acanthuridae	x	x	x	x
Apogonidae	x	x	x	x
Balistidae	x	x	x	
Caesionidae			x	
Chaetodontidae	x	x	x	x
Centriscidae		x	x	
Haemulidae	x	x		
Holocentridae	x		x	
Labridae	x	x	x	x
Lethrinidae				
Lutjanidae	x	x	x	x
Monacanthidae		x	x	
Mullidae	x	x	x	x
Ostracidae			x	
Ogcocephalidae			x	
Nemipteridae	x		x	x
Pempheridae	x	x		
Plotosidae	x	x	x	x
Pomacanthidae	x	x	x	x
Pomacentridae	x	x	x	
Scaridae	x	x	x	x
Scorpaenidae			x	
Serranidae	x	x	x	x
Siganidae	x		x	x
Synodontidae		x	x	
Tetraodontidae	x		x	
Zanclidae	x	x	x	
Total	19	18	24	12

CONCLUSION

The MPAs the study sites have played an important role in fishery conservation and this is evident in the higher levels of hard coral cover and fish species richness within the areas. However, they still need long-term protection and good management to improve fish population.

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