First comprehensive study of marine benthic macroalgae communities in Eastern Siargao Island, Mindanao, Philippines

[1]Tricia Joy C. Torres, [1]Maria Luisa S. Orbita, [1]Annielyn D. Tampus, [1]Ivane P. Gerasmio, [2]Shiela L. Dagondon, [2]Beverly C. Orong, [3]Ronaldo R. Orbita

[1] Department of Marine Science, College of Science and Mathematics, Mindanao State University-Iligan Institute of Technology, Iligan City, Philippines; [2] Department of Biological Sciences, College of Science and Mathematics, Mindanao State University-Iligan Institute of Technology, Iligan City, Philippines; [3] Department of Professional Education, College of Education, Mindanao State University-Iligan Institute of Technology, Iligan City, Philippines. Corresponding author: M. L. S. Orbita, marialuisa.orbita@g.msuiit.edu.ph

Abstract. This study surveyed macroalgal diversity across eight sites in Eastern Siargao Island, documenting 62 species categorized into Chlorophyta (29), Phaeophyta (18), and Rhodophyta (15). Twelve species were found at all sites, indicating broad environmental tolerance, while others were more site-specific, highlighting the need for diverse marine habitat protection. Exclusive species to Siargao Island suggest regional specificity. Diversity indices showed high diversity at all sites. Green algae were the most prevalent, with *Amphiroa fragilissima*, a dominant species of red algae, being the most prominent. This species plays a crucial role in shaping the reef ecosystem and provides essential habitats for various marine organisms.
Key Words: *Amphiroa fragilissima*, biodiversity, Chlorophyta, Phaeophyta, Rhodophyta, species distribution.

Introduction. Macroalgae, or seaweeds, are crucial components of marine ecosystems, playing significant roles in biodiversity, primary production, and coastal protection (Mann 1973). They are categorized into three primary groups based on pigmentation: green algae (Chlorophyta), which contain chlorophyll a and b; brown algae (Phaeophyta), characterized by xanthophylls and beta-carotene; and red algae (Rhodophyta), which have phycoerythrin and phycocyanin. Globally, there are approximately 1,200 species of green algae, 2,000 species of brown algae, and 6,000 species of red algae, each contributing vital functions to their ecosystems (Lee 2008; Gupta & Abu-Ghannam 2011; Raja et al 2013; Saharayaj et al 2014; Dhinakaran et al 2016).

Despite their ecological importance, there are significant gaps in our understanding of macroalgal diversity and distribution, particularly in less-studied regions such as Eastern Siargao Island in Mindanao, Philippines. This region offers a promising opportunity for marine biodiversity research. The need for comprehensive macroalgae biodiversity studies is growing as researchers seek to enhance taxonomic knowledge and explore distribution patterns. Currently, there are nearly 10,000 known macroalgae species worldwide, with 966 species reported in the Philippines (Ang et al 2013). However, AlgaeBase indicates that around 7,000 species of Rhodophyceae and 5,000 species of Chlorophyceae remain undescribed (Guiry 2012).

In the 1990s, the focus of macroalgal research shifted towards biotechnology and applied aspects, leaving biodiversity studies in underexplored regions like the Philippines relatively neglected. As a result, there is a significant gap in knowledge regarding macroalgal flora in this region (Clemente et al 2017).

Siargao Island, located in the Province of Surigao del Norte in Northeastern Mindanao, is a renowned ecotourism destination and is celebrated as the surfing capital of the Philippines. The island group is protected under Proclamation No. 902, emphasizing its natural beauty and ecological value. Despite its significance, there is a lack of baseline data on the macroalgal diversity and community structure within this protected area. This study aims to address this gap by providing the first comprehensive documentation of macroalgae in Eastern Siargao Island. The research focuses on identifying macroalgal species, evaluating their abundance, analyzing species distribution, assessing biodiversity, and examining community structure, thus contributing crucial data to the region's ecological knowledge.

Material and Method

Study area. Siargao Island is situated in the northeastern part of Mindanao, within the jurisdiction of Surigao del Norte province. Geographically, it is positioned between 125º50′ and 126º05′ East Longitude and between 9º03′ and 10º05′ North Latitude (Figure 1). Since 1996, the terrestrial, wetland, and marine areas of Siargao Island, along with the surrounding islets in northeastern Mindanao, Surigao del Norte, have been designated as protected areas (Siargao Island Protected Landscape and Seascape or SIPLAS) under the Republic Act No. 7586 covering 278,914.131 ha of landscape and seascape. SIPLAS is an oasis of inland and marine resources that are not only beneficial for people in terms of food source, livelihood, and recreation, but also hold immense ecological value. For this study, 8 sampling stations in the eastern part of Siargao Island were chosen as study sites: Malinao, Catangnan, Caridad, Pilaring, Tigasao, Pacifico, Baybay, and Poblacion 1. These locations were selected due to their notable macroalgal coverage.

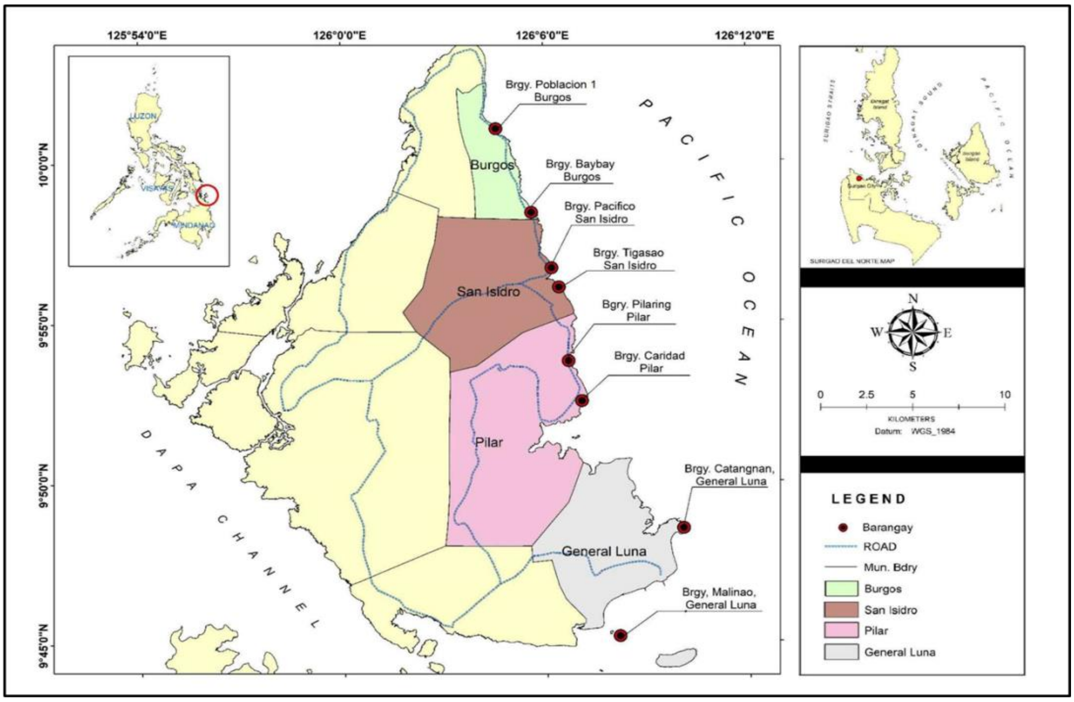

Figure 1. Map of the study area and location of the sampling stations in eastern Siargao Island, Surigao del Norte (Source: QGIS version 3.4).

Field sampling. The study was conducted in April – May 2021 during low tide, exposing the macroalgae, and sampling was performed using the transect-quadrat method as described by English et al (1997). A 50-meter transect line, with three replicates, was positioned perpendicular to the shore. At every 10-meter interval along this transect, a 1 m × 1 m quadrat was placed on the right side of the line (Campbell et al 2002). All macroalgae within each quadrat were identified, counted and recorded. A sample of each algal species was collected using a small shovel. The seaweed samples were rinsed with seawater and preserved in pre-labeled Ziploc bags containing a 3-5% buffered formalin solution. These samples were transported to the laboratory for species identification using the taxonomic references of Stockman et al (1967), Calumpong & Meñez (1997), Trono (1997), Mattio et al (2009), Noiraksar & Ajisaka (2009), Coppejans et al (2010), Mattio & Payri (2011), Belton et al (2014), Titlyanov et al (2016), Yip et al (2018), Guiry & Guiry (2020), and Lastimoso & Santiañez (2021).

Measurement of diversity, relative abundance, species distribution and community structure of macroalgae. The diversity indices included in this study were dominance, Shannon-Weiner diversity, Simpson richness and evenness. The Shannon-Weiner diversity index values were categorized according to the diversity scale established by Margalef (1972). Diversity indices were calculated with the Paleontological Statistics Software (PAST). The relative abundance of macroalgae at each sampling station was determined by calculating the proportion of macroalgae at each station compared to the total number of macroalgae across all stations. The distribution of macroalgal species was evaluated through direct observation at each sampling site, noting their presence or absence. The community structure was further analyzed using the importance value index (IVI), which combines relative density, relative frequency, and relative dominance of each species at the site. Calculated using the formula from Krebs (1989), the IVI is the sum of these three components: relative density (percentage of total density), relative frequency (percentage of total frequency), and relative dominance (percentage of total cover), with cover determined by the method of Saito & Atobe (1970). This index provides a comprehensive measure of each species' overall contribution to the macroalgal community structure.

Results and Discussion

Identification, classification and species distribution of macroalgae. The present study documented 62 macroalgal species across eight sampling sites in Eastern Siargao Island, Surigao del Norte, categorized into three primary groups: 29 species from Chlorophyta (green algae), 18 from Phaeophyta (brown algae), and 15 from Rhodophyta (red algae). Taxonomically, the 62 species belong to 36 genera, 23 families and 15 orders (Table 1). Notably, twelve species, Ca*ulerpa racemosa*, *Dictyosphaeria cavernosa*, *Dictyosphaeria versluysii*, *Halimeda opuntia*, *Halimeda velasquezii*, *Hormophysa cuneiformis*, *Padina australis*, *Padina minor*, *Sargassum polycystum*, *Gelidiella acerosa*, *Gracilaria salicornia* and *Mastophora rosea* - were found at all eight sampling sites (Table 2). Their widespread distribution suggests a broad environmental tolerance and adaptability, highlighting their ecological significance and stability across varied conditions on the island. In contrast, other species were found in some areas but not in others, indicating more specific habitat requirements or environmental preferences that are not met uniformly across all sites. This pattern suggests that these species are adapted to particular conditions or microhabitats, underscoring the need to protect diverse marine environments to support species with specialized needs. Additionally, seven species - *Caulerpa chemnitzia* (green), *Halimeda gigas* (green), *Penicillus* sp. (green), *Dictyota* sp. (brown), *Sargassum swartzii* (brown), *Asparagopsis taxiformis* (red), and *Botryocladia skottsbergii* (red) - were found exclusively on Siargao Island and not recorded on the five other Philippine islands listed in Table 3. This suggests that these species may be specific to Siargao Island. Moreover, species previously reported in Southern Palawan, such as *Sirophysalis trinodis* (Santiañez et al 2015), *Sargassum swartzii* (Lastimoso & Santiañez 2021), and *Penicillus* sp. (Lastimoso & Santiañez 2021), are now also recorded in Batan Island, Bataan and Negros Island, extending their known distribution to the Southern Philippines, particularly Eastern Siargao Island. The distribution of macroalgae is influenced by a variety of environmental factors, including anthropogenic impacts from local communities and tourism, as well as physico-chemical parameters such as tidal patterns, wave action, nutrient levels, substrate stability, desiccation, and sedimentation (Dawes 1998; Mushlihah et al 2021). Variations in current patterns and the presence of large islands also contribute to the distinct floristic compositions of macroalgae (Santiañez et al 2015).

Table 1

Classification of marine benthic macroalgae in Eastern Siargao Island, Surigao del Norte

Division	*Class*	*Order*	*Family*	*Genus*	*Species*
Chlorohyta	Ulvophyceae	Bryopsidales	Caulerpaceae	*Caulerpa*	*chemnitzia*
					lentillifera
					racemosa
					sertularioides
					taxifolia
					urvilleana
			Halimedaceae	*Halimeda*	*cylindracea*
					gigas
					incrassata
					macroloba
					opuntia
					simulans
					velasquezii
				Penicillus	sp.
				Udotea	*argentea*
					orientalis
			Codiaceae	*Codium*	*arabicum*
		Cladophorales	Anadyomenaceae	*Anadyomene*	*plicata*
			Siphonocladaceae	*Boergesenia*	*forbesii*
				Dictyosphaeria	*cavernosa*
					versluysii
			Boodleaceae	*Boodlea*	*composita*
			Valoniaceae	*Valonia*	*aegagropila*
					fastigiata
					ventricosa
		Dasycladales	Dasycladaceae	*Bornetella*	*oligospora*
				Neomeris	*annulata*
			Polyphysaceae	*Acetabularia*	*dentata*
		Ulvales	Ulvaceae	*Ulva*	*lactuca*

Phaeophyta	Phaeophyceae	Dictyotales	Dictyotaceae	*Canistrocarpus*	*cervicornis*
				Dictyota	sp.
				Lobophora	*variegata*
				Padina	*australis*
					gymnospora
					japonica
					minor
					tetrastromatica
		Ectocarpales	Scytosiphonaceae	*Hydroclathrus*	*clathratus*
		Fucales	Sargassaceae	*Hormophysa*	*cuneiformis*
				Sargassum	*aquifolium*
					ilicifolium
					oligocystum
					polycystum
					swartzii
				Sirophysalis	*trinodis*
				Turbinaria	*conoides*
					ornata
Rhodophyta	Florideophyceae	Bonnemaisoniales	Bonnemaisoniaceae	*Asparagopsis*	*taxiformis*
		Ceramiales	Rhodomelaceae	*Acanthophora*	*spicifera*
				Laurencia	*glomerata*
					nidifica
				Palisada	*perforata*
		Corallinales	Lithophyllaceae	*Amphiroa*	*fragilissima*
			Mastophoraceae	*Mastophora*	*rosea*
		Gelidiales	Gelidiellaceae	*Gelidiella*	*acerosa*
		Gigartinales	Rhizophyllidaceae	*Portieria*	*hornemannii*
		Gracilariales	Gracilariaceae	*Gracilaria*	*arcuata*
					salicornia
		Nemaliales	Galaxauraceae	*Actinotrichia*	*fragilis*
				Tricleocarpa	*fragilis*
		Rhodymeniales	Lomentariaceae	*Ceratodictyon*	*spongiosum*
			Rhodymeniaceae	*Botryocladia*	*skottsbergii*

Table 2

Distribution of macroalgae species across 8 sampling sites in Eastern Siargao Island

Species	*Sampling sites*							
	MAL	*CAT*	*PIL*	*CAR*	*TIG*	*PAC*	*BAY*	*POB 1*
Chlorophyta (green algae)								
Acetabularia dentata	+			+	+			+
Anadyomene plicata	+	+		+	+		+	+
Boergesenia forbesii		+	+	+	+	+	+	+
Boodlea composita		+	+	+	+		+	+
Bornetella oligospora	+	+	+	+	+		+	+
Caulerpa chemnitzia	+					+		
Caulerpa lentillifera					+	+		
Caulerpa racemosa	+	+	+	+	+	+	+	+
Caulerpa sertularioides	+		+	+			+	
Caulerpa taxifolia		+					+	+
Caulerpa urvilleana	+							
Codium arabicum	+					+		+
Dictyosphaeria cavernosa	+	+	+	+	+	+	+	+
Dictyosphaeria versluysii	+	+	+	+	+	+	+	+
Halimeda cylindracea	+			+		+		+
Halimeda gigas	+					+		
Halimeda incrassata	+		+			+	+	
Halimeda macroloba	+	+	+	+	+		+	
Halimeda opuntia	+	+	+	+	+	+	+	+
Halimeda simulans	+	+			+	+		
Halimeda velasquezii	+	+	+	+	+	+	+	+
Neomeris annulata	+		+	+	+	+	+	+
Penicillus sp.	+							+
Udotea argentea		+	+					+
Udotea orientalis		+					+	+
Ulva lactuca							+	
Valonia aegagropila	+	+						
Valonia fastigiata		+			+	+		
Valonia ventricosa	+		+	+		+	+	+
Phaeophyta (brown algae)								
Canistrocarpus cervicornis	+	+		+		+	+	+
Dictyota sp.	+	+	+	+	+	+		+
Hormophysa cuneiformis	+	+	+	+	+	+	+	+
Hydroclathrus clathratus				+			+	+
Lobophora variegata	+	+			+		+	+
Padina australis	+	+	+	+	+	+	+	+
Padina gymnospora					+			+
Padina japonica		+	+	+		+	+	+
Padina minor	+	+	+	+	+	+	+	+
Padina tetrastromatica	+	+		+			+	+
Sargassum aquifolium		+	+	+	+			
Sargassum ilicifolium		+	+		+	+	+	
Sargassum oligocystum	+	+	+	+	+	+	+	
Sargassum polycystum	+	+	+	+	+	+	+	+
Sargassum swartzii	+		+	+	+	+	+	+
Sirophysalis trinodis					+			
Turbinaria conoides	+	+		+	+	+	+	+
Turbinaria ornata	+		+	+		+	+	+
Rhodophyta (red algae)								
Acanthophora spicifera		+					+	+
Actinotrichia fragilis	+	+	+	+			+	

Amphiroa fragilissima	+	+	+	+	+	+		
Asparagopsis taxiformis	+	+					+	
Botryocladia skottsbergii		+						
Ceratodictyon spongiosum					+		+	+
Gelidiella acerosa	+	+	+	+	+	+	+	+
Gracilaria arcuata		+	+	+			+	+
Gracilaria salicornia	+	+	+	+	+	+	+	+
Laurencia glomerata	+							
Laurencia nidifica	+							+
Mastophora rosea	+	+	+	+	+	+	+	+
Palisada perforata	+	+						+
Portieria hornemannii	+							
Tricleocarpa fragilis	+	+			+	+		

Legend: (+) present; MAL is Malinao; CAT is Catangnan; PIL is Pilaring; CAR is Caridad; TIG is Tigasao; PAC is Pacifico; BAY is Baybay; POB 1 is Poblacion 1.

Table 3

Occurrence and distribution of 62 macroalgal species across six Philippine islands

Species	*Sampling sites*					
	SRI	*ATQ*	*RIG*	*PNY*	*DGI*	*BSP*
Chlorophyta (green algae)						
Acetabularia dentata	+					+
Anadyomene plicata	+					+
Boergesenia forbesii	+	+	+	+	+	+
Boodlea composita	+	+	+	+	+	+
Bornetella oligospora	+		+		+	+
Caulerpa chemnitzia	+					
Caulerpa lentillifera	+			+	+	+
Caulerpa racemosa	+	+	+	+	+	+
Caulerpa sertularioides	+		+	+	+	+
Caulerpa taxifolia	+		+	+		+
Caulerpa urvilleana	+					+
Codium arabicum	+	+	+	+	+	+
Dictyosphaeria cavernosa	+	+	+	+		+
Dictyosphaeria versluysii	+		+		+	
Halimeda cylindracea	+					+
Halimeda gigas	+					
Halimeda incrassata	+		+	+		+
Halimeda macroloba	+		+	+	+	+
Halimeda opuntia	+		+	+	+	+
Halimeda simulans	+		+		+	+
Halimeda velasquezii	+		+			
Neomeris annulata	+	+	+			+
Penicillus sp.	+					
Udotea argentea	+					+
Udotea orientalis	+		+	+		+
Ulva lactuca	+	+		+		+
Valonia aegagropila	+	+			+	
Valonia fastigiata	+					+
Valonia ventricosa	+			+	+	+
Phaeophyta (brown algae)						
Canistrocarpus cervicornis	+		+			+
Dictyota sp.	+					
Hormophysa cuneiformis	+		+	+		+
Hydroclathrus clathratus	+	+	+	+		+
Lobophora variegata	+	+	+	+		

Padina australis	+		+	+		+
Padina gymnospora	+		+			
Padina japonica	+		+	+		+
Padina minor	+	+	+	+	+	+
Padina tetrastromatica	+		+			
Sargassum aquifolium	+		+	+	+	+
Sargassum ilicifolium	+	+	+		+	+
Sargassum oligocystum	+		+	+	+	+
Sargassum polycystum	+	+	+	+	+	+
Sargassum swartzii	+					
Sirophysalis trinodis	+					+
Turbinaria conoides	+		+	+	+	+
Turbinaria ornata	+	+	+	+		+
Rhodophyta (red algae)						
Acanthophora spicifera	+	+	+	+		+
Actinotrichia fragilis	+	+	+	+	+	+
Amphiroa fragilissima	+	+	+	+		+
Asparagopsis taxiformis	+					
Botryocladia skottsbergii	+					
Ceratodictyon spongiosum	+			+		+
Gelidiella acerosa	+	+	+	+		+
Gracilaria arcuata	+	+	+	+	+	+
Gracilaria salicornia	+	+	+	+	+	+
Laurencia glomerata	+		+	+		+
Laurencia nidifica	+					+
Mastophora rosea	+	+	+		+	+
Palisada perforata	+	+	+		+	+
Portieria hornemannii	+		+	+		+
Tricleocarpa fragilis	+	+				

Legend: SRI is Siargao Island; ATQ is Antique; RIG Romblon Island Group; PNY is Panay; DGI is Dinagat; BSP is Balabac Southern Palawan.

***Diversity*, *relative abundance and community structure of macroalgae*.** Based on the Shannon-Wiener diversity index (H'), all sampling stations were identified as highly diverse (H' > 2.0; Margalef 1972), indicating that these areas support a rich variety of macroalgal communities, with total species counts of 62 (Table 4). This high diversity suggests a well-balanced and stable marine ecosystem, where different macroalgal species coexist and contribute to ecological processes such as primary production, nutrient cycling, and habitat formation. The presence of diverse macroalgal species also highlights the area's capacity to provide important ecosystem services, including supporting biodiversity, enhancing water quality, and offering food and shelter for various marine organisms. Additionally, the evenness index values were high (E > 0.6; Margalef 1962) across all sampling sites, indicating that no single species dominated the macroalgal communities on Eastern Siargao Island.

Table 4

Diversity profile of marine benthic macroalgae in eight sampling sites in Eastern Siargao Island, Surigao del Norte

Diversity indices	*Sampling sites*							
	MAL	*CAT*	*PIL*	*CAR*	*TIG*	*PAC*	*BAY*	*POB 1*
Taxa (S)	43	40	31	35	34	33	40	41
Individuals (I)	4120	8303	2529	3627	2626	3502	5756	7135
Dominance index (DI)	0.948	0.864	0.945	0.987	0.978	0.981	0.984	0.880
Diversity index (H’)	3.240	3.537	2.084	2.241	2.764	2.948	3.090	3.780
Evenness index (J’)	0.785	0.615	0.747	0.785	0.670	0.714	0.749	0.674

Legend: MAL is Malinao; CAT is Catangnan; PIL is Pilaring; CAR is Caridad; TIG is Tigasao; PAC is Pacifico; BAY is Baybay; POB 1 is Poblacion 1.

In terms of abundance among the taxonomic groups (green, brown, and red algae), green algae were the most prevalent, comprising 57.29% of the total individuals (Figure 2). Their highest abundance was observed in Catangnan (74.00%), Poblacion 1 (74.00%) and Baybay (68.00%). High densities of green algae have also been reported in Southern Palawan (Santiañez et al 2015), Lagonoy Gulf in the Bicol region (Mendoza & Soliman 2013), and Satang Besar Island, Sarawak, Malaysia (Esa et al 2013). Brown algae ranked second, representing 29.18% of the total, with the highest concentrations in Caridad (50.00%), followed by Malinao (48.00%). Typically, brown algae are more common in temperate regions, with fewer species found in tropical areas (Lee 1999; Pratama et al 2015). Red algae were the least abundant, accounting for 13.53% of the total, with their highest contributions in Pacifico (39.00%) and Tigasao (39.00%). Although red algae generally exhibit greater diversity and abundance in tropical regions like the Philippines compared to temperate areas (Lee 1999; Mayakun & Prathep 2005), they show significant adaptability to environmental changes (Romdoni et al 2018). Studies by Al Solami (2020) have shown that red algae can endure higher concentrations of heavy metals, nutrients, and other environmental stresses better than other algal groups. Furthermore, red algae are also dominant in the Romblon Island Group, as noted by Clemente et al (2017).

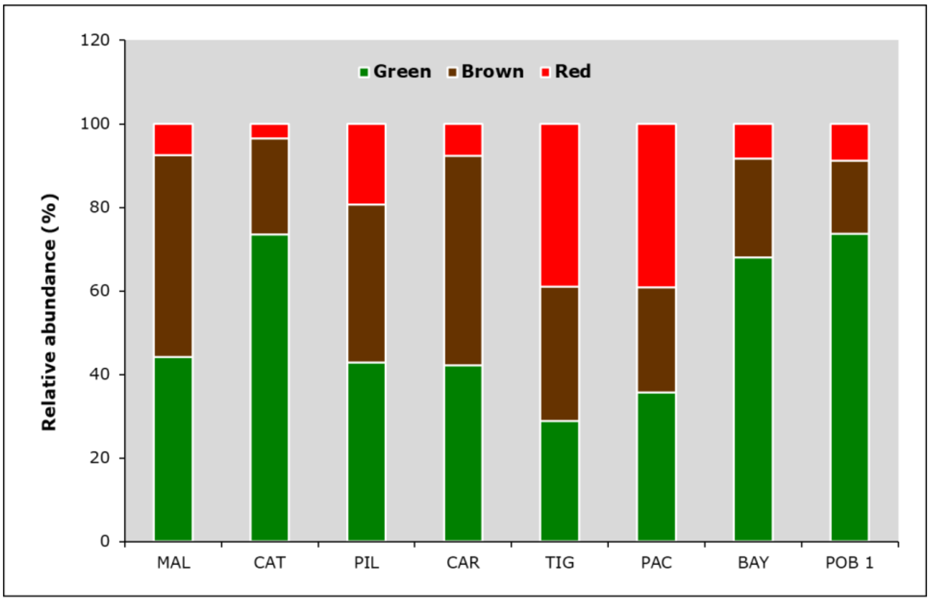

Figure 2. Relative abundance (%) of macroalgal groups in eight sampling sites in eastern Siargao Island, Surigao del Norte (MAL – Malinao; CAT – Catangnan; PIL – Pilar; CAR – Caridad; TIG – Tigaso; PAC – Pacifico; BAY – Baybay; POB 1 – Poblacion 1).

The macroalgal community in Eastern Siargao Island is predominantly comprised of eight species: *Amphiroa fragilissima* (IVI: 233.87), *Udotea argentea* (IVI: 155.97), *Lobophora variegata* (IVI: 123.93), *Dictyota* sp. (IVI: 113.63), *Caulerpa taxifolia* (IVI: 105.47), *Sargassum ilicifolium* (IVI: 104.75), *Gracilaria arcuata* (IVI: 100.30) and *Padina tetrastromatica* (IVI: 100.07) (Table 5). The high abundance of the macroalgal species mentioned above could be attributed to several factors, including rapid growth rates, resistance to herbivory, and effective reproductive strategies. Their ability to attach to a variety of substrates could also play a role in supporting their prevalence. Furthermore, the morphological complexity of these algae could potentially enhance their resilience to environmental stressors, which might contribute to greater community stability and, in turn, support their high abundance in specific habitats. Among these species, *A. fragilissima* has the highest IVI value (Table 5), underscoring its pivotal role in the macroalgal community of Eastern Siargao Island. This dominance reflects its exceptional competitive strength and adaptability to the local environment. The high IVI value indicates that *A. fragilissima* is not only highly abundant but also plays a crucial role in shaping the reef ecosystem, particularly in Eastern Siargao Island. Its prevalence significantly influences the biodiversity and functional dynamics of the macroalgal community, affecting interactions with herbivores, competitors, and other ecological processes. The species' robust growth, effective reproductive strategies, and resilience to environmental stresses further enhance its prominence within the community.

A. fragilissima is widespread in tropical and subtropical regions across all oceans, where it provides essential microhabitats for various epiphytes and invertebrates, and serves as nursery grounds for fish larvae (Wai 2018). Additionally, it remains a significant food source for herbivorous fish such as *Chanos chanos* (Yin 2020) and is noted for its bioactive compounds, which have potential anticancer properties (Viswanathan et al 2014).

Table 5

Importance value index (IVI, %) of marine benthic macroalgae in Eastern Siargao Island

Species	*Group*	*IVI (%)*	*Rank*
Amphiroa fragilissima	Red	233.87	1
Udotea argentea	Green	155.97	2
Lobophora variegata	Brown	123.93	3
Dictyota sp.	Brown	113.63	4
Caulerpa taxifolia	Green	105.47	5
Sargassum ilicifolium	Brown	104.75	6
Gracilaria arcuata	Red	100.30	7
Padina tetrastromatica	Brown	100.07	8
Neomeris annulata	Green	98.21	9
Sargassum swartzii	Brown	89.26	10
Acetabularia dentata	Green	89.09	11
Hydroclathrus clathratus	Brown	78.06	12
Laurencia glomerata	Red	68.63	13
Gelidiella acerosa	Red	66.56	14
Acanthophora spicifera	Red	65.31	15
Halimeda velasquezii	Green	58.00	16
Hormophysa cuneiformis	Brown	52.65	17
Caulerpa sertularioides	Green	46.09	18
Halimeda macroloba	Green	43.45	19
Halimeda cylindracea	Green	41.70	20
Caulerpa racemosa	Green	38.62	21
Tricleocarpa fragilis	Red	34.46	22
Ulva lactuca	Green	32.59	23
Codium arabicum	Green	32.40	24
Udotea orientalis	Green	30.38	25
Botryocladia skottsbergii	Red	29.46	26
Bornetella oligospora	Green	25.62	27
Sargassum aquifolium	Brown	24.56	28
Halimeda gigas	Green	23.37	29
Actinotrichia fragilis	Red	23.34	30
Valonia aegagropila	Green	22.64	31
Canistrocarpus cervicornis	Brown	21.12	32
Caulerpa lentillifera	Green	18.10	33
Sargassum polycystum	Brown	17.28	34
Dictyosphaeria cavernosa	Green	13.57	35
Boergesenia forbesii	Green	13.38	36
Valonia ventricosa	Green	11.39	37
Turbinaria ornata	Brown	11.17	38
Caulerpa chemnitzia	Green	11.00	39
Sirophysalis trinodis	Brown	10.61	40
Padina minor	Brown	10.27	41
Penicillus sp.	Green	9.92	42

Padina japonica	Brown	9.04	43
Asparagopsis taxiformis	Red	8.11	44
Mastophora rosea	Red	7.34	45
Gracilaria salicornia	Red	5.42	46
Ceratodictyon spongiosum	Red	5.19	47
Sargassum oligocystum	Brown	4.93	48
Valonia fastigiata	Green	4.58	49
Halimeda opuntia	Green	4.43	50
Dictyosphaeria versluysii	Green	4.18	51
Anadyomene plicata	Green	4.10	52
Portieria hornemannii	Red	4.05	53
Padina gymnospora	Brown	3.04	54
Turbinaria conoides	Brown	2.93	55
Laurencia nidifica	Red	2.50	56
Halimeda incrassata	Green	2.33	57
Halimeda simulans	Green	1.40	58
Boodlea composita	Green	1.37	59
Padina australis	Brown	0.74	60
Palisada perforata	Red	0.30	61
Caulerpa urvilleana	Green	0.28	62

Conclusions. The study of macroalgal diversity and distribution in Eastern Siargao Island reveals a rich and complex marine ecosystem with 62 identified species across Chlorophyta (29 species), Phaeophyta (18 species), and Rhodophyta (15 species). The widespread presence of the twelve species across all sampling sites indicates their broad environmental tolerance and adaptability, which plays a crucial role in maintaining the stability of the ecosystem. The high diversity in stations such as Malinao, Catangnan, Baybay, and Poblacion 1, contrasted with moderate diversity in other sites, highlights the varied habitat requirements of different species and underscores the need for diverse marine environments to support specialized needs.

Amphiroa fragilissima stands out with the highest important value index, reflecting its dominance and significant role in shaping the reef ecosystem. Its robust growth, adaptability, and ecological contributions, such as providing microhabitats for marine organisms and serving as nursery grounds for fish larvae, underscore its importance. Additionally, *Amphiroa fragilissima*'s role as a food source for herbivorous fish and its potential anticancer properties further highlight its ecological and economic significance. Overall, these findings emphasize the need for ongoing conservation efforts to maintain the delicate balance and biodiversity of this valuable marine ecosystem.

Acknowledgements. We would like to thank the DOST-ASTHRD for the scholarship and thesis grant of Tricia Joy C. Torres and the Department of Marine Science, College of Science and Mathematics, MSU - Iligan Institute of Technology for all the support in the conduct of this research.

Conflict of interest. The authors declare that there is no conflict of interest.

References

Al Solami M. A., 2020 Comparative response of red and green algae to the quality of coastal water of Red Sea, Haql, Saudi Arabia. Journal of Environmental Protection 11(10):793-806.

Ang Jr. P. O., Leung S. M., Choi M. M., 2013 A verification of reports of marine algal species from the Philippines. Philippine Journal of Science 142(3):5-49.

Belton G. S., van Reine W. F. P. H., Huisman J. M., Draisma S. G. A., Gurgel C. F. D., 2014 Resolving phenotypic plasticity and species designation in the morphologically challenging *Caulerpa racemosa–peltata* complex (Chlorophyta, Caulerpaceae). Journal of Phycology 50(1):32-54.

Calumpong H. P., Meñez E. G., 1997 Field guide to the common mangroves, seagrasses and algae of the Philippines. Bookmark, 197 pp.
Campbell P., Comiskey J., Alonso A., Dallmeier F., Nuñez P., Beltran H., Baldeon S., Nauray W., De La Colina R., Acurio L., Udvardy S., 2002 Modified Whittaker plots as an assessment and monitoring tool for vegetation in a lowland tropical rainforest. Environmental Monitoring and Assessment 76:19-41.
Clemente K. J. E., Baldia S. F., Cordero Jr. P. A., 2017 The marine macroalgal flora of the Romblon Island Group (RIG), Central Philippines. AACL Bioflux 10(5):983-1000.
Coppejans E., Prathep A., Leliaert F., Lewmanomont K., De Clerck O., 2010 Seaweeds of Mu Ko Tha Lae Thai (SE Thailand): methodologies and field guide to the dominant species (Vol. 11). Biodiversity Research and Training Program (BRT), 274 pp.
Dawes C. J., 1998 Marine botany. 2nd edition. John Wiley & Sons, 496 pp.
Dhinakaran D. I., Karthickraja P., Kumar K. K., Vigneshwaran G., Marimuthu T., 2016 Identification of novel metabolites along with the assessment of metal toxicity and its implication in marine red alga *Hypnea musciformis.* International Journal of Marine Science 6(20):1-6.
English S., Wilkinson C., Baker V., 1997 Survey manual for tropical marine resources. 2nd edition. Australian Institute of Marine Science, Townsville, Australia, 390 pp.
Esa F. A., Harith M. N., Hassan R., 2013 Diversity and abundance of seaweed at Satang Besar Island, Sarawak. Proceeding of The 7th International Symposium on Kuroshio Science, Pontianak, Indonesia, pp. 21-23.
Guiry M. D., 2012 How many species of algae are there? Journal of Phycology 48(5): 1057-1063.
Guiry M. D., Guiry G. M., 2020 Algaebase [Online]. Worldwide electronic publication, National University of Ireland, Galway.
Gupta S., Abu-Ghannam N., 2011 Recent developments in the application of seaweeds or seaweed extracts as a means for enhancing the safety and quality attributes of foods. Innovative Food Science and Emerging Technologies 12(4):600-609.
Krebs C., 1989 Ecological methodology. 2nd edition. Harper and Row Publishers Inc, 654 pp.
Lastimoso J. M. L., Santiañez W. J. E., 2021 Updated checklist of the benthic marine macroalgae of the Philippines. Philippine Journal of Science 150(S1):29-92.
Lee R. E., 1999 Phycology. 3rd edition. Cambridge University Press, 624 pp.
Lee R. E., 2008 Phycology. 4th edition. Cambridge University Press, 560 pp.
Mann K. H., 1973 Seaweeds: their productivity and strategy for growth: the role of large marine algae in coastal productivity is far more important than has been suspected. Science 182(4116):975-981.
Margalef R., 1962 Succession in marine populations. Advancing Frontiers of Plant Sciences 2:137-186.
Margalef R., 1972 Homage to Evelyn Hutchinson, or why there is an upper limit to diversity. Transactions of the Connecticut Academy of Arts and Sciences 44:211-235.
Mattio L., Payri C. E., 2011 190 years of *Sargassum* taxonomy, facing the advent of DNA phylogenies. The Botanical Review 77:31-70.
Mattio L., Payri C. E., Verlaque M., 2009 Taxonomic revision and geographic distribution of the subgenus *Sargassum* (Fucales, Phaeophyceae) in the western and central Pacific islands based on morphological and molecular analyses (1). Journal of Phycology 45(5):1213-1227.
Mayakun J., Prathep A., 2005 Seasonal variations in diversity and abundance of macroalgae at Samui Island, Surat Thani Province, Thailand. Songklanakarin Journal of Science and Technology 27(3):653-663.
Mendoza A. B., Soliman V. S., 2013 Community structure of macroalgae of Lagonoy Gulf, Bicol region, Philippines. Kuroshio Science 7:49-57.
Mushlihah H., Amri K., Faizal A., 2021 Diversity and distribution of macroalgae to environmental conditions of Makassar City. Journal Ilmu Kelautan SPERMONDE 7(1):16-26.
Noiraksar T., Ajisaka T., 2009 Taxonomy and distribution of *Sargassum* (Phaeophyceae) in the Gulf of Thailand. Journal of Applied Phycology 20:963-977.
Pratama W., Dewi S. C., Sari I. Z., Hardiyati A., Wajong A. E., 2015 Distribution and abundance of macroalgae in intertidal zone of Drini Beach, Gunungkidul, DIY. KnE Life Sciences 2(1):514-517.

Raja A., Vipin C., Aiyappan A., 2013 Biological importance of marine algae-an overview. International Journal of Current Microbiology and Applied Sciences 2(5):222-227.
Romdoni T. A., Ristiani A., Meinita M. D. N., Marhaeni B., Setijanto, 2018 Seaweed species composition, abundance and diversity in Drini and Kondang Merak Beach, Java. E3S Web Conf 47:03006.
Sahayaraj K., Rajesh S., Asha A., Rathi J. M., Raja P., 2014 Distribution and diversity assessment of the marine macroalgae at four southern districts of Tamil Nadu, India. Indian Journal of Geo-Marine Sciences 43(4):607-617.
Saito Y., Atobe S., 1970 Phytosociological study of intertidal marine algae: I. Usujiri Benten-Jima, Hokkaido. Bulletin of the Faculty of Fisheries, Hokkaido University 21(2):37-69.
Santiañez W. J. E., Sariego R. S., Trono Jr. G. C., 2015 The seaweed flora of the Balabac marine biodiversity conservation corridor (BMBCC), Southern Palawan, Western Philippines. Plant Ecology and Evolution 148(2):267-282.
Stockman K. W., Ginsburg R. N., Shinn E. A., 1967 The production of lime mud by algae in south Florida. Journal of Sedimentary Research 37(2):633-648.
Titlyanov A. E., Titlyanova V. T., Li X., Huang H., 2016 Coral reef marine plants of Hainan Island. 1st edition. Academic Press, 254 pp.
Trono G. C., 1997 Field guide and atlas of the seaweed resources of the Philippines. Vol. 1. Bookmark, 306 pp.
Viswanathan S., Ebciba C., Santhiya R., Nallamuthu T., 2014 Phytochemical screening and *in vitro* antibacterial, antioxidant and anticancer activity of *Amphiroa fragilissima* (Linneaus) JV Lamoroux. International Journal of Innovative Research in Science, Engineering and Technology 3(5):12933-12948.
Wai M. K., 2018 Morphotaxonomy, culture studies and phytogeographical distribution of *Amphiroa fragilissima* (Linnaeus) Lamouroux (Corallinales, Rhodophyta) from Myanmar. Journal of Aquaculture and Marine Biology 7(3):142-150.
Yin L. W., 2020 Influence of characteristics of marine macroalgae on feeding preferences of the milkfish (*Chanos chanos*) in Peninsular Malaysia. MSc thesis, University of Malaya, Malaysia, 79 pp.
Yip Z. T., Quek R. Z. B., Low J. K. Y., Wilson B., Bauman A. G., Chou L. M., Todd P. A., Huang D., 2018 Diversity and phylogeny of *Sargassum* (Fucales, Phaeophyceae) in Singapore. Phytotaxa 369(3):200-210.

Received: 26 September 2024. Accepted: 16 November 2024. Published online: 22 April 2025.
Authors:
Tricia Joy C. Torres, Mindanao State University-Iligan Institute of Technology, College of Science and Mathematics, Department of Marine Science, Iligan City 9200, Philippines, e-mail: triciajoy.torres@g.msuiit.edu.ph
Maria Luisa S. Orbita, Mindanao State University-Iligan Institute of Technology, College of Science and Mathematics, Department of Marine Science, Iligan City 9200, Philippines, e-mail: marialuisa.orbita@g.msuiit.edu.ph
Annielyn D. Tampus, Mindanao State University-Iligan Institute of Technology, College of Science and Mathematics, Department of Marine Science, Iligan City 9200, Philippines, e-mail: annielyn.tampus@g.msuiit.edu.ph
Ivane P. Gerasmio, Mindanao State University-Iligan Institute of Technology, College of Science and Mathematics, Department of Marine Science, Iligan City 9200, Philippines, e-mail: ivane.gerasmio@g.msuiit.edu.ph
Shiela L. Dagondon, Mindanao State University-Iligan Institute of Technology, College of Science and Mathematics, Department of Biological Sciences, Iligan City 9200, Philippines, e-mail: shiela.dagondon@g.msuiit.edu.ph
Beverly C. Orong, Mindanao State University-Iligan Institute of Technology, College of Science and Mathematics, Department of Biological Sciences, Iligan City 9200, Philippines, e-mail: beverly.cagod@g.msuiit.edu.ph
Ronaldo R. Orbita, Mindanao State University-Iligan Institute of Technology, College of Education, Department of Professional Education, Iligan City 9200, Philippines, e-mail: ronaldo.orbita@g.msuiit.edu.ph

How to cite this article:
Torres T. J. C., Orbita M. L. S., Tampus A. D., Gerasmio I. P., Dagondon S. L., Orong B. C., Orbita R. R., 2025 First comprehensive study of marine benthic macroalgae communities in Eastern Siargao Island, Mindanao, Philippines. AACL Bioflux 18(2):951-963.