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Macroalgae in the intertidal rocky shore of Iligan Bay

Frence Eliza E. Elecho[1], Tricia Joy C. Torres[1], Ronaldo R. Orbita[2], Maria Luisa S. Orbita[1*]

[1]*Department of Marine Science, Mindanao State University - Iligan Institute of Technology (MSU-IIT), Iligan City, Philippines*

[2]*Department of Professional Education, Mindanao State University - Iligan Institute of Technology (MSU-IIT), Iligan City, Philippines*

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Abstract

Rocky shores are commonly found in the coastal areas of Iligan Bay and mostly colonized by a great variety of macroalgae. Due to limited data, the diversity and abundance of macroalgae were investigated in eight sampling sites of Iligan Bay using the transect-quadrat method. A total of thirty-seven (37) species were identified including 17 green, 9 brown and 11 red algae, identified at eight sampling sites. Result showed that the seaweed biomass was highest in Buru-un and the major bulk of its dry weight materials were composed of *Ulva reticulata*. Moreover, Jampason had high species diversity because of its high species richness.

* **Corresponding Author:** Maria Luisa S. Orbita ✉ marialuisa.orbita@g.msuiit.edu.ph

Introduction

Macroalgae or seaweeds are a diverse group of organisms (Taylor, 1957 and 1960; Littler and Littler, 2000; Dawes and Mathiesen, 2008) which are important to the productivity, structure and function of coastal ecosystems. They are considered ecosystem engineers (Jones *et al.,* 1994), providing habitat for invertebrates (Marx and Herrnkind, 1985) and fishes (Holbrook *et al.,* 1990; Perez-Matus *et al.,* 2007), and supporting coastal food webs as nutrition sources for herbivores (Sammarco *et al.,* 1974; Lewis, 1986) and detritivores (Tenore, 1977). Economically, they are used around the world as foods and fertilizer, and for the extraction of valuable commercial product (Prathep, 2005). These organisms belong to three different divisions: Rhodophyta (red algae), Phaeophyta (brown algae) and Chlorophyta (green algae). Most of the macroalgae are growing in the intertidal zone throughout the world (Wong *et al*., 2012) and with few exceptions; they grow attached to hard surfaces, such as dead coral or rock (Diaz-Pulido and McCook, 2008). Rocky substrates are common in many coastal areas including the coast of Iligan Bay. This condition made it possible for the development of a great variety of benthic communities that are dominated, in most cases by different species of macroalgae. However, macroalgal studies in the intertidal rocky habitat of Iligan Bay received less attention and thus, the information concerning the diversity and abundance of these communities is still limited. This study was conducted to determine the species diversity and abundance of benthic macroalgae in selected sites of Iligan Bay. The result of this study would impact future biodiversity literature reviews of the macroalgae most, especially in Iligan Bay.

Materials and methods

Study area

The study was conducted in eight (8) selected sites of Iligan Bay namely; Tubigan (8°32'20" North, 124°18'50" East), Jampason (8˚31'21" North, 124˚18'30" East), Gimangpang (8°28'48" North, 124°17'39" East), Pagahan (8°27'20" North, 124°17'10" East), Calangahan (8˚22'10" North, 124˚15'39" East), Biga (8˚21'2" North, 124˚15'30" East), Dalipuga (8˚18'37" North, 124˚15'9" East) and Buru-un (8°11'29" North, 124°10'40" East; Fig. 1).

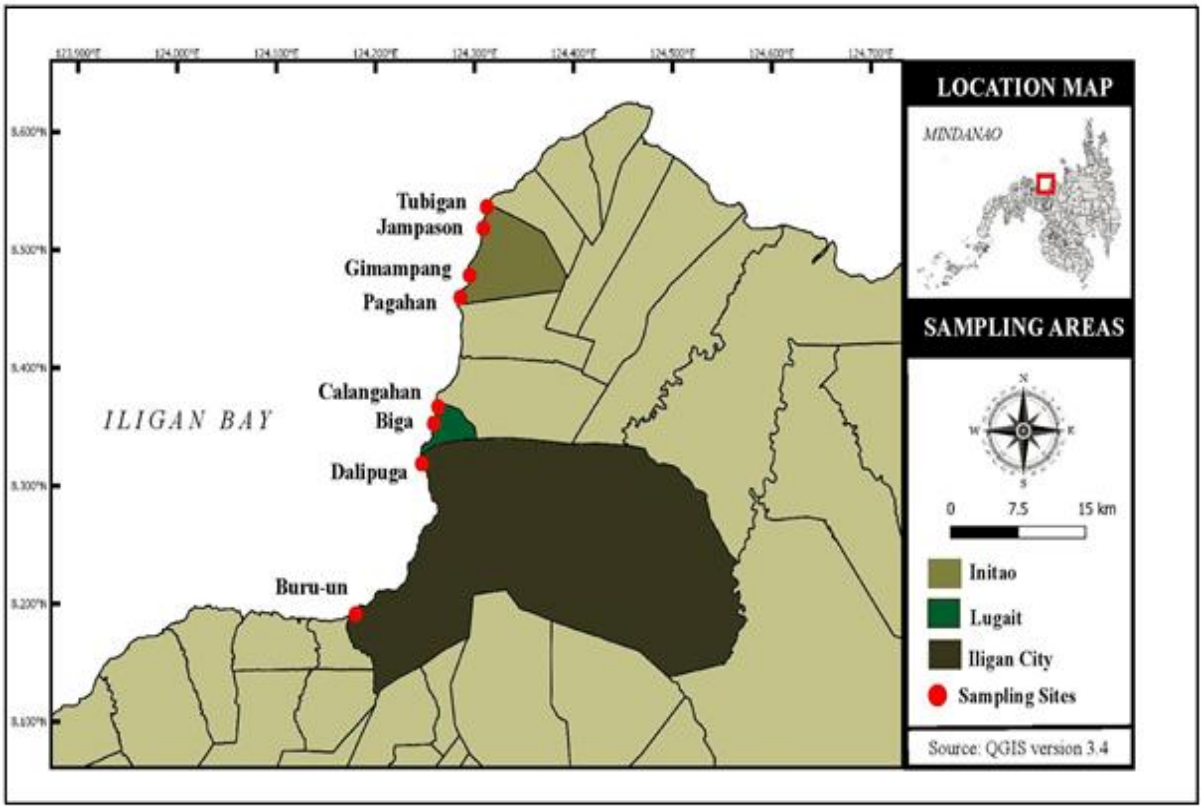

Fig. 1. Location of the sampling area in Iligan Bay (Source: QGIS Version 3.4).

All sampling sites were composed of rocky intertidal shores and mostly colonized by macroalgae.

Field sampling

The study was carried out during low tide when macroalgae were exposed and sampling was done using the transect-quadrat method (English *et al.,* 1997). A 50-meter transect line (with 3 replicates) was placed parallel to the shore, and for every 10 m-interval, a 0.5 m × 0.5 m quadrat was laid down at the right side of the transect line. All macroalgae that were inside the quadrat were identified and recorded following the taxonomic keys of Trono (1997) and Calumpong and Meñez (1997). After classifying, all samples inside the quadrat were harvested and brought to the laboratory for biomass determination. The samples were sorted, washed and cleaned after which they were oven dried at 60°C until constant weight. The biomass was expressed in terms of production per unit area (g DW m^{-2}).

Statistical analysis

The species diversity indices such as dominance (DI), Shannon diversity (H'), Simpson richness (R) and evenness (J') were analyzed through PAST software (version 3.0).

Results and discussion

A total of thirty-seven (37) species of macroalgae were identified from eight (8) sampling sites of Iligan Bay (Table 1). The green macroalgae (Chlorophyta) is represented by fourteen (14) genera with seventeen (17) species, brown algae (Phaeophyta) by four (4) genera and nine (9) species and red algae (Rhodophyta) by nine (9) genera with eleven (11) species. The green algae were the richest taxon in terms of species richness accounted for 46% of the total species number with its highest contribution in Gimangpang amounting to 67% (Fig. 2). Red algae ranked the second (30%) with its highest contribution in Jampason valuing 47%, while brown algae ranked the third (24%) with its highest contribution in Dalipuga amounting to 57%. Green algae are known to thrive in habitat with high light intensity (e.g. intertidal flat) which might have affected its high species richness. Also, the intertidal area is closed to land and receives more nutrient inputs which could increase the species richness of this algal group. Low predation in the habitat would also increase species richness of green algae as they are good food source for marine animals. An increase in species richness could also be an adaptation to tolerate extreme environmental condition in the rocky intertidal habitat. Rocky shores are biologically rich in terms of the number and variety of species including macroalgae, however they are also exposed to physical factors like waves, temperatures, dessication and exposure to tidal periods (Denny and Gaines, 2007). It was observed that the green species of *Enteromorpha intestinalis* and the red species of *Laurencia patentiramea* has mostly occurred in all sites (Table 1). The high occurrence of *E. intestinalis* might be due to the ability of this species to easily grow to any type of substratum in all types of season, making it a pioneer species (Hill, 2001) whereas *Laurencia patentiramea* is commonly found on benthic intertidal zones and easily grows even within rock crevices or under the rocks where the species was mostly found (Manchin-Sanchez *et al.,* 2016).

Among the eight sampling sites, Jampason had the highest number of species (21) followed by Biga (16), Calangahan (14) and Dalipuga (14), Tubigan (12), Pagahan and Buru-un (10) and Gimangpang (9), respectively. This was probably due to the sampling site being far from household residence; hence anthropogenic activities might be low. Moreover, it was observed that there was no brown algal species found in Gimangpang and Buru-un because brown algae grow in the subtidal zone.

Seaweed biomass determines the amount of primary production in marine ecosystems because macroalgae are used as food sources of many marine animals (Terawaki *et al.,* 2001; Eklöf *et al.,* 2005). In this study, it shows that the primary production in Iligan Bay is being represented by different macroalgal groups. As shown in Table 1, the macroalgal biomass was greatest in Buru-un (516.11 g DW m^{-2}) and green algae accounted for the highest biomass (84%).

Table 1. Lists, biomass (g DW m^{-2}) and occurrence of macroalgae in eight (8) sampling sites of Iligan Bay.

Species	Sampling area							
	TBG	JPS	GMP	PGH	CLN	BGA	DLG	BRU
Green algae								
Anadyomene plicata	(2.73) +				(10.72) +	(1.89) +		
Boergesenia forbesii	(2.67) +	(4.21) +	(3.00) +	(3.39) +				
Boodlea composita		(16.42) +		(9.99) +	(1.75) +	(10.49) +		
Bornetella oligospora						(1.09) +	(1.67) +	
Chaetomorpha crassa	(1.84) +	(9.67) +	(39.23) +	(2.16) +				(6.32) +
Chlorocladus philippinensis	(5.94) +							
Chlorodesmis fastigiata					(8.67) +			
Cladophora dalmatica								(68.47) +
Cymopolia vanbosseae	(1.35) +				(5.80) +	(3.88) +	(3.13) +	
Dictyosphaeria versluysii		(5.02) +	(5.12) +					
Enteromorpha clathrata			(26.01) +					(20.68) +
Enteromorpha intestinalis	(31.38) +	(11.52) +	(10.36) +	(3.00) +	(38.14) +	(9.20) +		(8.57) +
Halimeda opuntia							(12.00) +	
Halimeda simulans							(35.00) +	
Valonia aegagrophila	(5.41) +		(8.85) +	(23.17) +				
Ulva fasciata								(13.15) +
Ulva reticulata		(24.56) +			(5.95) +			(317.97) +
Total biomass	51.32	71.40	92.57	41.71	71.03	26.55	51.80	435.16
Total number of species	7	6	6	5	6	5	4	6
Brown Algae								
Hormophysa cuneiformis					(13.44) +			
Padina australis					(7.41) +		(6.24) +	
Padina japonica		(5.84) +			(7.85) +	(8.80) +	(18.52) +	
Padina minor	(2.08) +	(10.03) +		(1.70) +	(8.00) +	(19.83) +	(28.51) +	
Padina tetrastomatica		(3.03) +				(11.16) +	(15.09) +	
Sargassum cristaefolium							(46.42) +	
Sargassum oligocystum		(20.45) +				(15.56) +	(36.67) +	
Sargassum polycystum						(19.65) +	(110.47) +	
Turbinaria conoides		(10.55) +					(63.82) +	
Total biomass	2.08	49.90		1.70	36.70	75.00	325.74	
Total number of species	1	5		1	4	5	8	
Red algae								
Acanthophora spicifera		(12.33) +						
Amphiroa rigida	(1.75) +				(2.25) +		(1.35) +	
Galaxaura oblongata		(18.80) +						
Gelidiella acerosa		(5.76) +						
Gracilaria arcuata		(10.96) +		(1.08) +	(2.67) +	(5.25) +		(22.23) +
Gracilaria salicornia	(8.76) +	(7.45) +	(51.59) +	(18.95) +	(14.18) +			
Hypnea nidulans	(5.17) +	(8.03) +				(9.75) +	(6.28) +	(9.03) +
Laurencia papillosa		(11.81) +				(5.69) +		
Laurencia patentiramea	(7.08) +	(4.61) +	(28.57) +	(15.04) +	(11.53) +	(11.36) +		(11.19) +
Lomentara articulata								(28.87) +
Wurdemannia miniata			(5.02) +	(6.61) +	(9.62) +	(7.47) +	(20.82) +	(9.63) +
Total biomass	22.76	79.75	85.18	41.68	40.25	39.52	28.45	80.95
Total number of species	4	10	3	4	4	6	2	4
Overall number of species	12	21	9	10	14	16	14	10
Overall total biomass	76.16	201.05	177.75	85.09	147.98	141.07	405.99	516.11

Legend: (+) presence; TBG is Tubigan, JPS is Jampason; GMP is Gimangpang, PGH is Pagahan; CLN is Calangahan; BGA is Biga; DLG is Dalipuga; BRU is Buru-un.

This was followed by Dalipuga (405.99 g DW m^{-2}) in which brown algae accounted for the highest biomass (80%) and lastly Jampason (201.05 g DW m^{-2}) in which red algae accounted for the highest biomass (40%), respectively. High biomass indicates high food source for marine organisms inhabiting these areas.

Based on the diversity scale provided by Fernando (1998), the calculated diversity index using Shannon-Wiener (H') was high in Jampason. Calangahan, Biga and Dalipuga had moderate diversity while Tubigan, Gimangpang, Pagahan and Buru-un had low diversity index (Table 2).

Table 2. Diversity profile of macroalgae in eight (8) sampling sites of Iligan Bay.

Diversity indices	Sampling area							
	TBG	JPS	GMP	PGH	CLN	BGA	DLG	BRU
Biomass (g DW m^{-2})	76.16	201.05	177.75	85.09	147.98	141.07	405.99	516.11
Dominance index (DI)	0.21	0.07	0.19	0.18	0.11	0.09	0.15	0.41
Diversity index (H')	2.485	3.045	2.197	2.303	2.639	2.773	2.639	2.303
Richness index (R)	4.427	6.569	3.641	3.909	4.926	5.410	4.926	3.909
Evenness index (J')	0.61	0.87	0.71	0.68	0.76	0.84	0.60	0.38

Legend: TBG is Tubigan, JPS is Jampason; GMP is Gimangpang, PGH is Pagahan; CLN is Calangahan; BGA is Biga; DLG is Dalipuga; BRU is Buru-un.

The high diversity index in Jampason is considerable as this sampling site also has the highest richness index (R) with twenty-one (21) number of species present. The sampling site of Jampason is far from human settlements hence disturbance of benthic organisms was low. Based on biomass value, the evenness index (J') was high in Jampason and Biga indicating that the distribution of macroalgae in these sampling sites was homogenous. Buru-un had the lowest evenness index and it also had the highest index of dominance.

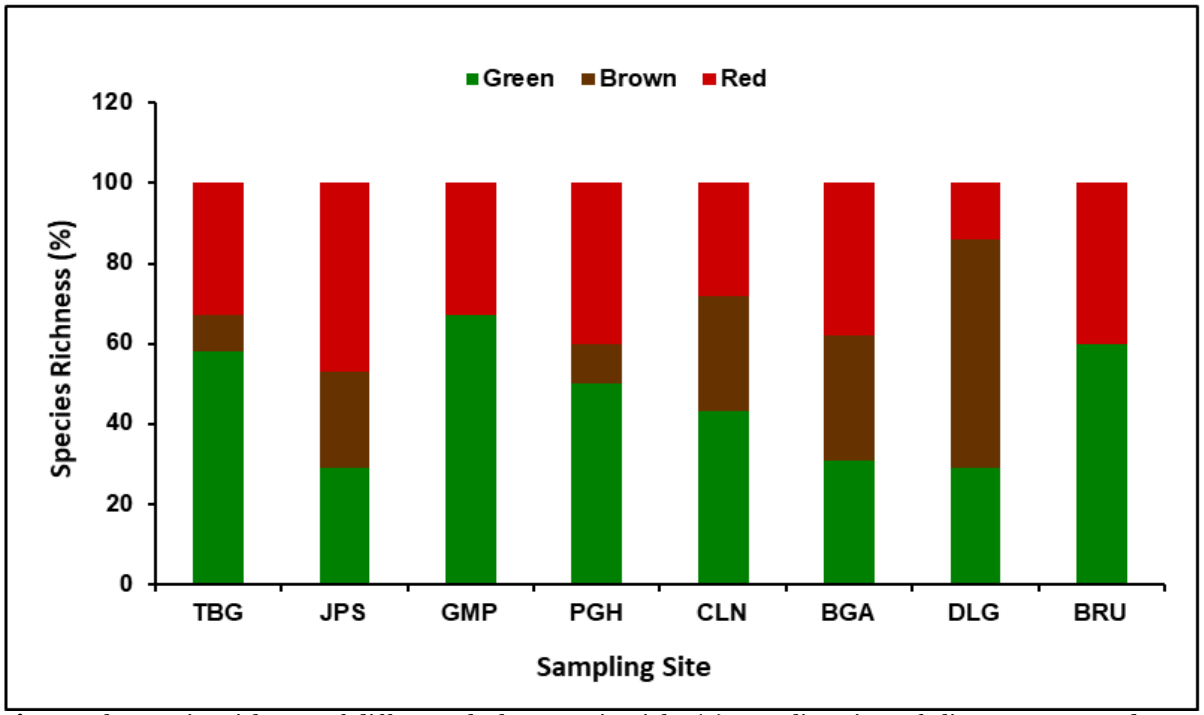

Fig. 2. The species richness of different algal groups in eight (8) sampling sites of Iligan Bay. Legend: TBG (Tubigan), JMP (Jampason). GMP (Gimangpang), PGH (Pagahan), CLN (Calangahan), BGA (Biga), DLG (Dalipuga) and (BRU-Un).

This result indicates that the distribution of macroalgae in Buru-un was heterogenous and that the macroalgal community was dominated by one or two species. In this case, *Ulva reticulata* was the most dominant species occupying 62% of the total biomass in the area. This species is known to be fast-growing opportunistic species of the intertidal area, with high reproductive capability, and has wide tolerance to any environmental stress (Gorostiaga and Diez, 1996).

Conclusion

A total of thirty-seven (37) species, including 17 green, 9 brown and 11 red, were identified from eight (8) selected intertidal rocky shores of Iligan Bay. Seaweed biomass was highest in Buru-un and *Ulva reticulata* accounted for the highest biomass in the area being an opportunistic species. Besides, the species diversity was high in Jampason because it also had the highest species richness and vice-versa.

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