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Status of Selected Coral Reef Ecosystem in Zambales, Philippines

ANNIE MELINDA PAZ-ALBERTO
ORCID NO. 0000-0002-2828-432X
anniealberto@clsu.edu.ph
melindapaz@gmail.com
Central Luzon State University
Nueva Ecija, Philippines

JOSHUA A. CAPONES
ORCID NO. 0000-0002-5234-656X
joshuacapones@clsu.edu.ph
Central Luzon State University
Nueva Ecija, Philippines

DARYL A. JUGANAS
ORCID NO. 0000-0003-0298-1095
daryljuganas@gmail.com
Central Luzon State University
Nueva Ecija, Philippines

ABSTRACT

Biodiversity loss is one of the current issues we are facing today. From the past years, biodiversity loss still continues, particularly in various ecosystems. The Coral reef ecosystem is one of the ecosystems near coastal areas where the biodiversity is degrading due to anthropogenic activities and natural causes. Coastal community`s food and livelihood rely heavily on coral reef ecosystems. Illegal fishing and overfishing are the main activities that contribute to the degradation of the coral reef ecosystem. As a result, the natural habitat of marine animals commonly found in coral reef ecosystems and mangrove ecosystems are affected, which leads to its degradation. An assessment was conducted to determine the current status of coral reef ecosystems in the selected coastal municipalities in Zambales. The methods used to assess the coral reef ecosystems are the photo transect method, manta tow, and snorkeling method to measure and determine the present coral cover of the study areas. Results of the study revealed that only the coral reef ecosystem in Sta. Cruz has good condition status. However, the coral reef ecosystems of Candelaria, Masinloc, and Palauig have only fair coral reef conditions. The total average percentage cover of dead corals is higher than the percentage of live hard coral cover. Thus, results indicate that the coral reef ecosystems, which serve as habitats of marine organisms, are already degraded due to human activities, climate change, natural forces such as strong waves, and predators.

Keywords: Biodiversity, Coral Reef Ecosystem, Degradation, Status, Human Activities.

INTRODUCTION

The Philippines is the second-largest archipelagic country in the world and the apex of the "Coral Triangle" (CT), and known as the world's center of marine biodiversity. The Philippines is also one of the 18-megadiversity countries (Heaney & Mittermeier, 1998). Seventy-six percent (76%) of known coral species, 37% of known coral reef fish species, and 33% of the world's coral reefs is contained on the entire CT region.

Coastal zones have mangrove forests, seagrass beds, and coral reefs that primarily provide food and livelihood to many people in coastal communities. The coastal zones in the Philippines significantly contributes to the country`s economic growth and gross domestic product.

Coral reef ecosystems are one of the earth's most diverse, beautiful, and complex ecosystems but also considered among the most sensitive ecosystems (Paz-Alberto, 2005). Coral reef ecosystems can be degraded in various causes. From later years until now, coral reef ecosystems are constantly being degraded by natural disturbances, anthropogenic causes, and climate change. Coral bleaching is one of the causes of coral damage. Saltwater is needed by the coral to survive, but during seasonal tides or extreme low tides, when the water level is low, shallow coral reefs are exposed to the sea surface. Without water, the sunlight heats up and dries the coral reef damaging the exposed part of the coral reef. Sixteen percent of coral reefs were destroyed throughout the world during the 1998 coral bleaching event and was the worst recorded event by far. The 1998 El Nino event coincided with prolonged periods of drought and was recorded to have higher than average sea surface temperatures (Cesar et al., 2003). Strong and powerful waves also cause destruction and fragmentation to coral reefs and can also destroy slow-growing coral colonies or communities. Natural predators such as sea stars, specifically crown of thorns (*Acanthaster planci* Linn.) feed on polyps of corals. Other predators of coral include fishes, marine worms, barnacles, crabs, snails (NOAA, 2020).

Coastal ecosystems of Zambales are heavily affected by mining industries manifested through water, air, soil, and sediment pollution (Espiritu & Paz-Alberto, 2018), sedimentation of coastal ecosystems (Paz-Alberto et al., 2021), and forest denudation leading to soil erosion(Paz-Alberto et al., 2013; Rivera & Paz-Alberto, In-Press). Further, the increase in population has also contributed to coastal ecosystem destruction due to the rampant use of illegal fishing techniques and gears. Rampant illegal fishing activities contributed to the degradation of the marine environment in Palauig, which eventually lead to the decrease in fish catch (BFAR & DENR, 2010). Population increase along Masinloc's coastline has also increased resource use and development. Municipalities of Candelaria and Sta. Cruz share the same sources of environmental degradation, which are dynamite fishing, soil erosion, and quarrying (Paz-Alberto et al., 2013; Paz-Alberto et al., 2015; BFAR & DENR, 2010). Other human activities, especially tourists and fishers that directly hit the corals, is the careless stepping on them that causes damages. Other causes with similar effects are boat sagging, anchoring, and coral harvesting.

OBJECTIVES OF THE STUDY

This study aimed to assess the status or condition of coral reef ecosystems in the marine protected areas in four municipalities of Sta. Cruz, Candelaria, Masinloc and Palauig, and to determine the percentage cover and the possible sources of coral reef degradation.

MATERIALS AND METHODS

Description of Study Areas

Zambales is one of the provinces of Region III or Central Luzon (Figure 1), geographically located at 15°30'13"N and 120°02'10"E. It covers an area of 3,714.40 km2. It is under Type I climate characterized with two pronounced seasons: dry (October to June) and wet (July to September). The coastal areas of Zambales are composed of seagrasses, coral reef, and mangrove ecosystems and some of these coastal areas are protected areas, such as the Masinloc-Oyon Bay

Seascape and Landscape, Panglit Protected Area (San Salvador Island), Hermana Mayor and Hermana Menor (Paz-Alberto et.al., 2021).

Scope of the Study

The study covered the coastal barangays of four municipalities of the province of Zambales, namely Candelaria, Palauig, Masinloc, and Sta. Cruz. The study site is the northern part of Zambales which is composed of four coastal municipalities, namely, Santa Cruz, Candelaria, Masinloc, and Palauig.

Coral Reef Assessment

Prior to conducting the coral reef assessment, the project research team secured a Prior Informed Consent (PIC) to the LGUs as well as the Local Transport Permit and Gratuitous Permit to the Department of Environment and Natural Resources (DENR) and Protected Area Management Board (PAMB).

The methods of assessment that were used to determine the present status of all the coral reef habitats present in all the marine protected area were manta tow method, snorkel method (quadrat and transect), and point intercept method. Three 100m transect lines were separately positioned inside the study area, wherein the observations using manta tow, point intercept and photo transect were done.

The manta tow method involved the snorkeler who observed an underwater area of good visibility while being pulled by a boat. It was the first and foremost assessment method used by the diving team to initially determine the presence of coral reefs in the locality. The snorkel method was executed by swimming over the transect line, which was within the area of counting of the quadrat held by the observer. The point intercept method involved the counting of corals present in the area of observation of the transect line with a 25cm interval between two points. The habitat criteria rating developed by the Philippine Coral Reef Assessment Training Guide of Bureau of Fisheries and Aquatic Resources (BFAR) was utilized to determine the status of the coral reef (Table 1).

Table 1

Habitat criteria rating chart for coral reefs

CONDITION	CRITERIA
Excellent	76% -100% hard coral cover
Good	51%-75% hard coral cover
Fair	26%-50% hard coral cover
Poor	0%-25% hard coral cover

Source: Participatory Coastal Resource Assessment Training Guide

Figure 1. Photo-transect in the coral reef ecosystem of Potipot Island, Candelaria, Zambales.

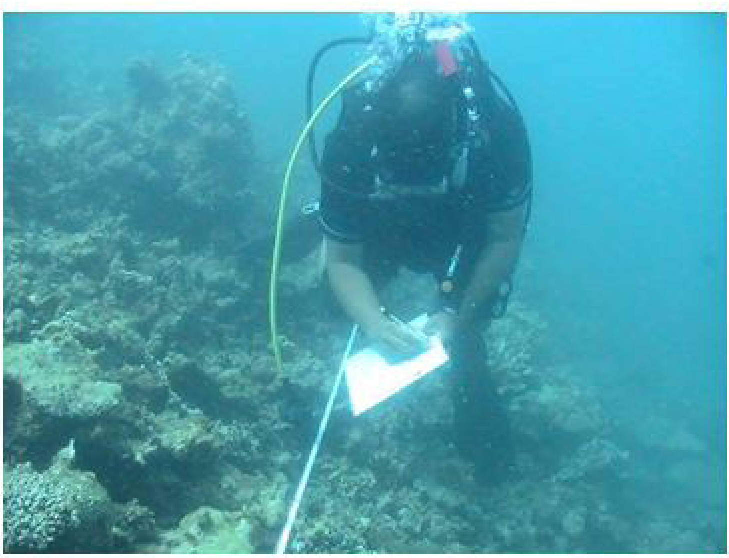

Figure 2. Photo-transect in the coral reef ecosystem of Hermana Menor, Sta. Cruz, Zambales.

Figure 3. Coral Photo-transect in the coral reef ecosystem of San Salvador Island, Masinloc, Zambales.

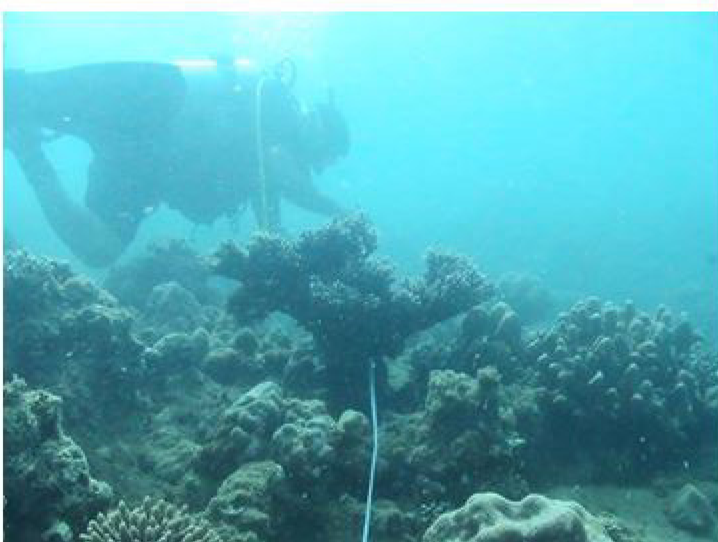

Figure 4. Coral Photo-transect in the coral reef ecosystem of Brgy. Garreta, Palauig, Zambales.

RESULTS AND DISCUSSION

Biodiversity Monitoring and Assessment of Coral Reef Ecosystem in Sta Cruz, Zambales

Table 2 shows the percent cover of the benthic life forms or the coral reef components using the transect line method at the three stations established in the Marine Protected Area of Sta. Cruz, Zambales.

Table 2

Percentage cover of coral reef components observed at the Marine Protected Area of Hermana Menor, Sta. Cruz, Zambales

Type of Corals	Benthic Life Forms	Percent Cover			
		Station 1	Station 2	Station 3	Average
Hard corals *Acropora*	*Acropora* Coral Branching (ACB)	0.48	0.00	0.00	**17.01**
	Acropora Coral Digitate (ACD)	5.22	4.26	0.00	
	Acropora Coral Encrusting (ACE)	0.00	0.00	0.00	
	Acropora Coral Submassive (ACS)	0.00	0.00	0.00	
	Acropora Coral Tabulate (ACT)	13.68	8.88	18.52	
	Sub-total	**19.38**	**13.14**	**18.52**	
Hard Corals Non-*Acropora*	Coral Branching (CB)	20.20	13.18	13.12	40.74
	Coral Encrusting (CE)	3.44	9.16	0.20	
	Coral Floise (CF)	0.60	0.00	0.00	
	Coral Massive (CM)	16.56	21.70	23.56	
	Coral Submassive (CS)	0.00	0.00	0.00	
	Coral *Millepora* (CME)	0.00	0.00	0.00	
	Coral Mushroom (CMR)	0.50	0.00	0.00	
	Coral *Heliopora* (CHE)	0.00	0.00	0.00	
	Sub-total	**41.30**	**44.04**	**36.88**	
Dead *Scleractinia*	Dead Corals (DC)	21.70	15.36	10.98	**24.02**
	Dead Coral with Algae (DCA)	6.60	9.76	7.68	
	Sub-total	**28.30**	**25.12**	**18.66**	
Algae	AA	0.00	0.00	0.00	**0.00**
	Halimeda (HA)	0.00	0.00	0.00	
	Macroalgae (MA)	0.00	0.00	0.00	
	Coral with Algae (CA)	0.00	0.00	0.00	
	Turbinaria (TA)	0.00	0.00	0.00	
	Sub-total	**0.00**	**0.00**	**0.00**	
Other Fauna	Other (OT)	0.00	0.00	0.00	**1.66**
	OTAS	0.00	0.00	0.00	
	OTBR	0.00	0.00	0.00	
	OTGO	0.00	0.00	0.00	
	OTHY	0.00	0.00	0.00	
	Zoanthids	0.00	0.00	0.00	
	SP	0.00	0.00	0.00	
	SC	2.52	1.96	0.50	
	CTU	0.00	0.00	0.00	
	Sub-total	**2.52**	**1.96**	**0.50**	
Abiotic	WA	0.00	0.00	0.00	**18.53**
	Rubble (RB)	0.50	4.00	1.20	
	Rock (RCK)	0.00	8.86	0.00	
	Sand (S)	9.90	6.90	24.24	
	Silt (SI)	0.00	0.00	0.00	
	Sub-total	**10.40**	**19.76**	**25.44**	
	TOTAL	**100**	**100**	**100**	**100**

The highest percentage of coral cover was recorded by hard corals with 17.01% in Hermana Menor Marine Protected Area (MPA) in Sta. Cruz, Zambales. *Acropora* and non-*Acropora* particularly the branching corals, are the dominant corals with 40.74% cover. This was followed by dead *Scleractinia* with 24.02% cover. Rubbles, rock, and silt were also recorded in all stations, with an average of 25.44% cover. In addition, another faunal composition was also recorded, and there was no algae observed in this coral reef ecosystem.

Figure 5 shows the graph of percentage cover of lifeform in the coral reef ecosystem in Hermana Menor Marine Protected Area (MPA) in Sta. Cruz, Zambales.

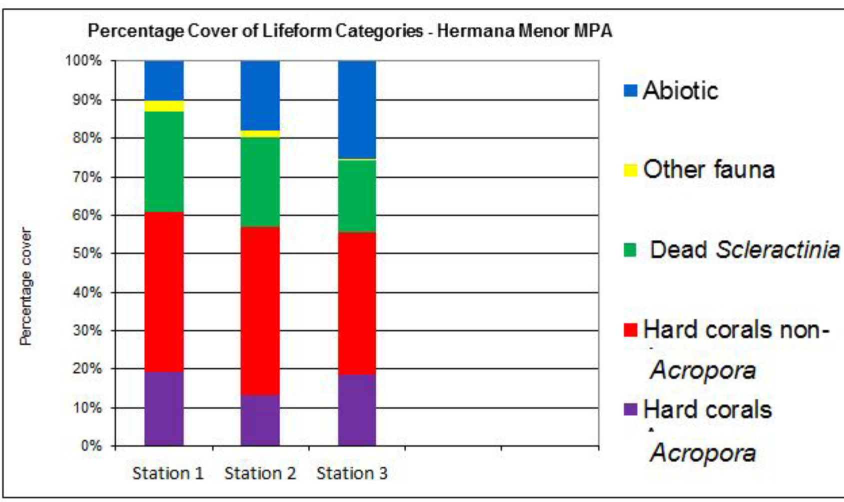

Figure 5. Percentage cover of lifeform in Hermana Menor.

Results show that there is a high percentage cover of living hard coral in all stations in Hermana Menor. Station 2 had the highest hard non-*acropora* coral, and station 1 had the highest percentage of *Acropora.* Station 1 recorded the highest percentage of dead corals, and station 3 had the least dead corals. Other fauna such as reef fishes was observed to have the least percentage in Station 3. Station 3 obtained the highest percentage of the abiotic composition.

Hermana Menor is listed as one of the protected areas in Zambales and is privately owned (Figure 6). Their strict rule with serious punishment greatly limits anthropogenic activity there, which helps to its conservation and preservation. Passing through the MPA requires permission from the owner even conducting a research study like what we did. The area is closed for fishing and other activities related to it. A less human activity sustains the coral reefs' function in maintaining the coral reef ecosystems in a more natural state, which means that the dead corals found are due only to natural causes and climate change. In addition, strong waves do not affect the coral reef ecosystem that much because it is situated inside the Hermana Menor Island, which serves as a barrier to the waves that reduces and stabilize the water flow.

Figure 6. Coral reef ecosystem in Hermana Menor, Sta. Cruz, Zambales.

Biodiversity Monitoring and Assessment of Coral Reef Ecosystem in Candelaria, Zambales

Table 3 shows the percent cover of the benthic life forms or the coral reef components in the Marine Protected Area (MPA) of Candelaria, Zambales.

The highest percentage of coral cover was recorded by non-*Acropora* hard corals with 21.09%. The present hard corals *Acropora* cover is only 5.55%. All stations were covered by dead *Scleractinia* with an average of 55.77%, which means most of the hard corals are dead. Rubbles and sand have 17.15%, and they were all observed in Station 2. Other faunas were also observed with 2.02%, and there were no algae observed in the area.

Figure 7 shows the percentage cover of lifeform in the coral reef ecosystem in Potipot Island Marine Protected Area (MPA) in Candelaria, Zambales.

The percent cover of dead Scleractinia was high, which indicates that live hard coral cover is low in the MPA of Potipot Island MPA. There were no recorded

Acropora in Station 3 but it had the highest living hard coral cover. There were no recorded fauna in Station 2, but it got the highest abiotic component.

The coral reef ecosystem near Potipot Island was declared as the MPA of Candelaria (Figure 8). There is a high percentage of dead corals in the MPA. According to the Bantay-Dagat, there is a lack of enforcers in the area hence; illegal fishers are very persistent in doing illegal fishing in the area. Illegal fishing methods, specifically dynamite fishing, were happening at night during the rest period and sleeping time of the guard which destroys the coral reefs faster than its natural death resulting in biodiversity loss and destruction of the coral reef ecosystem. Dynamite fishing is done easily and cheaply with dynamite created from locally available materials. Fish are killed by the shock waves and then collected from the bottom by divers. This method was used by a lot of fishermen due to the high initial value of catches. However, the value of catch rapidly depletes as the habitat of marine organisms is destroyed (Chan & Hodgson, 2017). Blast fishing kills not only marine organisms but also the physical structure of coral reefs (The Coral Reef Alliance, 2005). Scientists estimate that 56 % of the coral reefs in Southeast Asia are at risk from destructive fishing (Burke et al., 2002). Destructive fishing destroys the natural habitat where marine animals live and breed.

Table 3

Percentage cover of coral reef components observed at the Marine Protected Area of Potipot Island, Candelaria, Zambales

Type of Corals	Benthic Life Forms	Percent Cover			
		Station 1	Station 2	Station 3	Average
Hard corals *Acropora*	*Acropora* Coral Branching (ACB)	0.40	2.86	0.00	
	Acropora Coral Digitate (ACD)	5.70	0.00	0.60	
	Acropora Coral Encrusting (ACE)	0.00	0.00	0.00	
	Acropora Coral Submassive (ACS)	0.00	0.00	0.00	
	Acropora Coral Tabulate (ACT)	1.00	6.10	0.00	
	Sub-total	**7.10**	**8.96**	**0.60**	**5.55**
Hard corals non-*Acropora*	Coral Branching (CB)	0.00	1.26	1.50	
	Coral Encrusting (CE)	2.84	0.10	0.00	
	Coral Floise (CF)	0.40	0.00	0.00	
	Coral Massive (CM)	12.22	14.08	28.28	
	Coral Submassive (CS)	0.00	0.00	0.00	
	Coral *Millepora* (CME)	0.00	0.00	0.00	
	Coral Mushroom (CMR)	0.80	0.00	1.80	
	Coral *Heliopora* (CHE)	0.00	0.00	0.00	
	Sub-total	**16.26**	**15.44**	**31.58**	**21.09**
Dead *Scleractinia*	Dead Corals (DC)	15.00	30.66	42.32	
	Dead Coral with Algae (DCA)	47.38	10.04	21.92	
	Sub-total	**62.38**	**40.70**	**64.24**	**55.77**

Table 3 continued.

Type of Corals	Benthic Life Forms	Percent Cover Station 1	Station 2	Station 3	Average
	AA	0.00	0.00	0.00	
	Halimeda (HA)	0.00	0.00	0.00	
	Macroalgae (MA)	0.00	0.00	0.00	
	Coral with Algae (CA)	0.00	0.00	0.00	
Algae	*Turbinaria* (TA)	0.00	0.00	0.00	
	Sub-total	**0.00**	**0.00**	**0.00**	**0.00**
	Other (OT)	0.00	0.00	0.44	
	OTAS	0.00	0.00	0.00	
	OTBR	0.00	0.00	0.00	
	OTGO	0.00	0.00	0.00	
	OTHY	0.00	0.00	0.00	
	Zoanthids	0.00	0.00	0.00	
	SP	0.00	0.00	0.00	
	SC	4.52	0.20	0.90	
Other Fauna	CTU	0.00	0.00	0.00	
	Sub-total	**4.52**	**0.20**	**1.34**	**2.02**
	WA	0.00	0.00	0.00	
	Rubble (RB)	0.00	20.64	2.56	
	Rock (RCK)	0.00	0.00	0.00	
	Sand (S)	9.40	15.96	2.90	
Abiotic	Silt (SI)	0.00	0.00	0.00	
	Sub-total	**9.40**	**36.60**	**5.46**	**17.15**
	TOTAL				**100**

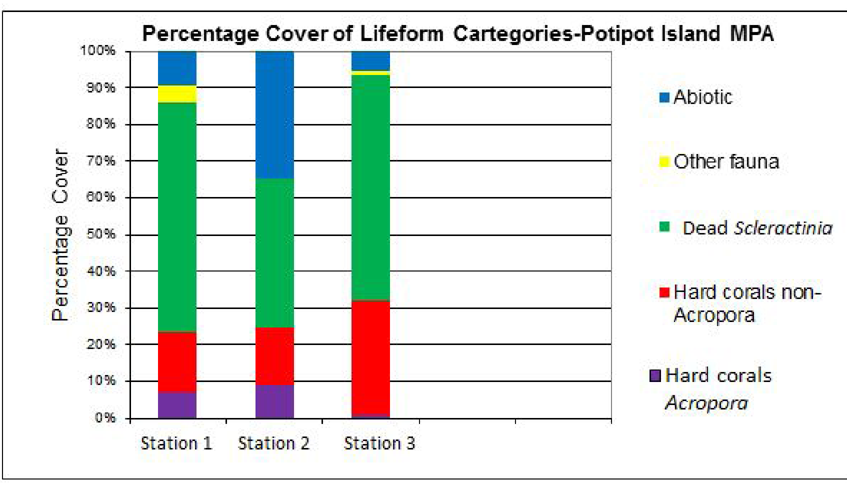

Figure 7. Percentage cover of lifeform in Potipot Island.

Figure 8. Coral reef ecosystem in Potipot Island, Candelaria, Zambales.

Biodiversity Monitoring and Assessment of Coral Reef Ecosystem in Masinloc, Zambales

Table 4 shows the percent cover of the benthic life forms and the coral reef components in the Marine Protected Area (MPA) of Masinloc, Zambales.

Table 4

Percentage cover of coral reef components observed at the Marine Protected Area of San Salvador Island, Masinloc Zambales

Type of Corals	Benthic Life Forms	Percent Cover			
		Transect 1	Transect 2	Transect 3	Average
Hard corals *Acropora*	*Acropora* Coral Branching (ACB)	0.76	0.00	0.80	
	Acropora Coral Digitate (ACD)	0.00	0.00	0.00	
	Acropora Coral Encrusting (ACE)	0.00	0.00	0.00	
	Acropora Coral Submassive (ACS)	0.00	0.00	0.00	
	Acropora Coral Tabulate (ACT)	0.00	0.00	0.00	
	Sub-total	**0.76**	**0.00**	**0.80**	**0.52**
Hard corals non-Acropora	Coral Branching (CB)	2.38	0.00	0.40	
	Coral Encrusting (CE)	0.00	0.60	0.00	
	Coral Floise (CF)	0.00	0.00	0.00	
	Coral Massive (CM)	21.44	39.94	11.18	
	Coral Submassive (CS)	0.00	0.00	0.00	
	Coral *Millepora* (CME)	0.00	0.00	0.00	
	Coral Mushroom (CMR)	0.10	0.60	0.00	
	Coral *Heliopora* (CHE)				

Table 4 continued.

Type of Corals	Benthic Life Forms	Percent Cover			
		Transect 1	Transect 2	Transect 3	Average
		0.00	0.00	0.00	
		23.92	**41.14**	**11.58**	**25.54**
Dead *Scleractinia*	Dead Corals (DC)	10.26	8.10	8.60	
	Dead Coral with Algae (DCA)	50.12	49.18	18.08	
	Sub-total	**60.38**	**57.28**	**26.68**	**48.11**
Algae	AA	0.00	0.00	0.00	
	Halimeda (HA)	0.00	0.00	0.00	
	Macroalgae (MA)	0.00	0.00	0.00	
	Coral with Algae (CA)	0.00	0.00	0.00	
	Turbinaria (TA)	0.00	0.00	0.00	
	Sub-total	**0.00**	**0.00**	**0.00**	**0.00**
Other fauna	Other (OT)	0.80	0.80	8.84	
	OTAS	0.00	0.00	0.00	
	OTBR	0.00	0.00	0.00	
	OTGO	0.00	0.00	0.00	
	OTHY	0.00	0.00	0.00	
	Zoanthids	0.00	0.00	0.00	
	SP	0.00	0.20	0.50	
	SC	0.00	0.00	0.00	
	CTU	0.00	0.00	0.00	
	Sub-total	**0.80**	**1.00**	**9.34**	**3.71**
Abiotic	WA	0.00	0.00	0.00	
	Rubble (RB)	4.94	0.58	25.34	
	Rock (RCK)	0.00	0.00	0.00	
	Sand (S)	9.20	0.00	26.44	
	Silt (SI)	0.00	0.00	0.00	
	Sub-total	**14.14**	**0.58**	**51.78**	**22.16**

The hard *Acropora* corals cover only a tiny average of 0.52%, but there are no *Acropora* corals present in Station 2, and the non-*Acropora* covers a total of 25.54%. Station 2 obtained the highest hard coral cover. Dead *Scleractinia* had an average of 48.11%, and these were mostly observed in Stations 1 and 2, with the highest dead corals recorded in the area. Rubbles and sand got an average of 22.16% where most of them were seen in Station 3. Other fauna had 3.71%, and there were no algae observed in the area.

Figure 9 shows the graph of percentage cover of lifeform in Marine Protected Area (MPA) located in San Salvador, Masinloc, Zambales.

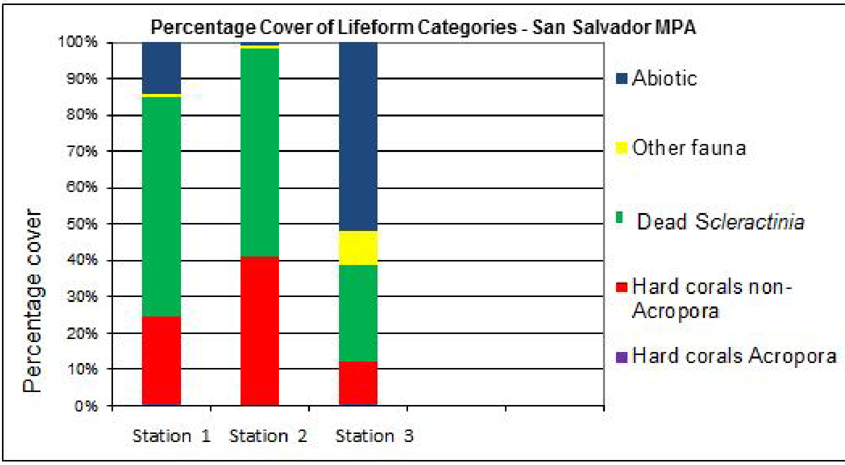

Figure 9. Percentage cover of lifeform in San Salvador.

In San Salvador, Station 2 had the highest hard coral cover but no recorded *Acropora* present in Stations 1 and 2. However, dead corals were observed to be high in both Stations 1 and 2. Station 3 had the highest abiotic components, more than the combined percentage of the hard coral, dead and other fauna. Station 2 had the least abiotic components.

Masinloc Oyon Bay is an MPA surrounding San Salvador Island (Figure 10). The part of the Masinloc Oyon Bay where the study was conducted is on the open sea where waves are strong. It contributes to the destruction of the corals as a natural cause because corals act as a barrier for strong waves, especially to branching corals growing in shallow water. Large and powerful waves from tropical cyclones can break apart large coral heads, scattering their fragments (NOAA, 2020). In addition, other animals such as crown-of-thorns were observed in the study area, particularly in Station 3.

Figure 10. Coral reef ecosystem in San Salvador, Masinloc, Zambales.

Biodiversity Monitoring and Assessment of Coral Reef Ecosystem in Palauig, Zambales

Table 5 shows the percent cover of the benthic life forms or the coral reef components in the Marine Protected Area (MPA) of Palauig, Zambales.

The average *Acropora* coral cover is 9.30%, where they had been observed in Station 2. Non-*Acropora* had an average of 31.17%. More massive corals were seen in Station 3. The average percentage cover of dead *Scleractinia* is 42.32%. Algae got a percentage cover of 2.5%, and the other fauna observed had 1.31% but there was no fauna observed in Station 3. The average percentage cover of abiotic components in all stations is 13.09%.

Figure 11 presents the percentage cover of lifeform in the coral reef ecosystem in Garetta Marine Protected Area (MPA) in Garetta, Paluig, Zambales.

MPA of Brgy. Garetta was observed to have hard corals in all stations (Figure 12). Station 3 was recorded to have the highest hard coral cover but Station 2 had the most *Acropora* coral cover. Station 3 also had the lowest dead corals observed among Stations 1 and 2, but with the highest abiotic components. No other fauna species were seen in Stations 2 and 3.

The study area is located where large waves are present that can stumble a small boat. Large waves in the area limit human activities such as fishing. Moreover, the major destructive factors in the destruction of coral reef ecosystems in Zambales are the sedimentation and siltation from coastal development and inland activities, destructive fishing, and overfishing. Also, boat anchors of fishermen can cause considerable damage to coral reefs, including coral breakage and fragmentation.

Table 5

Percentage cover of coral reef components observed at the Marine Protected Area of Garetta, Palauig, Zambales

Type of Corals	Benthic Life Forms	Percent Cover			
		Transect 1	Transect 2	Transect 3	Average
Hard corals *Acropora*	*Acropora* Coral Branching (ACB)	1.92	1.34	1.32	
	Acropora Coral Digitate (ACD)	0.00	0.00	0.00	
	Acropora Coral Encrusting (ACE)	0.00	0.00	0.00	
	Acropora Coral Submassive (ACS)	0.00	0.00	0.00	
	Acropora Coral Tabulate (ACT)	4.64	12.70	6.00	
	Sub-total	**6.56**	**14.04**	**7.32**	**9.30**
Hard corals non-*Acropora*	Coral Branching (CB)	5.58	4.38	8.84	
	Coral Encrusting (CE)	3.64	6.22	4.26	
	Coral Floise (CF)	3.24	1.06	2.94	
	Coral Massive (CM)	16.18	13.50	21.42	
	Coral Submassive (CS)	0.00	0.00	0.00	
	Coral *Millepora* (CME)	0.00	0.00	0.00	
	Coral Mushroom (CMR)	1.76	0.50	0.00	
	Coral *Heliopora* (CHE)	0.00	0.00	0.00	
	Sub-total	**30.40**	**25.66**	**37.46**	**31.17**
Dead *Scleractinia*	Dead Corals (DC)	0.20	0.92	3.28	
	Dead Coral with Algae (DCA)	50.04	43.18	29.34	
	Sub-total	**50.24**	**44.10**	**32.62**	**42.32**
Algae	AA	1.70	5.80	0.00	
	Halimeda (HA)	0.00	0.00	0.00	
	Macroalgae (MA)	0.00	0.00	0.00	
	Coral with Algae (CA)	0.00	0.00	0.00	
	Turbinaria (TA)	0.00	0.00	0.00	
	Sub-total	**1.70**	**5.80**	**0.00**	**2.50**
Other Fauna	Other (OT)	0.70	0.00	0.00	
	OTAS	0.00	0.00	0.00	
	OTBR	0.00	0.00	0.00	
	OTGO	0.00	0.00	0.00	
	OTHY	0.00	0.00	0.00	
	Zoanthids	0.00	0.00	0.00	
	SP	0.00	0.00	0.00	
	SC	3.08	0.16	0.00	
	CTU	0.00	0.00	0.00	
	Sub-total	**3.78**	**0.16**	**0.00**	**1.31**
Abiotic	WA	0.00	0.00	0.00	
	Rubble (RB)	7.28	8.84	19.10	
	Rock (RCK)	0.00	0.00	0.00	
	Sand (S)	0.00	0.00	4.06	
	Silt (SI)	0.00	0.00	0.00	
	Sub-total	**7.28**	**8.84**	**23.16**	**13.09**
	TOTAL				100

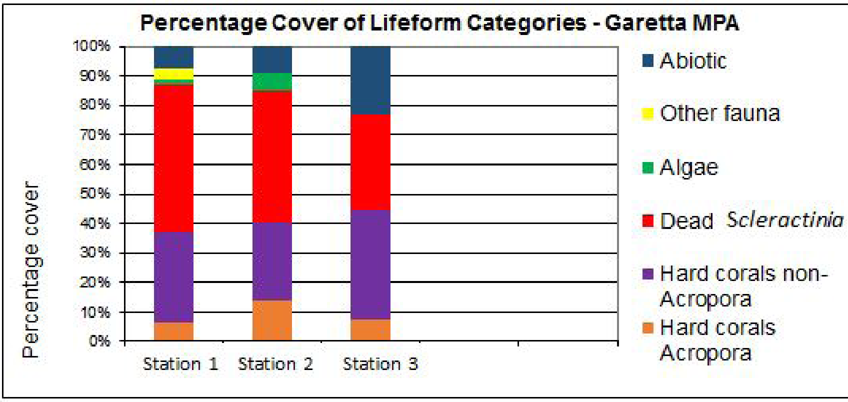

Figure 11. Percentage cover of lifeform in Brgy. Garetta, Palauig, Zambales.

Figure 12. Coral reef ecosystem in Brgy. Garetta MPA, Palauig, Zambales.

Status / Condition of the coral reef ecosystem

Sta. Cruz has still a good condition of coral reef ecosystem with a 57.75% combined average of both *Acropora* and non-*Acropora* hard coral cover in all 3 stations (Table 6). Colonies with good coral conditions indicate fish abundance, low coral-eating animals, low algae, low seaweed population, fewer dead corals and high living hard corals. However, high fish abundance may attract fishers specifically who practice illegal and destructive ways of fishing, which also cause degradation and destruction to coral reef colonies. The area was open for tourism by the owner but with strict rules. Hermana Menor`s waters are well protected and strictly guarded, which contributes to its protection from illegal fishers and coral collectors. Even passing through the protected area is not allowed without permission from the government and the owner.

Table 6

Habitat condition of coral reef in four municipalities of Zambales

MUNICIPALITY	% COVER	CONDITION
Sta. Cruz	57.75	Good
Candelaria	26.64	Fair
Masinloc	26.06	Fair
Palauig	40.47	Fair

The coral reef ecosystem of Candelaria has a fair condition of the coral reef only (Table 6). The three stations average of hard corals *Acropora* and non-*Acropora* resulted to 26.64%. Dynamite fishing is one of the problems that is facing by this MPA until today. Continuing dynamite fishing activities will reduce the coral reef ecosystem diversity at a faster, higher rate. Other life forms were also affected due to the effect of the explosion, especially the sensitive aquatic plants and animals.

Masinloc coral reef average percentage cover had 26.06%, cohich is the lowest among the three towns and also had a fair condition. Many of species of coral eating animals like a crown of thorns were also found in the study site in Masinloc which contributes to the degradation of coral reefs aside from the illegal fishing activities.

Palauig has a total percentage cover of combined *Acropora* and non-*Acropora* with 40.47% that indicates a fair condition. Coral bleaching was observed outside the study areas during the conduct of study due to extreme low tide, and this phenomenon was also observed by the residents, specifically by the personnel of Bantay Dagat, who patrols around the MPA. Moreover, exposed corals were being hit by waves during low tide, which destroyed most of them.

Figure 13 shows the overall total average of the hard-living corals and the dead *Scleractinia* of the four (4) study areas.

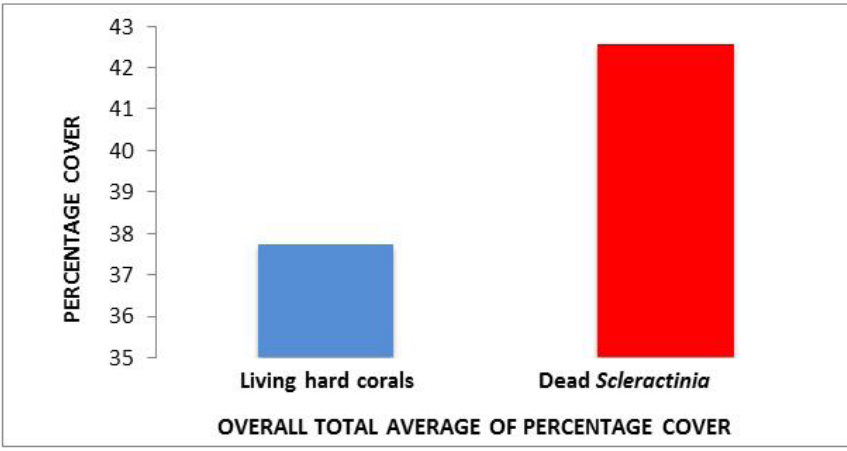

Figure 13. The comparison of living hard coral and dead *Scleractinia.*

The total overall live hard coral cover *Acropora* and non-*Acropora* in all established study areas from Sta.Cruz, Candelaria, Masinloc and Palauig was 37.73%, which indicates a "Fair" condition of the overall percentage cover of coral reef. The total overall percentage of dead coral is 42.56%, which is higher than the overall living hard *Acropora* and non-*Acropora* corals. According to Empeño (2016), there are reports of coral bleaching in Zambales which may be due to climate change. Climate change might have caused the bleaching, for there are indications of warmer-water temperatures in the area, which can cause coral bleaching. When water gets too warm, corals reportedly expel the algae living in their tissues, causing the corals to turn white (NOAA, 2020). Other factors for the destruction of the coral reef ecosystem are the development of the marine sanctuary and ecotourism sites near the coal-fired thermal power plant in the municipality of Masinloc. In addition, an outflow of mine drainage pollution into the sea is highly toxic to the aquatic environment, which could have devastating effects on the coral reef ecosystem and are likely to be knock-on effects up the food chain (Cotter & Breigden, 2006).

CONCLUSIONS

Coral reefs are already in decline in the four coastal municipalities of Zambales. Only one municipality (Sta. Cruz) in the study areas has a good condition of the coral reef ecosystem, and the three coastal municipalities (Candelaria, Masinloc and Palauig) have only fair conditions of their coral reef ecosystems. Human activities, natural hazards, and climate change contribute to the coral reef degradation in the study areas. These have resulted in adverse environmental and ecological effects, which might somehow affect the livelihood of the local communities living near the coastal resources in Zambales.

RECOMMENDATIONS

Conduct of a system approach research with regard to monitoring and assessment of the coral reef ecosystem must be done in all coastal municipalities in Zambales. Coral reef restoration must be done by the Local Government Units with the help of the local communities and other stakeholders to restore the habitat and corals which have been lost. An improvement of the coral reef resilience to mitigate future disturbances must also be performed. Efforts should be further made by every stakeholder to raise awareness and transfer technologies such as distribution of IEC materials and conduct of seminars and trainings to protect the coastal resources. Therefore, tremendous promotional activities must be executed to conserve the coral reef ecosystems and to increase the effectiveness of various conservation and management measures in the marine protected areas.

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