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Status of macroflora inside and outside marine sanctuaries of Apid, Mahaba and Digyo Islands, Inopacan leyte, Western Philippines

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Abstract

The study was conducted to determine the species composition, diversity, distribution and abundance of seaweeds and seagrass sinside and outside marine sanctuaries of Apid, Mahaba and Digyo Islands in Leyte, Philippines. Quantitatively, the data were collected using the transect-quadrat method. Three 50-100 m transects were laid perpendicular to the shoreline in each of the sampling sites. A total of 58 species of macroflora were recorded, of which51 species were seaweeds and 7 species were seagrasses. Seaweeds were dominated by chlorophytes (green algae) and rhodophytes (red algae) with 20 and 19 species, respectively. Macroflora inside marine sanctuaries were less diverse than outside marine sanctuaries based on Shannon diversity index. Generally, results also had shown that the status (abundance) of seagrass-seaweed inside the marine sanctuaries were in poor condition with a mean cover of 6.8% while outside marine sanctuaries had fair condition with a mean cover of 14.7%. The findings of the study concluded that the species diversity (seaweeds; P=0.02 and seagrass; P=0.001) and abundance (P=0.04) of macroflora between marine sanctuaries differed significantly. However, further t-test results revealed that there were no significant difference observed of its status when compared outside the marine sanctuaries. The poor status was attributed to the reef structure and substrate types of the sampling sites. The structure of the reefs from relatively wider and shallow reefs provide colonization of seaweeds and seagrasses compared to narrow reefs due to steep bottom topography. Substrate types vary from sandy, coral rubbles to coralline rocks providing habitat for diverse macroflora.

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Introduction

Seaweeds and seagrasses are major primary producers in the sanctuaries. Apart from their role in primary production, they prevent soil erosion and serve as habitat and feeding ground for shallow organisms. Seaweeds are valued as food for humans, sources of gels and chemicals used in every commodity (Ohno *et al.*, 1993). Seagrasses on the other hand, also serve as alternative feeding sites for young fish and nursery-ground for many invertebrates of commercial value, turtles, and seacows (Phillips and Meñez, 1988; Fortes, 1990). The economic importance of seagrasses although has not yet been quantified but it has been valued as source of food for coastal communities according to Fortes (1990).

The Cuatro Islas in Leyte of which the islands of Apid, Mahaba and Digyo belong, where this study was conducted are not exempted to the alarming situations on habitat degradation. Too much pressure on the resource base due to human exploitation has affected the ecosystems of these islands. Fishers from the island resort to destructive fishing methods thus destroying the vital resources, which support their livelihood to an irreversible loss of biodiversity and productivity.

To mitigate the destructions, efforts to improve the living standard of coastal people in the islands have been done through the establishment of Community-Based Marine Sanctuary (CB-MS) and implementation of alternative livelihood program of the three (3) islands. A program supported by the Federal Government of Germany from 1994 to 1999. The program assisted the island inhabitants in rehabilitating the degraded coastal environment; protect the marine resources from over fishing; and promote sustainable use. In March 1994, two marine sanctuaries were established, in Apid 7.2 hectares and Mahaba 7.8 hectares. A year after in June 1995, marine sanctuary in Digyo 4.5 hectares was established. The sanctuaries in the islands were embodied with legal protection through Barangay Ordinance (Ordinance No. 1, Series of 1994) and Municipal Ordinance (Ordinance No. 62, Series of 1994), whereas no fishing or any activity, except research is permitted inside the sanctuaries. In April 2000, Cuatro Islas was declared as Protected Seascape through Presidential Proclamation No. 270. The three islands are now under National Integrated Protected Area System (NIPAS Act of 1992) pursuant to R. A. 7586.

Marine Protected Areas (MPAs) are a response to the growing awareness that there is a need to conserve unique or representative spaces while they still exist. It has been tested that MPAs can conserve biological diversity by identifying and protecting representative spaces. By protecting the MPAs will, at the same time conserving the species that live there. There has been giving ample evidence that reef fishes abundance have increased considerably within MPAs due to protected management (Alcala and Russ, 2002).

While most biophysical monitoring done on MPAs particularly in the Philippines focused only on adult fishes and corals, macrophytes (seagrasses and seaweeds) were left out. Since these groups are also major contributors to the development and productivity of the reef, or are commercially exploited, their quantity or abundance should be of utmost important. Yet evidence of their increase due to the “no take policy” inside the MPAs have not been quantified, hence, this study to determine the present composition, diversity, distribution and abundance of seaweeds and seagrasses within marine sanctuary of Apid, Mahaba and Digyo Islands, Inopacan, Leyte and compare the results to outside marine sanctuaries in order to determine impact of protection and to make a conclusive inference about the changes in the abundance, distribution and species diversity of the major groups of seaweeds and seagrass.

Materials and methods

Study sites

The study was conducted in Apid, Mahaba and Digyo Islands, all are located off the shore of Inopacan, Leyte. The sites lie within Camotes Sea (Fig. 1).

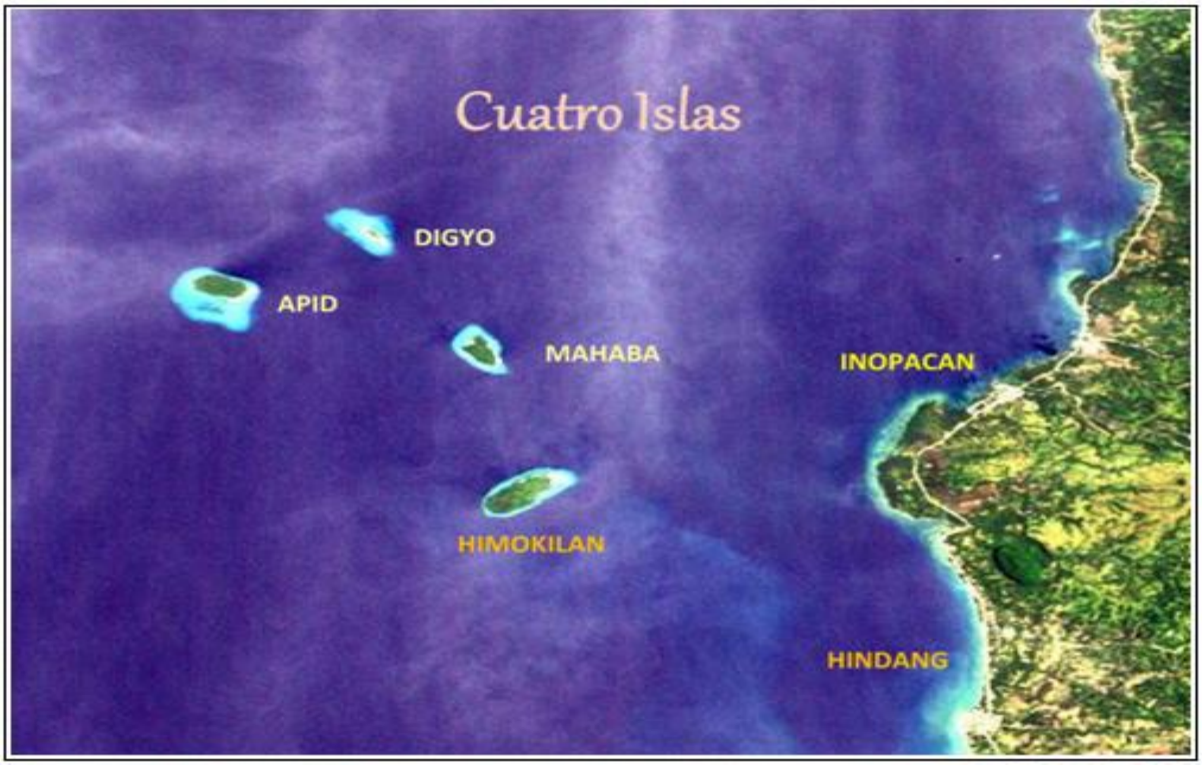

Fig. 1. Map of Cuatro Isla showing the three study sites, Apid, Mahaba and Digyo Islands, Inopacan, Leyte (Inset: Map of Leyte Philippines).(©Google Maps).

The three islands are under the administrative jurisdiction of the Municipality of Inopacan, Leyte. These formed part of the so called Cuatro Islas with Himokilan Island as the fourth island belonging to the Municipality of Hindang, Leyte.

The three islands have a total land area of 59.40 has of which the island of Apid is the largest with land area of 35.6 hectares followed by Mahaba with 20.3 hectares and Digyo is the smallest island with land area of 3.5 hectares. The size of the three marine sanctuaries vary with 4.5 hectares in Digyo as the smallest and 7.8 hectares in Mahaba as the largest while the sanctuary in Apid contained an area of 7.2 hectares. These sites can be located in the following coordinates (Fig. 1; Table 1).

Field sampling

Transect-quadrat method (English *et al.*, 1997) was used to quantify the seaweeds and seagrasses in and outside the sanctuaries. Of the three Marine Sanctuaries, only 50 m long transect was made in two sites (site A and B) of the Apid sanctuary where the tidal flat is narrow and the 3rd transect (C), 100m long was laid while Mahaba and Digyomarine sanctuaries, three (3) 100-m transect lines were laid perpendicular to the shoreline with the 0m of the transect line placed at the landward margin of the seaweed-seagrass bed and the 50-100m end at the seaward margin.

Ten (10) quadrats, each measuring 0.25 m^2 divided into 25 grids (10×10 cm each grid) were placed at 10m intervals along the right side of each transect line. Locations of these transect lines were approximately the same as in the previous monitoring. GPS coordinates in each of the replicate sites and land marks were followed (Fig. 2).

Sampling sites outside the marine sanctuary were located at the southern part of Apid, western part of Digyo and northern part of Mahaba sanctuary (Fig. 2). Three replicates with only 50-m long transects at Apid were laid perpendicular to the shoreline due to its barren and deep bottom while the other two sampling sites (Mahaba and Digyo), three 100-m transect lines were established and distance between transects was approximately 50 – 100m apart.

Data collection

Species composition

All seaweed and seagrass species within the quadrat were identified and recorded both inside and outside the marine sanctuary. Unidentified samples were collected and their taxon were verified based on Trono (1997) for seaweeds; Calumpong and Meñez (1997) for seagrass.

Cover and frequency

The percent cover of seaweeds and seagrasses in each quadrat was determined by recording the cover of each species in each of the 25 sectors based on the method used by Saito and Atobe (1970) in English *et al.* (1997). Present status of seaweed and seagrass cover was compared from outside status of the marine sanctuaries.

Data analysis

Abundance and distribution

Abundance and distribution of macroalgae and seagrass inside and outside (adjacent to) the marine sanctuaries were determined. Abundance was determined in terms of cover (C) for seaweeds and seagrasses. Distribution pattern of seaweeds and seagrasses were determined using Morisita's Index (Bakus, 1990) and calculated using the following equations:

$$= \frac{S\,(\sum n^2) - N}{N\,(N-1)}$$

Where is the total density and/ or cover per quadrat, *N* is the total density and/ or cover in all quadrats per transect, and *S* is the total no. of quadrats. Results of the Morisita's Index were interpreted using the arbitrary values (Table 2).

Species diversity index

To determine the relationship between the numbers of species to the number of individuals in an area (Murray, 1973), species diversity of seaweeds and seagrasses for each sampling sites were analyzed and calculated using Shannon-Weaver Diversity Index:

$$H = -\sum_{i=1}^{S} pi \ln pi$$

where *S*is the total number of species in each transect, $p_i$is the density/cover of species divided by the total density/cover per transect.

Statistical analyses

Two-factor Analysis of Variance (ANOVA) was computed using Microsoft Excel. This is to determine whether differences in species diversity, percentage cover of macroflora are significant among and between Marine Sanctuaries through time and within and outside the marine sanctuaries. Further analyses were done on the parameters that showed significant differences using Duncan's Multiple Range Test (DMRT) through SPSS (version 10) program.

Results

Species composition and diversity of macroflora within and outside marine Sanctuaries

Seaweed resources

There are 51 algal species identified within and outside the three marine sanctuaries.

Table 1. Coordinates area of the three marine sanctuaries.

Marine Sanctuary	Coordinates	Area (has.)	Orientation
Apid	10°32.389'N 124°38.321'E	7.20	North-eastern part of the island
Mahaba	10°31.049'N 124°40.189'E	7.80	South-western part of the island
Digyo	10°31.796'N 124°39.417'E	4.5	Western-part of the island

These species belonged to four algal groups (Cyanophytes, Chlorophytes, Phaeophytes and Rhodophytes). Of these, chlorophytes or the green algae are more number of species representing 20 species followed by rhodopytes or red algae with 19 species, phaeophytes or brown algae with 12 species and specie of cyanophyte (Table 3). Of the total seaweeds identified, *Bornetella nitida, Turbinaria ornata and Actinotrichia fragilis* were the common species distributed in and outside marine sanctuaries (Table 3). Among the three islands evaluated, Digyo and Mahaba have the highest number of algal species both in and outside marine sanctuaries, while Apid recorded 14 species both in and outside marine sanctuaries.

Table 2. Morisita's Index.

Morisita's Index (I)	Distribution pattern
1 (variance = mean)	Random
0	Uniform
> 1	Aggregate

Table 3. Species composition and distribution of seagrass-seaweeds between inside and outside marine sanctuary at Apid, Mahaba and Digyo Island, Inopacan, Leyte.

		Inside			Outside		
No.	Species	Apid	Mahaba	Digyo	Apid	Mahaba	Digyo
	Cyanophyta (blue-green algae)	1					
1	*Lyngbya majuscula*	x					
	Chloropgytes (green algae)	3	7	5	4	8	14
2	*Acetabularia dentata*						x
3	*Anadyomene plicata*					x	
4	*Boergesenia forbesii*		x				x
5	*Bornetella nitida*	x	x	x	x	x	x
6	*Bornetella oligosphora*				x		
7	*Bornetella sphaerica*		x			x	x
8	*Caulerpa racemosa*				x		x
9	*Caulerpa serrulata*						x
10	*Caulerpa sertularoides*						x
11	*Chlorodesmis sp.*	x	x	x			x
12	*Codium arabicum*						x
13	*Codium edule*						x
14	*Dictyosphaeria cavernosa*			x		x	x
15	*Dictyosphaeria versluysii*					x	x
16	*Halimeda opuntia*						x
17	*Tydemania expeditionis*	x	x		x	x	
18	*Udotea orientalis*			x			
19	*Valonia aegagrophila*		x			x	
20	*Valonia ventricosa*		x	x		x	x
	Phaeophyta (brown algae)	2	2	5	4	8	9
21	*Dictyota cervicornis*						x
22	*Dictyota dichotoma*			x	x	x	x
23	*Hormophysa cunieformis*					x	
24	*Padina japonica*						x
25	*Padinanimor*			x		x	x
26	*Sargassum crassifolium*				x	x	x
27	*Sargassum cristaefolium*			x	x		x
28	*Sargassum oligocystum*					x	

29	*Sargassum polycystum*					x	x
30	*Turbinaria conoides*		x				
31	*Turbinaria decurrens*	x		x		x	x
32	*Turbinaria ornata*	x	x	x	x	x	x
	Rhodophyta (red algae)	8	9	8	6	9	11
33	*Acanthophora specifera*						x
34	*Actinotrichia fragilis*	x	x	x	x	x	x
35	*Amansia glomerata*		x			x	
36	*Amphiroa foliacea*		x	x	x	x	x
37	*Amphiroa fragilissima*	x		x	x	x	x
38	*Galaxaura fasciculata*	x			x		
39	*Galaxaura oblongata*	x	x		x		
40	*Gelidiella acerosa*	x	x			x	x
41	*Gracilaria conoides*			x			
42	*Gracilaria licheumoides*	x					x
43	*Gracilaria salicornia*	x				x	
44	*Hypnea cervicornis*		x		x		
45	*Hypnea charoides*	x					
46	*Hypnea pannosa*		x	x		x	x
47	*Laurencia nidifica*			x			x
48	*Laurencia papillosa*		x	x		x	x
49	*Liagora farinosa*		x	x			x
50	*Mastophora rocea*					x	
51	*Peyssonnelia rubra*						x
	Seagrasses	7	0	5	4	0	6
1	*Cymodocea rotundata*	x		x	x		x
2	*Cymodocea serrulata*	x		x			x
3	*Halodule pinifolia*	x					
4	*Halodule uninervis*	x		x			x
5	*Halophila minor*	x			x		x
6	*Halophila ovalis*	x		x	x		x
7	*Syringodium isoetifolium*	x		x	x		x
	Total No. of Species	21	18	23	18	25	40

The bulk of algal species within marine sanctuaries was attributed to the red algal species and this holds true outside marine sanctuaries. Green and brown algae are the species rich outside the three marine sanctuaries, specifically Mahaba and Digyo (Table 4).

Table 4. Seaweed composition and distribution in and outside Apid, Mahaba and Digyo Marine Sanctuary.

Algal groups	No. of species					
	Apid		Mahaba		Digyo	
	In	Out	In	Out	In	Out
Cyanophytes (blue-green algae)	1					
Chlorophytes (green algae)	3	4	7	8	5	14
Phaeophytes (brown algae)	2	4	2	8	5	9
Rhodophytes (red algae)	8	6	9	9	8	11
Total	14	14	18	25	18	34

As to the species diversity of algal resources within and outside marine sanctuaries, results of Shannon-Weaver Diversity Index showed that Digyo had the highest diversity index (H'=1.93±0.13; H'=2.28±0.14) followed by Mahaba (H'=1.70±0.37; H'=2.23±0.30) and Apid (H'=1.20±0.63; H'=1.63±0.23). Comparing between marine sanctuaries, results of the 2-way ANOVA has significant difference (P=0.02) on the number of species between marine sanctuaries and the control sites (outside marine sanctuaries) and among sanctuaries (P=0.01). Further test by DMRT showed that Apid differed significantly with that of Digyo and Mahaba Marine Sanctuary. While Mahaba and Digyo were not significantly different from each other (Fig. 3).

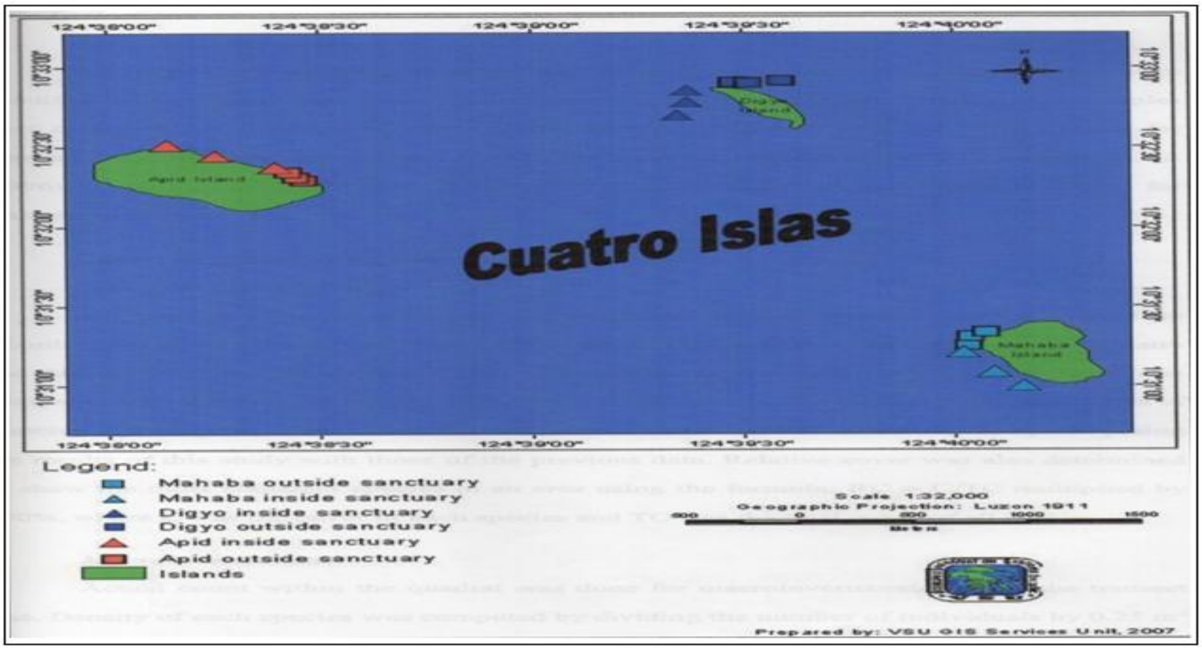

Fig. 2. Map of the three study sites (Apid, Mahaba and Digyo Islands) inside (▲) andoutside (■) the marine sanctuary with reference on the location of the transect lines.

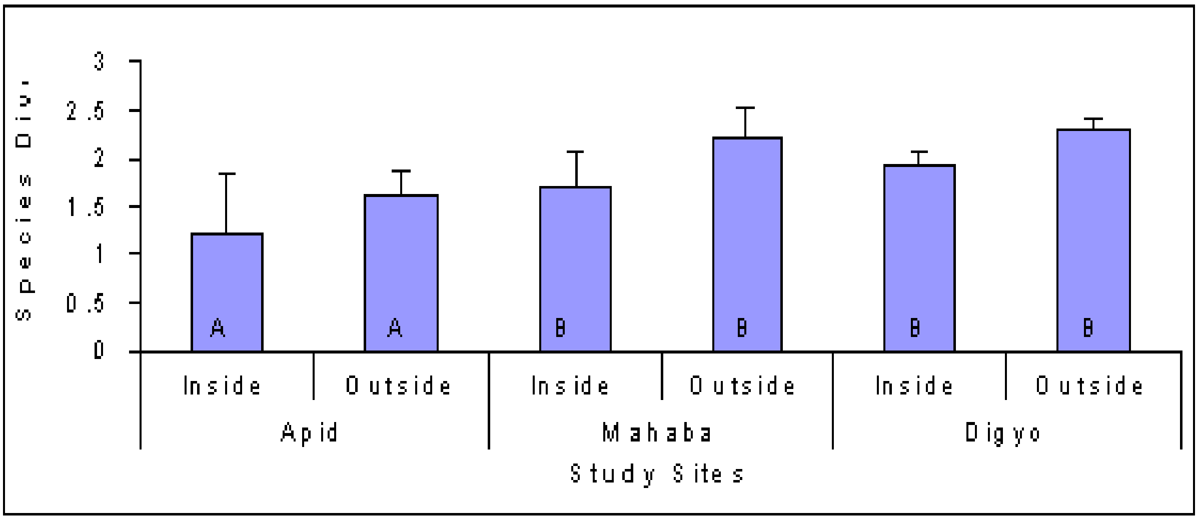

Fig.3. Results of DMRT for seaweed Species Diversity (*H'*) within and outside marine sanctuaries of Apid, Mahaba and DigyoIslands, Inopacan, Leyte. Bars indicates the Standard Deviation and bars with common letter do not differ significantly based on Duncans pair wise post hoc comparison.

Seagrass resources

A total of seven seagrass species identified within and outside marine sanctuaries. These species were recorded in Apid and Digyo both inside and outside marine sanctuaries while there was no seagrass species found within and outside Mahaba marine sanctuary (Fig. 4). The results found out that *Cymodocea rotundata*, *Halophila ovalis* and *Syringodium isoetifolium* are the species common inside and outside marine sanctuaries of Apid and

Digyo (Table 3). Species Diversity Index of seagrass species showed that Digyo (H'=1.04±0.39; H'=1.38±0.09) was higher compared to Apid (H'=0.66±0.94; H'=0.84±0.25) both in and outside marine sanctuary. Statistical analyses using 2-way ANOVA showed that among marine sanctuaries (P=0.001) there was a significant difference but not within and outside marine sanctuaries (P=0.41). Based on the DMRT testing, Apid and Digyo marine sanctuary did not differed significantly (Fig. 5).

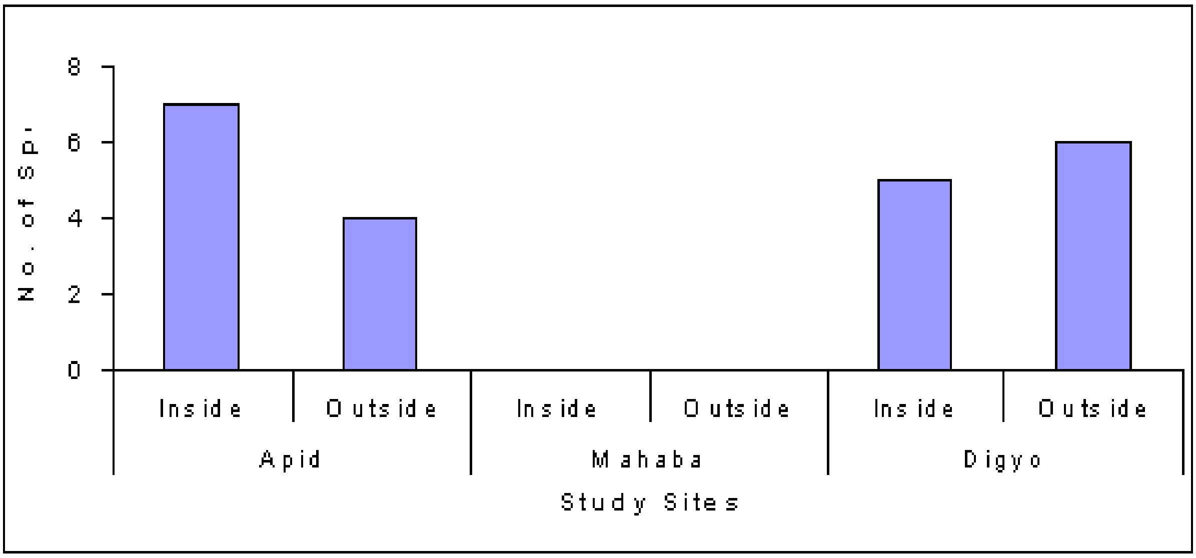

Fig.4. Number of seagrass species identified in and outside marine sanctuaries of Apid, Mahaba and Digyo Islands, Inopacan, Leyte.

Abundance and distribution pattern of macroflora in and outside marine sanctuaries

Seaweed and Seagrass

Results of seaweed and seagrass cover in and outside marine sanctuaries of the three Islands (Apid, Mahaba and Digyo) are shown in Fig. 6. Of the seaweed species recorded, the 5 most abundant species included *Bornetella nitida* having the highest total percent coverwith 3.93 or 6.09% RC (relative cover); followed by *Gelidiella acerosa* with 3.59 or 5.57% RC; *Actinotrichia fragislis* with 3.21 or 4.98% RC; *Sargassum crassifolium* with 2.22 or 3.45% RC and *Laurencia papillosa* rank the least among the algal species with 2.01 or 3.12% RC.

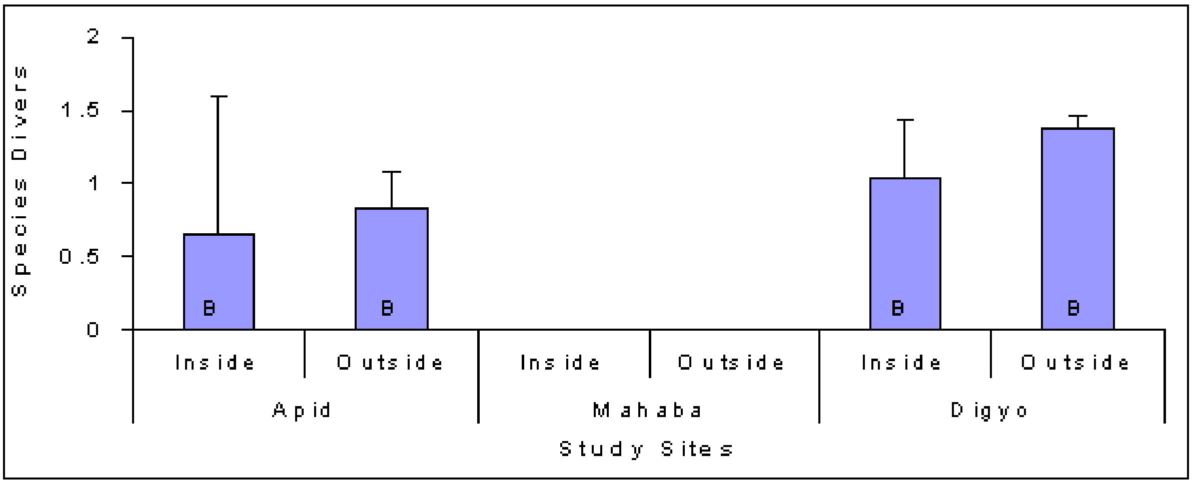

Fig. 5. Results of DMRT for seagrass Species Diversity (*H'*) within and outside marine sanctuaries of Apid, Mahaba and DigyoIslands, Inopacan, Leyte. Barsindicates the Standard Deviation and bars with common letter do not differ significantly based on Duncans pair wise post hoc comparison.

The species of *Turbinaria conoides* (0.03%), *Anadyomene plicata* (0.02%), *Peyssonnelia rubra* (0.02%) and *Acetabularia dentata* (0.01%) were the species having lowest total percent cover within and outside marine sanctuary. Among the 3 control sites (outside marine sanctuary), seaweeds % cover were higher in Mahaba (11.3%) followed by Digyo(10.2 %) thenApidwith 4.6% algal cover. On the other hand, among the seagrass species, *Cymodocea rotundata* had the highest total parentage cover with 12.3 or 19.07 RC; *Halodule uninervis* with 7.08 or 10.98% RC; *Syringodium isoetifolium* with 5.73 or 8.88% RC; *Halophila ovalis* with 1.67 or 2.59% RC; and then *Halodule pinifolia* with only 1.25 or 1.94% RC. Among the 3 study sites, seagrass cover was abundant in Apidboth in and outside the sanctuary with 13.9 % (poor condition) while there was no seagrass species within and outside Mahaba Marine Sanctuary but were present in the area along the transect. The results of Morisita's Index showed that distribution pattern (I > 1) of seaweeds and seagrasses within and outside marine sanctuaries are aggregated (Fig. 7). The ANOVA results revealed that the abundance of seagrass and seaweed differed significantly between marine sanctuaries (P=0.040) and among control sites (P=0.001). However, results of the DMRT between and among sites showed no difference, they fall on the same subset.

Discussion

The three (3) marine sanctuaries though have common supported algal groups, each of the islands differed in composition. The chlorophytes (green algae) and rhodophytes (red algae) were found to be the most abundant macroalgae within the sampling sites. The green algae usually prefer and grow well in shallow areas where light is sufficient, thus the presence of these algae are abundant outside Digyomarine sanctuary, while most of the red algae grow at deeper areas both the marine sanctuaries around 15-20 meters deep where light is insufficient though light is also important for their growth. This might be due for a fact that the green pigments of the green algae can absorb both long and shorter wavelengths of the light while the pigments of the red algae of the so called phycoerythrin and phycocyanin are most efficient at absorbing the blue-green light that penetrates in the deepest water area (Lalli and Parsons, 1993). While most of the seagrasses identified were found mainly in the marine sanctuary of Apid and outside marine sanctuary of Digyo Island.

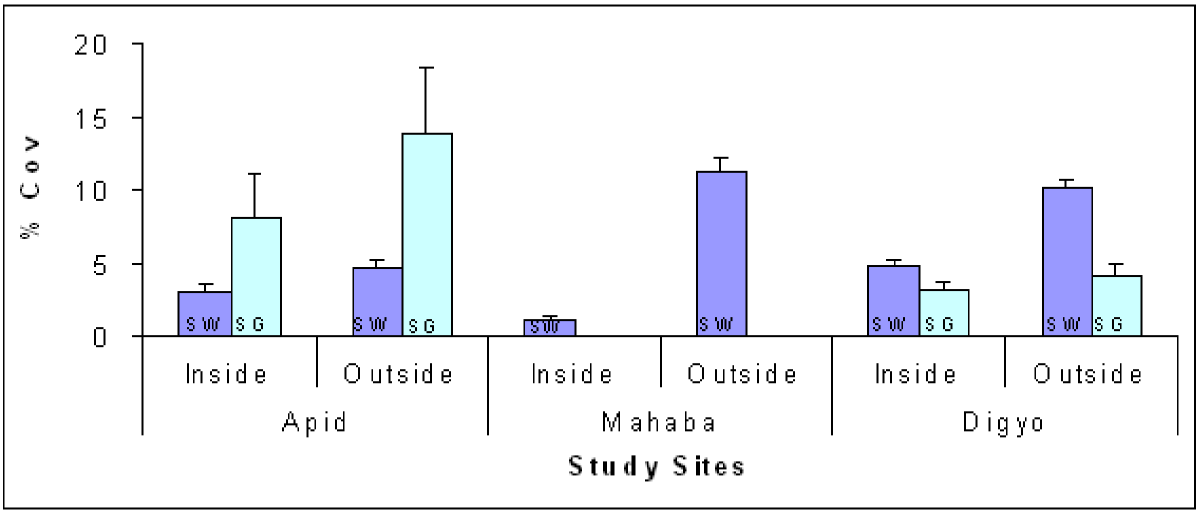

Fig. 6. Seaweed and seagrass cover within and outside the marine sanctuaries of Apid, Mahaba and Digyo. Bars indicate the standard deviations.

The occurrence and absence of these seaweeds and seagrasses could also be attributed to the substrate condition within and outside marine sanctuaries. The narrow reef area in Apid Marine Sanctuary has mainly rocky-coralline substrate that favors the growth of the seaweeds while sandy substrate dominated the deeper parts as well as outside sanctuary area that favors the growth of the seagrasses which could explained a healthy seagrass meadow in the entire area. The relatively wider, shallow reef and coralline substrate in Mahaba Marine Sanctuary provided suitable growth of seaweeds species compared to seagrasse seven outside the marine sanctuary area. Substrate in these sites are mixed of sandy-coralline substrate. The extensive reef of Digyo Marine Sanctuary was relatively deep with gradually sloping bottom topography having sandy and coralline substrates which favors the growth of rhodophytes (red algae)while outside sanctuary has wider, shallow sandy-coralline substrate wherein seaweeds grow mostly within this type of substrate.

The species diversity (*H'*) of seaweed-seagrasses between marine sanctuaries showed significant difference. These further suggest that diversity (*H'*) of seaweeds and seagrasses are greatly affected by the types of substrate among and between inside and outside sanctuary.

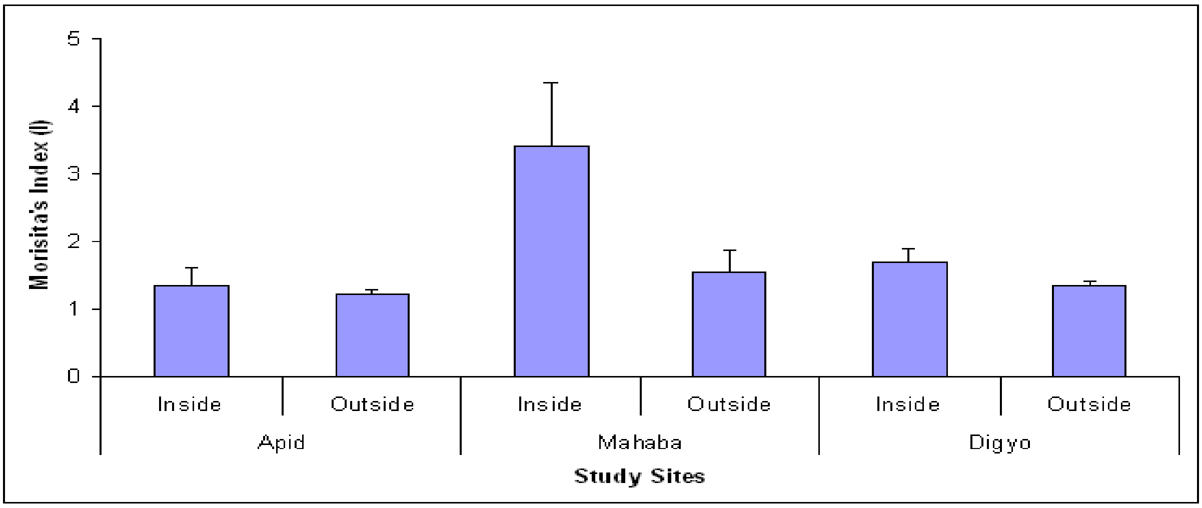

Fig.7. The macroflora species distribution (I) inside vs outside MPAs of Apid, Mahaba and Digyo Islands, Inopacan, Leyte. Bars indicate the standard deviations.

Abundance of the seaweed and seagrass resources was determined inside and outside the marine sanctuaries for comparison in effect of the management implemented in the three marine sanctuaries. Generally, seaweed and seagrass cover was higher outside marine sanctuary than inside marine sanctuary. These findings confirmed the results of the difference in the two-way Analysis of Variance (ANOVA). Such findings contradicted the findings of McClanahan *et al*. (1999) on the effects of marine parks and fishing on coral reefs in northern Tanzania on the abundance of fleshy algae (*Sargassum*, *Turbinaria* and *Dictyota*), differences were not statistically significant between protected and unprotected reefs. Such findings are also true in the work of Miller and Murdoch (2003) on the monitoring of coral reef macroalgae using different methods that there were no consistent differences in macroalgal abundance between the no-take reserves and the reference site of the studied area. The richness of the marine sanctuaries brought about by a good coral cover harbor quite a number of herbivorous fish species in the study area could also be one of the factors affecting to the low abundance of seaweeds and seagrass resources because of grazing activity. These findings holds true in the work of Sluka and Miller (2001) on the herbivorous fish assemblages and herbivory pressure among the four types of habitat on Laamu Atoll, Maldives, results showed that on the herbivory process using bioassay technique the herbivorous organisms like the acanthurids, scarids and siganids preferred to graze on seaweeds like *Eucheuma cottonii*, *Lobophora* and *Padina* and *Thalassia* and *Cymodocea* among the seagrasses. Furthermore, competition under natural conditions such as profuse blooms of seaweeds may cover the seagrass beds and positively a competitive influence to coral growth (Miller and Hay, 1996), which in this notion conforms the results of the study wherein the three marine sanctuaries are purely coral reef area, thus, resulting to lower seaweed and seagrass cover and so it is not comparable to outside sanctuary where dense of seaweed and seagrass can be found.

Morisita's Index of distribution (I) obtained from frequency data were very much related to the low cover and species diversity recorded in the six sampling sites (protected and unprotected area).According to Bakus (1990), that the higher the I value (I>1) the higher aggregation of distribution will be. Sand movement due to waves, strong currents appears to be an important factor affecting the distribution of seaweed bed (Trono, 1997). Furthermore, the distribution of these organisms might be greatly however affected by substrate type.

Conclusion

The islands of Apid, Mahaba and Digyo supported the major algal groups comprising 51 species and 7seagrasses. Generally, the species composition, diversity, abundance and distribution were higher outside than inside marine sanctuaries. Because the sanctuary are very rich with the presence of the herbivorous organisms which are the main grazers of the seaweeds and seagrasses might affect their abundance and distribution. But the highest probability could be the influenced on the reef structure and type of substrates (in and outside and between marine sanctuaries).

Nevertheless, the economic importance and significant ecological roles played by these resources require their protection and proper management from the expected destruction of the growing population. It is therefore recommended that the protection of the marine sanctuaries as well as outside marine sanctuaries will be sustained. The expansion of the buffer zone will also be done to harbor more marine flora species while providing wider settlement for economically important invertebrates.

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