DAVAO RESEARCH JOURNAL

P-ISSN 2244-4432
E-ISSN 2984-7125

Community structure of macroinvertebrates in protected and exploited areas of Baganga, Davao Oriental, Philippines

Jay Mark D. BANTAYAN[1]*, Nezel Ann Lomoljo-BANTAYAN[2], Jhonnel P. VILLEGAS[3]

[1]Davao de Oro State College, Maragusan, Davao de Oro, Philippines. https://orcid.org/0000-0002-0361-1929
[2]Davao del Norte State College, Panabo City, Davao del Norte, Philippines. https://orcid.org/0000-0003-4437-0831
[3]Davao Oriental State University, City of Mati, Davao Oriental, Philippines. https://orcid.org/0000-0001-6387-2381
**Corresponding author: jaymark.bantayan@ddosc.edu.ph*

ABSTRACT. Macroinvertebrates are vital in coastal marine environments, with functions: ecological (e.g., food chain) and socio-economic (e.g., income generation for coastal gleaners). Different anthropogenic activities, including unregulated gleaning, pose potential threats to the assemblages of macroinvertebrates. However, studies related to assessing and comparing the community structures of macroinvertebrates in protected and exploited areas are poorly documented in the Philippines. Hence, this study aims to provide valuable information to formulate proper fisheries management, including the protection and conservation of macroinvertebrates and their supporting habitats. A fishery-independent and fishery-dependent surveys were conducted in three coastal barangays of Baganga, Davao Oriental, Philippines: one protected (control site) in Ban-ao and two exploited (gleaning grounds) in San Victor and Kinablangan to determine macroinvertebrate community structure and document local gleaning activities. Seventeen (17) macroinvertebrates were recorded, comprising nine (9) mollusks, three (3) crustaceans, and five (5) echinoderms. Four species (4) were abundant in the study sites: *Dardanus* sp., *Monetaria annulus*, *Thalamita crenata*, and *Trochus maculatus*. The community structure of macroinvertebrates in both exploited areas was influenced by gleaning of the coastal residents, resulting in lower species richness, density, and diversity compared to the protected area where collection was highly restricted. There is a need to ensure the sustainability of gleaning in these areas by providing protection on the existing macroinvertebrates in the area through a formulation of local subsistence fisheries management.

Keywords: *distribution, diversity, gleaning practices, marine protected area, species richness*

How to Cite: Bantayan, J. M., Lomoljo-Bantayan, N. A., and Villegas, J. (2023). Community structure of macroinvertebrates in protected and exploited areas of Baganga, Davao Oriental, Philippines. Davao Research Journal, 14(1), 17-31. https://doi.org/10.59120/drj.v14i1.7

OPEN ACCESS

Submitted: 18 January 2023
Revised: 2 March 2023
Accepted: 29 March 2023
Published: 27 June 2023

https://davaoresearchjournal.ph

INTRODUCTION

The coastal marine habitats are culturally and economically important throughout Southeast Asia (Cullen-Unsworth and Unsworth, 2016), along with its associated fisheries, considered one of the most important but heavily exploited natural resources on the planet (Exton, 2010). Marine resources such as macroinvertebrates are significant in the different kinds of fisheries, especially in the Philippines (Del Norte-Campos et al., 2005). Gleaning, locally known as "*pagpanginhas*," is a common and traditional coastal activity that involves simple handpicking of macroinvertebrates from the reef flats during low tide or by employing other methods such as wading or raking the sediments (Craig et al., 2008; de Jesus et al., 2010; Olavides et al., 2010; De Guzman et al., 2016). The gleaned seafood items are utilized in three different ways in some parts of the Visayas and Mindanao: (a) mainly consumed as food by the households; (b) mainly sold to generate supplemental income; and (c) both eaten and sold (De Guzman et al., 2016).

Gleaning macroinvertebrates is a source of income and food. In fact, it is the only effective form of subsistence fishing primarily destined for human consumption, securing households' daily food in coastal areas (Palomares and Pauly, 2010; Cesar et al., 2003). In Banate Bay of Eastern Panay Island, gleaning is the primary source of livelihood. The annual catch of the gleaners ranges from 20,988.7 kg to 43,527.62 kg. These provide them a total annual value of PhP 421,047.11 when their collected macroinvertebrates are sold in the local market and price is comparatively higher when sold in the city (PhP 897,140.00) (del Norte-Campos et al., 2005).

Ecologically, since most macroinvertebrate species are slow-moving, overharvesting causes their population to decline (Nieves et al., 2010). The study of De Guzman et al. (2016) revealed a decrease in the daily catches from gleaning activities over the decades, with a drastic drop in catch per unit effort (CPUE) in some areas of the country like Tubajon, Kauswagan, and Lopez Jaena. In addition, Brenier et al. (2011) stressed that reef gleaning affects benthic habitats and their living resources.

There were several studies conducted on gleaning across the Philippines: (1) Malalison Island, Antique (Villarta et al., 2021); (2) Laguindingan, Misamis Oriental; Kauswagan, Lanao del Norte; Lopez Jaena, Misamis Occidental; Cortes, Surigao del Sur and Tubigon, Bohol (De Guzman 2019; De Guzman et al., 2019; De Guzman et al., 2016); (3) Mabini, Batangas (Palomares et al., 2014); (4) Bais Bay, Negros Island (Cabanban et al., 2014); Banate Bay (Cabanban et al., 2014; del Norte-Campos et al., 2005); (5) Albay Side of Lagonoy Gulf (Nieves et al., 2010); (6) Bohol Marine Triangle (Samonte et al., 2007); and (7) Estancia and Batan of Panay Island; Nueva Valencia of Guimaras Island (Primavera et al., 2002). However, the impact of gleaning on the community structures of macroinvertebrates is poorly documented in the country (Maynawang and Macusi, 2023). Consequently, unmanaged and unregulated harvesting of marine macroinvertebrate resources could lead to overexploitation of the species and further influence the deterioration of its habitat (De Guzman et al., 2016).

This study aims to assess and document gleaning in protected and exploited areas to determine the community structure of macroinvertebrates. This assessment is essential in providing valuable information on its impacts on macroinvertebrate resources' ecology, associated habitats, and the socio-economy of subsistence fishery-dependent communities. This will further assist the coastal barangays and municipalities in Davao Oriental in formulating subsistence fisheries management to protect and conserve the macroinvertebrates and their associated natural habitats, including the rocky intertidal, seagrass beds, mangrove areas, and coral reefs. The results of the study will serve as a guide in evaluating the effectiveness of Marine Protected Area (MPA) management as a tool for conserving and protecting marine resources and natural habitats.

DOI: https://doi.org/10.59120/drj.v14i1.7

MATERIALS AND METHODS

Study Areas

The study was conducted in the municipality of Baganga, located in the southeastern part of Davao Oriental, Philippines. In 2017, it had a total population of 56,241 (DTI, 2017). The fishery-independent and fishery-dependent surveys of this research were employed in the 3 coastal barangays of Baganga: one (1) Marine Protected Area (control site) in Ban-ao and two (2) exploited areas (e.g., gleaning grounds) of Kinablangan and San Victor (Figure 1). The description of each study area is presented in Table 1.

Table 1. The description of study areas in Baganga, Davao Oriental.

Study area	Location	Habitat characteristic	Gleaning activity
Ban-ao	07.7389 N 126.5367 E	Wide sandy-rocky intertidal with algal and seagrass beds	Gleaning is strictly prohibited within the marine protected area
Kinablangan	07.7067 N 126.5671 E	A wide sandy substrate with seagrass beds	Gleaning is allowed; gleaners live close to shorelines
San Victor	07.6639 N 126.5595 E	Sandy-muddy substrate with mangrove stands and seagrass beds	Gleaning is allowed; gleaners live far from shorelines

Field Survey

Fishery-independent surveys

The fishery-independent surveys were conducted using the Belt-Transect method to assess the macroinvertebrates during low tide and daytime in 6 days in the 3 study areas. Five 50-meter transects were laid perpendicular to the shore with 2.5 meters on each side, and 25-meter intervals from one transect to another.

The total area was estimated through Google Earth Pro. Its extent was validated through ground-truthing and gleaners' local knowledge to locate the common gleaning grounds, especially in the exploited areas of Kinablangan and San Victor. The macroinvertebrates observed from each transect line in rocky intertidal, seagrass beds, and mangrove areas were identified and counted. Partially-drained wet samples were also collected as voucher specimens for further documentation in the Science Laboratory of Davao de Oro State College.

In addition, in-situ informal interactions with the gleaners in the exploited areas were done to note and document species of macroinvertebrates observed in their catches. Physical measurements of the different species, such as lengths calibrated to the nearest 0.01 cm, were measured using a Vernier caliper, while wet weights calibrated to the nearest 0.01 g were obtained using a kitchen scale. Thirty fresh samples for each commonly gleaned economically-important bivalve species like *Austriella corrugata* (Deshayes, 1843), *Codakia tigerina* (Linnaeus, 1758), and *Pegophysema philippiana* (Reeve, 1850) were collected from the gleaners in San Victor to determine their maximum lengths. These were then determined to classify if the species' wild stock's sizes were small, medium, or large following the online database, www. sealifebase.org.

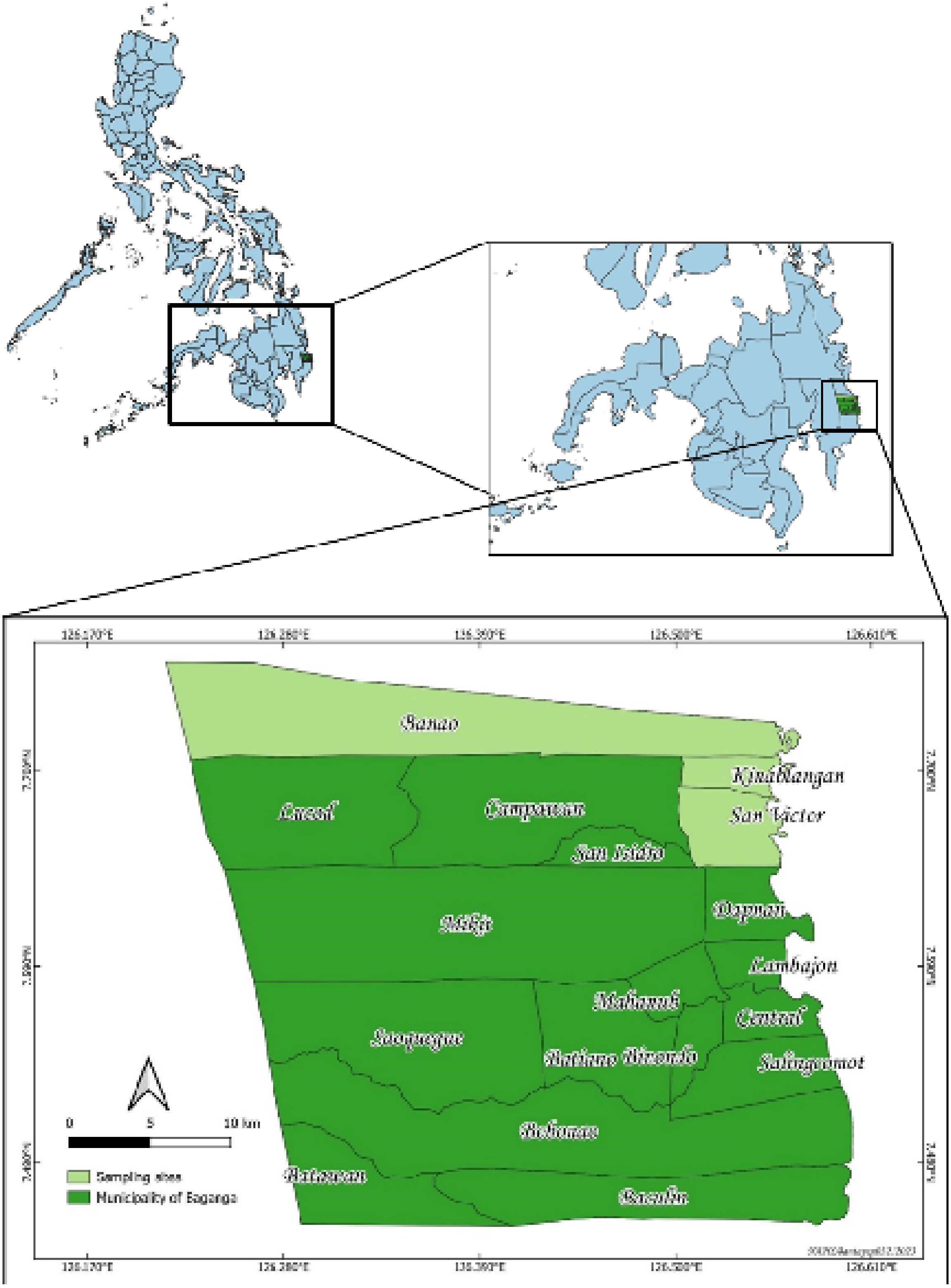

Figure 1. Map of the study areas in Baganga, Davao Oriental, Philippines.

Fishery-dependent surveys

Since coastal households typically occur in irregular clusters along the exploited areas of Kinablangan and San Victor, simple random sampling adopted from De Guzman et al. (2016) was used in fishery-dependent surveys to cover at least 20% of the population or just a minimum of 30 household respondents in each of these 2 study areas. Sixty-one local gleaners: Kinablangan (10 men; 21 women) and San Victor (8 men; 22 women), were interviewed using semi-structured questionnaires to document their gleaning practices. In addition, observations were also conducted to understand their movement and distribution in gleaning grounds.

Identification of macroinvertebrates

Macroinvertebrates collected and documented during both surveys were identified through the use of field identification guides such as the Food and Agriculture Organization (FAO) Species Identification Guide for Fishery Purposes (1985), Field Guide for the Edible Crustacea of the Philippines by Moto (1980), Commonly gleaned macro-benthic invertebrates in a small offshore island of Cawili, Cagayancillo, Palawan, Philippines by Ardines et al. (2020), Purcell et al. (2012) for sea cucumbers, and open-access online databases such as World Register of Marine Species (WoRMS) or SeaLifeBase, and local ecological knowledge of the gleaners.

Data analysis

The abundance, density, and diversity indices of macroinvertebrates were determined using the Paleontological Statistics Software (PAST) version 3.24, free software for ecological data analysis. In addition, One-Way ANOVA and Tukey's test (post-hoc) were then performed to determine the statistical difference in the abundance of macroinvertebrates assessed across the 3 study areas. Variance/mean density ratio tests were also used to determine the spatial distribution of macroinvertebrates in both protected and exploited areas. Patterns of distribution were determined and interpreted as follows:

a. if the variance to mean density (*S2*) value is equal to the mean density x, that is (*S2*= x), the distribution is random;
b. if the computed *S2* value is less than the mean density (*S2*<x), the distribution is uniform; and
c. if the computed value of *S2* is greater than the mean density (*S2*>x), then the pattern of distribution is clumped.

RESULTS AND DISCUSSION

Species Richness of Macroinvertebrates

A total of 17 species recorded across the three study areas comprising different groups: Mollusca (9), Crustacea (3), and Echinodermata (5) (Table 2). The mollusks *Monetaria annulus* and *Trochus maculatus*, crustaceans *Dardanus* sp., and *Thalamita crenata* were the most commonly observed macroinvertebrates in all areas. The least common species recorded in one study area only include the mollusks *Atrina pectinata*, *Lambis lambis*, *Mopalia muscosa* and *Turbo bruneus*, and echinoderms *Synapta maculata*, *Ophiocoma echinata*, *Protoreaster nodosus* and *Tripneustes gratilla*. The protected area of Ban-ao has the highest species richness of 14, followed by the exploited areas of Kinablangan and San Victor, with 10 and 6 species richness, respectively.

Ban-ao had the same number of species with 3. Further, both Ban-ao and Kinablangan had the same number of echinoderm species, with 3, but none were found in San Victor. The differences in species richness across the study areas were attributed to human disturbances present. For instance, gleaning or collection of macroinvertebrates is highly prohibited/ restricted, especially in Ban-ao which is a protected area, whereas the exploited areas of Kinablangan and San Victor which are considered gleaning grounds, are highly exposed to gleaning activities by either the barangay residents, and even those living outside the barangay, who find gleaning as an economic activity providing a supplemental source of income or an individual/family recreational activity. This observation is similar to Nordlund and Gullström (2013), where the species richness of marine invertebrates in Inhaca Island, Mozambique, of the Western Indian Ocean were significantly higher in the protected site than the harvested site.

Table 2. The species richness of macroinvertebrates found in the study areas.

Taxon/Group	**Family**	**Scientific name**	**Common name**	**Study areas**		
				Exploited		**Protected**
				Kinablangan	San Victor	Ban-ao
MOLLUSCA:						
Bivalvia	Pinnidae	*Atrina pectinata*	comb pen shell	x	x	✓
Gastropoda	Strombidae	*Canarium urceus*	little pitcher conch	✓	x	✓
Gastropoda	Strombidae	*Lambis lambis*	spider conch	x	x	✓
Gastropoda	Strombidae	*Strombus canarium*	conch	x	✓	✓
Gastropoda	Cypraeidae	*Cypraea moneta*	cone shell	✓	x	✓
Gastropoda	Cypraeidae	*Monetaria annulus*	gold ring cowrie	✓	✓	✓
Gastropoda	Trochidae	*Trochus maculatus*	maculated top (pink)	✓	✓	✓
Gastropoda	Turbinidae	*Turbo bruneus*	brown Pacific turban	x	x	✓
Polyplacophora	Mopaliidae	*Mopalia muscosa*	mossy chiton	✓	x	x
			Subtotal	**5**	**3**	**8**
CRUSTACEA:						
Malacostraca	Diogenidae	*Dardanus* sp.	hermit crab	✓	✓	✓
Malacostraca	Menippidae	*Ozius rugulosus*	stone crab	x	✓	✓
Malacostraca	Portunidae	*Thalamita crenata*	crenate swimming crab	✓	✓	✓
			Subtotal	**2**	**3**	**3**
ECHINODERMATA:						
Holothuroidea	Holothuriidae	*Holothuria leucospilota*	white threads fish	✓	x	✓
Holothuroidea	Synaptidae	*Synapta maculata*	spotted worm sea cucumber	x	x	✓
Ophiuroidea	Ophiocomidae	*Ophiocoma echinata*	spiny ophiocoma	✓	x	x

Asteroidea	Oreasteridae	*Protoreaster nodosus*	horned sea star	x	x	✓
Echinoidea	Toxopneustidae	*Tripneustes gratilla*	collector urchin	✓	x	x
			Subtotal	**3**	**0**	**3**
			TOTAL	**10**	**6**	**14**

As presented in Table 3, the protected area of Ban-ao has the highest mean density of macroinvertebrates (0.3), followed by the exploited areas of Kinablangan (0.1) and San Victor being the least (0.0). The mean density of macroinvertebrates in Ban-ao was attributed to its productive intertidal zones, where seagrass and algal beds provide food and protection to macroinvertebrates. In addition, restrictions made against extractive activities such as gleaning, macroinvertebrate species are protected against this noticeable human disturbance, as opposed to Kinablangan and San Victor. Nordlund and Gullström (2013) reported that the seagrass meadows in the protected site supported substantially higher densities of marine invertebrates than exploited sites where anthropogenic activities such as gleaning affect the community composition of seagrass-associated fauna.

The macroinvertebrates *Atrina pectinata* and *Lambis lambis* were the only species of mollusks observed in Ban-ao. The species *Ozius rugulosus* was the only crustacean found in San Victor and Ban-ao with the same lowest density of 0.0 ± 0.001. Surprisingly, no echinoderms were recorded in San Victor. However among the echinoderms observed in the other two areas, *Holothuria leucospilota* in Kinablangan (0.0 ± 0.0) and Ban-ao (0.0 ± 0.003) and *Tripneustes gratilla* in Kinablangan (0.0 ± 0.0) were the only economically-important species recorded.

In the exploited area of Kinablangan, the macroinvertebrate *Ophiocoma echinata* got the highest density of 0.1 ± 0.11, while *Monetaria annulus* and *Mopalia muscosa* had the lowest densities (0.0 ± 0.0). In the exploited area of San Victor, *Dardanus* sp. had the highest density (0.0 ± 0.01), while *Ozius rugulosus* got the lowest (0.0 ± 0.001). In the protected area of Ban-ao, *Canarium urceus* got the highest density (0.1 ± 0.04). At the same time, three species of macroinvertebrates had the lowest density, namely *Lambis lambis*, *Ozius rugulosus*, and *Turbo bruneus* (0.0 ± 0.001).

Generally, among the 17 species of macroinvertebrates recorded in three areas, 76% are considered economically important. Mollusks were found to be the most diverse group in all areas (53%), with gastropods as the most common, followed by echinoderms (29%), and crustaceans got the lowest percentage (18%) comprising Malacostraca.

Table 3. Mean density and relative abundance of macroinvertebrates found in the study areas.

Species	**Exploited Areas**				**Protected Area**	
	Kinablangan		**San Victor**		**Ban-ao**	
	Mean Density *(ind/m²)*	Relative Abundance *(%)*	Mean Density *(ind/m²)*	Relative Abundance *(%)*	Mean Density *(ind/m²)*	Relative Abundance *(%)*
MOLLUSKS:						
Atrina pectinata	-	-	-	-	0.0 ± 0.002	0.3
Canarium urceus	0.0 ± 0.02	5.0	-	-	0.1 ± 0.04	28.2
Cypraea moneta	0.0 ± 0.01	1.4	-	-	0.0 ± 0.01	7.2

Lambis lambis	-	-	-	-	0.0 ± 0.001	0.2
Monetaria annulus	0.0 ± 0.0	0.4	0.0 ± 0.005	11.8	0.0 ± 0.02	3.6
Mopalia muscosa	0.0 ± 0.0	0.4	-	-	-	-
Turbo bruneus	-	-	-	-	0.0 ± 0.001	0.2
Trochus maculatus	0.0 ± 0.01	8.1	0.0 ± 0.006	13.7	0.1 ± 0.07	24.3
Strombus canarium	-	-	0.0 ± 0.006	9.8	0.0 ± 0.01	4.6
CRUSTACEANS:						
Dardanus sp.	0.0 ± 0.01	5.9	0.0 ± 0.01	58.8	0.0 ± 0.03	4.9
Ozius rugulosus	-	-	0.0 ± 0.001	2.0	0.0 ± 0.001	0.2
Thalamita crenata	0.0 ± 0.0	1.4	0.0 ± 0.002	3.9	0.0 ± 0.002	0.3
ECHINODERMS:						
Holothuria leucospilota	0.0 ± 0.0	1.8	-	-	0.0 ± 0.003	0.3
Ophiocoma echinata	0.1 ± 0.11	73.4	-	-	-	-
Protoreaster nodosus	-	-	-	-	0.1 ± 0.05	19.5
Tripneustes gratilla	0.0 ± 0.0	2.2	-	-	-	-
Synapta maculata	-	-	-	-	0.0 ± 0.02	6.2
		100%		**100%**		**100%**

Table 4 shows the species richness, diversity, dominance, evenness, and similarity of macroinvertebrates which varied across the three study areas. The protected area of Ban-ao had the highest species richness of 14, followed by the exploited areas of Kinablangan and San Victor, with 10 and 6, respectively. Similarly, Ban-ao got the highest diversity (0.81), while Kinablangan got the lowest value of 0.46. However, the highest dominance was observed in Kinablangan (0.55), while the lowest was in Ban-ao (0.19). San Victor and Ban-ao had the same values on evenness, with 0.71 higher than Kinablangan, with the lowest value of 0.46. The similarity among macroinvertebrates in all areas was 16.86. In gathering grounds across northeastern and western Mindanao, the species diversity and population levels of macroinvertebrates like sea cucumbers tend to be higher in no-take MPAs than in open-access sites where regulation is otherwise absent. Essentially, these MPAs help conserve the diversity and maintain the wild stocks of sea cucumbers, allowing their successful natural recruitment (De Guzman and Quiñones, 2021).

Table 4. Species richness, diversity, dominance, evenness, and similarity of macroinvertebrates found in the study areas.

Study Areas	Species Richness *(S)*	Shannon-Wiener Index *(H)*	Index of Dominance *(D)*	Index of Evenness *(EH)*	Index of Similarity *(S)*
EXPLOITED					
Kinablangan	10	0.46	0.55	0.46	
San Victor	6	0.55	0.39	0.71	16.86
PROTECTED					
Ban-ao	14	0.81	0.19	0.71	

It was revealed in One-Way ANOVA that there is a significant difference in the abundance of macroinvertebrates among the three areas ($p<0.05$). Tukey's test (also revealed that the macroinvertebrates in these areas were significantly different (Table 5).

Table 5. The Tukey's test result.

Study Areas	Turkey range	Mean	Remarks
Ban-ao – San Victor	0.1195 - 3.054	44.4000	Significant
San Victor – Kinablangan	0.0002216 - 9.982	10.2000	Significant
Ban-ao – Kinablangan	0.001135 - 6.929	122.000	Significant

Distribution of Macroinvertebrates

The spatial distribution patterns of benthic species are scale-dependent to spatial gradients of environmental conditions, and these may be clumped, random, or uniform. These depend on the individual's degree of aggregation and spatial arrangement (Añorve et al., 2017).

Most macroinvertebrate species had clumped distribution in all areas (Table 6). Mollusks such as bivalves and gastropods exhibited uniform, random, and clumped distribution patterns. This is similar to the observation of Dewiyanti et al. (2021), where bivalves and gastropods in the mangrove ecosystem of Pusung Cium Island, Indonesia, exhibited the three distribution patterns.

In Kinablangan, most mollusks exhibited clumped distribution. Only the species *Monetaria annulus* and *Mopalia muscosa* had random patterns. In addition, all crustaceans exhibited clumped distribution while only one species of echinoderm *Holothuria leucospilota* exhibited a uniform distribution. All mollusks in San Victor exhibited clumped distribution, while crustaceans exhibited the three types of distribution (clumped, random, and uniform). In Ban-ao, among all species of mollusks, *Atrina pectinata* and *Lambis lambis* exhibited uniform and random distributions, respectively. The crustaceans *Dardanus* sp., *Ozius rogulosus* and *Thalamita crenata* had the same distribution patterns as San Victor. Lastly, all echinoderm species exhibited clumped distribution, with *Holothuria leucospilota* notably exhibited both uniform and clumped distributions. The study of Añorve et al. (2017) observed that another holothurian, *Holothuria atra*, were found to exhibit clumped and uniform distribution patterns in the coral reef system of the eastern tropical Pacific. Accordingly, this broad distribution was due to its being a "habitat generalist species," tolerance to high temperatures, and ability to reproduce sexually and asexually.

Table 6. Distribution patterns of macroinvertebrates.

Species	Study Areas		
	Exploited		**Protected**
	Kinablangan	San Victor	Ban-ao
MOLLUSCS:			
Atrina pectinata	-	-	Uniform
Canarium urceus	Clumped	-	Clumped
Cypraea moneta	Clumped	-	Clumped
Lambis lambis	-	-	Random
Monetaria annulus	Random	Clumped	Clumped
Mopalia muscosa	Random	-	
Turbo bruneus	-	-	Random
Trochus maculatus	Clumped	Clumped	Clumped
Strombus canarium	-	Clumped	Clumped
CRUSTACEANS:			
Dardanus sp.	Clumped	Clumped	Clumped
Ozius rugulosus	-	Random	Random
Thalamita crenata	Clumped	Uniform	Uniform
ECHINODERMS:			
Holothuria leucospilota	Uniform	-	Clumped
Ophiocoma echinata	Clumped	-	-
Protoreaster nodosus	-	-	Clumped
Tripneustes gratilla	Clumped	-	-
Synapta maculata	-	-	Clumped

Gleaning Practices

The findings of Bantayan (2022) highlighted gleaning practices in Baganga where men and women gleaners were noticeably different in their traditional/ modern methods used (e.g., tools/ implements), the presence and absence of target macroinvertebrate species (e.g., low-valued vs. high-valued), and accessibility to gleaning grounds (e.g., inshore vs. offshore) during low tide and good weather condition.

In this study, the macroinvertebrate species were comparatively recorded from both established transects and gleaner's catch in the two exploited areas of San Victor and Kinablangan (Table 7). More species were observed in the gleaner's catch than the macroinvertebrates found inside the belt transect in San Victor, while opposite findings were observed in Kinablangan (belt transect > gleaners catch). These differences were attributed to the type and economic value of macroinvertebrates recorded during the surveys. Generally, the macroinvertebrates observed from the catches of gleaners had direct-use value, mainly for food and income. The gleaners did not collect other species observed, especially in the transects, since they can't either be sold or eaten.

DOI: https://doi.org/10.59120/drj.v14i1.7

Majority of the species were collected by the gleaners through simple handpicking only. Moreover, those burrowing bivalves and gastropods were then gleaned using certain tools/implements. Among these species, the mollusks *Strombus canarium* and *Trochus maculatus* were the most commonly observed in both transect and gleaner's catch in the two exploited areas. It is interesting to note that the bivalves *Pegophysema philippiana* and *Austriella corrugata* were only observed in the catch of gleaners, mainly gathered through digging using a flat blade in the muddy substrate of mangrove areas of San Victor. The species *Pegophysema philippiana* is considered one of the most valued marine invertebrates in the Davao Region (Bersaldo et al., 2023). The other bivalve *Codakia tigerina* and gastropod *Lambis lambis* of economic importance were commonly collected by men in Kinablangan during low tide, 500 meters away from the shore, through digging using a tool like a wooden stick with pointed steel. Among these gleaned species documented, only the sea cucumbers *Holothuria leucospilota* and *Actinopyga echinites* were categorized as least concern and vulnerable based on the International Union for Conservation of Nature's (IUCN) Red List. These two sea cucumber species in Kinablangan are collected by the gleaners from the wild, processed, and then sold to the middlemen to generate more income to support their families' daily needs. The dried sea cucumber products or *trepang* or beche-de-mer are then imported and re-exported across the globe (Purcell, 2014).

Table 7. Species compositions of macroinvertebrates in the exploited areas.

Species Name	English Name	Local Name	Exploited areas			
			San Victor		Kinablangan	
			Transect	Catch	Transect	Catch
MOLLUSCA:						
Anadara inaequivalvis	inequivalve ark	"litob"	-	x	-	✓
Angaria delphinus	common delphinula	"guba-guba"	-	x	-	✓
Pegophysema philippiana	chalky buttercup	"imbao"	-	✓	-	x
Austriella corrugata	corrugated lucine	"imbao"	-	✓	-	x
Atrina pectinata	comb pen shell	"wasay-wasay"	x	-	✓	-
Canarium urceus	little pitcher conch	"aninikad"	x	-	✓	-
Codakia tigerina	pacific tiger lucine	"tambayang"	-	✓	-	✓
Conus sp.	cone snail	"kibul"	-	x	-	✓
Cypraea moneta	cone shell	"bulalo"	x	-	✓	-
Cypraea tigris	tiger cowrie	"bulalo"	-	✓	-	✓
Lambis lambis	spider conch snail	"saang"	x	✓	✓	✓
Monetaria annulus	ring cowrie	"sigay"	✓	✓	✓	x
Mopalia muscosa	mossy chiton	-	x	-	x	-
Strombus canarium	conch	"sikad"	✓	✓	✓	✓
Trochus maculatus	top shell	"amomongpong"	✓	✓	✓	✓
Turbo bruneus	brown pacific turban	"taktakon"	x	✓	✓	✓

CRUSTACEA:						
Dardanus sp.	hermit crab	"umang"	✓	-	✓	-
Ozius rugulosus	stone crab	"kumong"	✓	-	✓	-
Thalamita crenata	crenate swimming crab	"kasag"	✓	✓	✓	x
ECHINODERMATA:						
Actinopyga echinites	deepwater redfish	"bat mani-mani"	-	✓	-	x
Holothuria leucospilota	whitethreads fish	"bat-pisot"	x	✓	✓	✓
Synapta maculata	spotted worm sea cucumber	"bat"	x	-	✓	✓
Thelenota anax	amberfish	"balat-sapatos"	-	✓	-	x
Ophiocoma echinata	spiny ophiocoma	-	x	-	x	-
Protoreaster nodosus	horned sea star	-	x	-	✓	-
Tripneustes gratilla	collector urchin	"swaki"	x	x	x	✓
		TOTAL	**6**	**15**	**14**	**12**

Some economically-important bivalves were recorded from the catch of gleaners in San Victor (Figure 2). Most of the sizes of the species *Austriella corrugata* (n=26), *Codakia tigerina* (n=30), and *Pegophysema philippiana* (n=30) had measurements above 4 cm, ranging between 4.1-4.3 cm. Only *Austriella corrugata* had shell lengths below 4 cm (n=4), ranging between 3.36-4 cm. These indicate that the gleaned bivalves were sexually mature. This is similar to the observation of Bersaldo et al. (2023) where the shell lengths of the commonly gleaned mangrove clam *Pegophysema philippiana* ranged from 3.7-4.4 cm, indicating that its population was in good condition. Bersaldo et al. (2022) emphasized that the maturity of mangrove clams *Anodontia philippiana* is a useful indicator of overexploitation of the species in a certain area. Women in mangrove areas commonly collected these bivalves by digging using knives or flat blades.

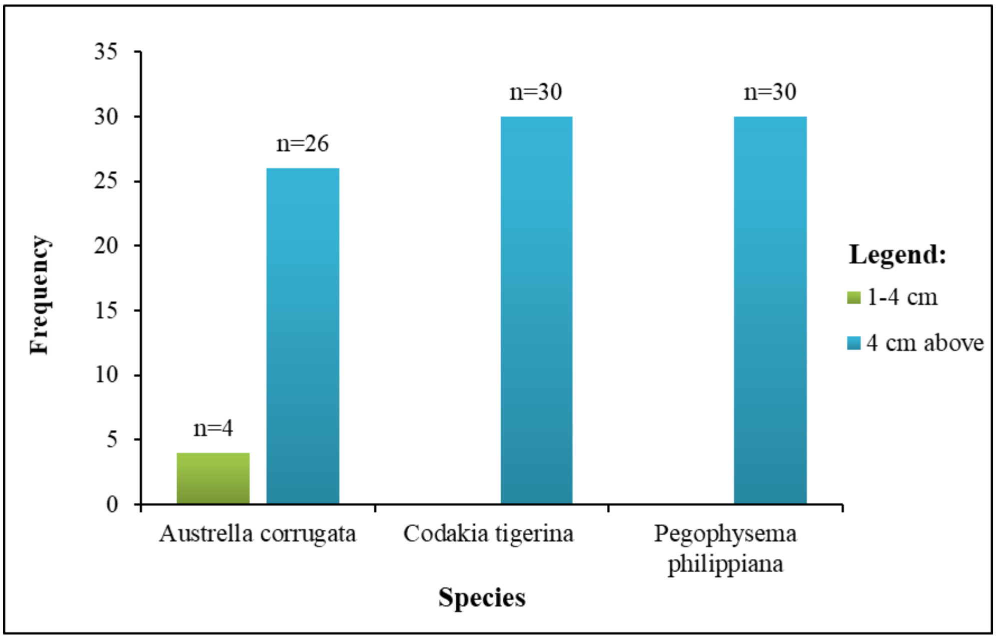

Figure 2. Shell length of some economically-important bivalves in San Victor.

In the exploited areas of San Victor and Kinablangan, men and women were commonly observed using one or more methods in gleaning. Simple handpicking was used by all women in both areas. Though handpicking needs only bare hands to collect macroinvertebrates, this particular method is still considered exploitative to reef flats, seagrasses, and mangroves if unregulated. Other methods, such as digging with a flat spade or knife, using a wooden stick with pointed steel (used by men to collect high-valued bivalves and gastropods), and overturning rocks, are also perceived as potentially destructive to the environment. De Guzman et al. (2016) emphasized that different tools for digging macroinvertebrates have minimal impact since they can also uproot seagrasses. The practice of tilling or excavating wide tidal areas by the Central Philippines gleaners without prior locating the clams *Anodontia edentula* damages mangrove roots, and may kill seedlings, saplings, and young trees (Primavera et al., 2002). Overturning of rocks otherwise can increase disturbance to the ecosystem by removing more species from their natural habitat, consequently reducing potential colonists (McCabe and Gotelli, 2000).

CONCLUSION

In the municipality of Baganga, Province of Davao Oriental, 17 macroinvertebrate species, including nine mollusks, three crustaceans, and five echinoderms, were documented. Fourteen species were documented in Ban-ao, 10 in Kinablangan, and 6 in San Victor. *Dardanus* sp., *Monetaria annulus*, *Thalamita crenata*, and *Trochus* sp. were among the most abundant species in the study areas. Protection policies deter anthropogenic disturbances as species richness, density, and diversity were found higher in the protected area of Ban-ao than exploited areas of San Victor and Kinablangan. However, it should be noted that locals are highly dependent on gleaning, a subcomponent of subsistence fisheries, as their primary source of food and income. At least 76% of all species observed are known to be economically important. Men and women demonstrated different target species and gleaning methods, which can be environmentally damaging if regulatory policies are inefficient. As such, there is a need to establish regulatory measures and policies to ensure that the conservation of gleaning resources is achieved without undermining the economic benefits of the local communities.

ACKNOWLEDGEMENT

The authors wish to acknowledge Dr. Asuncion B. De Guzman for providing inputs to this research, and Community Environment and Natural Resources Office (CENRO) of Baganga: Mr. Franz Von Laguidong, Mr. Brexan Manliguez, and Ms. Lenie Pamaylaon, who assisted during field surveys. Special acknowledgment is also given to Mr. Atilano Ibañez, Punong Barangay of Kinablangan, Mr. Servillano Fontillas, Jr., Punong Barangay of San Victor, and Ms. Mera Ching, Punong Barangay of Ban-ao for permitting the conduct of fishery-dependent and fishery-independent surveys.

REFERENCES

Añorve, L.S., Marin, F.A.S., Weiss, V.S., Santan, E.L. (2017). Population density and spatial arrangement of two holothurian species in a coral reef system: is clumping behavior an anti-predatory strategy? Cah. Biol. Mar. (2017) 58 (307-315).

Ardines, R.B., Mecha, N.J.M.F., Dolorosa, R.G. (2020). Commonly gleaned macro-benthic invertebrates in a small offshore island of Cawili, Cagayancillo, Palawan, Philippines. The Palawan Scientist 12 (102-125).

Bantayan, J.M.D. (2022). Involvement of men and women in gleaning macro-invertebrates in Baganga, Davao Oriental, Philippines. Davao Research Journal 13 (59-75).

Bersaldo, M.J.I., Lacuna, M.L.D., Macusi, E.D. (2023). Length-weight relationship of mangrove clam (Pegophysema philippiana) in different sites within the Baganga, Davao Oriental Province, Philippines. Marine and Fishery Science 36 (2). https://doi.org/10.47193/mafis.3622023010502

Bersaldo, M.J.I., Lacuna, M.L.D., Macusi, E.D. (2022). Status of mangrove clam (Anodontia philippiana Reeve, 1850) in Bagana, Davao Oriental, Philippines. ABAH Bioflux 14 (2).

Brenier, A., Ferraris, J., Mahafina, J. (2011). Participatory assessment of the Toliara Bay reef fishery, southwest Madagascar. Madagascar Conservation and Development. 6 (2).

Cabanban, A.S., Teves-Maturan, D.M., Parducho, V.A., Palomares, M.L.D. (2014). Marine artisanal fisheries of the Philippines, Subzone C – Visayas (Regions VI-VIII). In: Palomares, M.L.D., Pauly, D. (eds.), Philippine Marine Fisheries Catches: A Bottom-up Reconstruction, 1950 to 2010, p. 62-76. Fisheries Centre Research Report 22(62-76).

Cesar, H., Burke, L., Soede, L.P. (2003). The Economics of Worldwide Coral Reef Degradation. Cesar Environmental Economics Consulting.

Craig, P., Green, A., Tuilagi, F. (2008). Subsistence harvest of coral reef resources in the outer islands of American Samoa: Modern, historic and prehistoric catches. Fisheries Research, 89 (3), 230–240. doi:10.1016/j.fishres.2007.08.018

Cullen-Unsworth, L.C., Unsworth R.K.F. (2016). Strategies to enhance the resilience of the world's seagrass meadows. Journal of Applied Ecology, (), n/a–n/a. doi:10.1111/1365-2664.12637

Del Norte-Campos, A.G.C., Campos, W.L., Villarta, K.A. (2005). A Survey of Macro-invertebrate Gleaning in the Banate Bay Intertidal Area, Eastern Panay Island. Science Diliman.

De Guzman, A.B., Quiñones, M.B. (2021). Sea Cucumbers (Holothuroidea) of Northeastern and Western Mindanao, Philippines: The Potential Role of Marine Protected Areas in Maintaining Diversity and Abundance. Journal of Environment and Aquatic Resources. 6(47-70). https://doi.org/10.48031/msunjear.2021.06.04

De Guzman, A.B., Sumalde, Z.M., Colance, M.D.B., Ponce, M.F.V., Rance, G.M.S. (2019). Contribution of Gleaning Fisheries to Food Security and Nutrition of Poor Coastal Communities in the Philippines. Journal of Environmental Science and Management. 1(58-71).

De Guzman, A.B. (2019). Women in subsistence fisheries in the Philippines: The undervalued contribution of reef gleaning to food and nutrition security of coastal households. SPC Women in Fisheries Information Bulletin 29.

De Guzman, A.B., Sumalde, Z.M., Colance, M.D.B., Ponce, M.F.V., Rance, G.M.S. (2016). Economics of Reef Gleaning in the Philippines: Impact on the Coastal Environment, Household Economy and Nutrition. WorldFish.

De Jesus S.C., Dioneda, R.R., Revale, I.H., Doloiras, A.D., Nolial, A.L., Ocampo, A., Alcaraz, D.S. (2010). Assessment of the Ecological Habitats of Bacon District, Sorsogon City in the Philippines. Kuroshio Science 4-1 (43-52).

Department of Trade and Industry. https://cmci.dti.gov.ph/provprofile.php?prov=Davao%20Orientalandyear=2020(accessed Mar 24, 2023)

Dewiyanti, I., Harbi, H., ElRahimi, S.A., Ulfah, M., Damora, A. (2021). International and National Symposium on Aquatic Environment and Fisheries IOP Conf. Series: Earth and Environmental Science 674. doi:10.1088/1755-1315/674/1/012026

Exton, D.A. (2010). Nearshore fisheries of the Wakatobi. Pages 89–111 in J. Clifton, R.K.F. Unsworth, editors. Marine conservation and research in the Coral Triangle: the Wakatobi Marine National Park. Nova Scientific, New York. ISBN 9781616684730.

Food and Agriculture Organization. (1980). FAO Species Identification Sheets for Fishery Purposes. Food and Agriculture Organization, Rome.

Maynawang IS, Macusi ED. Catch assessment of commercially important gastropods in Guang-Guang, Mati City, Davao Oriental, Philippines. Academia Biology 2023;1. https://doi.org/10.20935/AcadBiol6029

McCabe, D.J., Gotelli, N.J. (2000). Effects of disturbance frequency, intensity, and area on assemblages of stream macro-invertebrates.

Nieves, P.M.S., de Jesus, C., Macale, A.M.B., Pelea, J.M.D. (2010). An Assessment of Macro-Invertebrate Gleaning in Fisheries on the Albay Side of Lagonoy Gulf. Kuroshio Science 4-1 (27-35).

Nordlund, L.M., Gullstrom, M. (2013). Biodiversity loss in seagrass meadows due to local invertebrate fisheries and harbour activities. Estuarine, Coastal and Shelf Science. 135 (231-240).

Olavides, R.D.D., Edullantes, C.M.A., Meñez, M.A.J. (2010). Assessment of the sea cucumber resource and fishery in the Bolinao-Anda reef system. Science Diliman (July-December 2010) 22:2 (1-12).

Palomares, M.L.D., Parducho, V.A., Bimbao, M.A., Ocampo, E., Pauly, D. (2014). Philippine marine fisheries 101. In: Palomares, M.L.D., Pauly, D. (eds.), Philippine Marine Fisheries Catches: A Bottom-up Reconstruction, 1950 to 2010. Fisheries Centre Research Report 22(1-13).

Palomares, M.L.D., Pauly, D. (2010). Philippine Marine Fisheries Catches: A Bottom-up Reconstruction, 1950 to 2010. Fisheries Centre Research Reports 22(1).

Primavera, J.H., Lebata, M.J.H.L., Gustilo, L.F., Altamirano, J.P. (2002). Collection of the clam Anodontia edentula in mangrove habitats in Panay and Guimaras, central Philippines. Wetlands Ecology and Management 10 (363–370). https://doi.org/10.1023/A:1020983218203

Purcell, S.W. (2014). Value, Market Preferences and Trade of Beche-De-Mer from Pacific Island Sea Cucumbers. PLoS ONE 9(4): e95075. doi:10.1371/journal.pone.0095075

Purcell, S., Samyn, Y., Conand, C. (2012). Commercially important sea cucumbers of the world. Food and Agriculture Organization, Rome.

Samonte-Tan, G.P.B., White, A.T., Tercero, M.A., Diviva, J., Tabara, E., Caballes, C. (2007) Economic Valuation of Coastal and Marine Resources: Bohol Marine Triangle, Philippines, Coastal Management, 35:2-3 (319-338). http://dx.doi.org/10.1080/08920750601169634

Villarta, K., Del Norte-Campos, A.G., Burgos-Nu ñeza, L. O. R. E. L. I. E. (2021). Reassessment of the Mollusc Gleaning Fishery in Malalison Island, Antique Province, West Central Philippines. Asian Fisheries Society. 34 (225-235). https://doi.org/10.33997/j.afs.2021.34.3.004