Density and species composition: An initial record of the marine macroinvertebrates in Malamawi Island, Isabela City, Basilan Province, Philippines

[1]Nur Inih U. Sahidjan, [2]Ivane R. Pedrosa-Gerasmio, [1]Wella Tiu-Tatil

[1] Department of Environmental Science, School of Interdisciplinary Studies, Mindanao State University-Iligan Institute of Technology, Iligan City, Philippines;
[2] Department of Marine Science, College of Science and Mathematics, Mindanao State University-Iligan Institute of Technology, Iligan City, Philippines
Corresponding author: N. I. U. Sahidjan, nurinih.sahidjan@g.msuiit.edu.ph

Abstract. The coastal ecosystems in Malamawi Island play a significant role in the lives of most coastal households dependent on sustenance provided through gleaning. This dependence, coupled with the monsoonal dynamics of the island, may alter the macroinvertebrate diversity and lead to overexploitation. This study was done to understand the biotic components of the gleaning grounds in different seasons, which would help better manage the island's invertebrate gleaning fisheries. The study determined the macroinvertebrate diversity in Malamawi Island and compared monsoonal variations in species composition and abundance. The transect-quadrat method was used with triplicate quadrats laid perpendicular to the shoreline to determine diversity and abundance of macroinvertebrates in three sites across the island. Physico-chemical parameters were also taken to describe the ecological condition of the gleaning ground. Sixty-four macroinvertebrates from four phyla were identified, and seventy percent of them are edible, with the seagrass ecosystem having the highest species composition. Species diversity indices indicated very low to moderate diversity. Species composition did not vary with monsoon, and the poor biodiversity of the marine macroinvertebrate assemblage in the island may be a result of anthropogenic disturbances rather than the natural environmental conditions. There is a need to conserve these marine resources for the local community dependent on them through regulating gleaning activities and protecting the coastal ecosystems that support them.
Key Words: diversity, coastal ecosystem, invertebrate gleaning, intertidal resources, monsoonal variation.

Introduction. The Philippines is endowed with rich marine resources that provide multiple ecosystem services to the people and support the country's biological diversity. As an archipelago of more than 7,000 islands situated near the Pacific Ocean, it is considered the center of marine biodiversity but also dubbed one of the world's marine biodiversity hotspots (Palomares et al 2014). Most coastal communities living in the country derive their sustenance from fisheries, particularly from nearshore fishing and gleaning activities. Gleaning is a practice that involves gathering marine macroinvertebrates in intertidal zones through the use of hand or simple tools (De Guzman 2019).

Macroinvertebrates play an important role in the marine ecosystem. Bivalves are responsible for filter feeding, nutrient cycling, and phytoplankton regulation, while gastropods entrap primary production (Stiepani et al 2022). They also possess a broad range of functional traits that make them excellent models for trait-based studies. They also play a part in human health since marine macroinvertebrates are highly nutritious food, composed of essential nutrients such as proteins and essential vitamins (Lauritsen 2019). In the Philippines, gleaning in the intertidal zones generates income and provides food security for coastal communities (Aldea 2023). Because of the slow-moving and sometimes sessile nature of macroinvertebrates, gleaners prefer harvesting them with the aid of simple traditional tools, which contribute significantly to the intense collection of these species. Mollusks and sea cucumbers that live on the sandy-muddy substrate and those that are attached to corals are also collected by some gleaners using fishing implements (Cabanban et al 2014).

In Malamawi Island, most locals rely on artisanal fishing for their sustenance. Ecotourism is also the lifeblood of the island, being one of the popular tourist destinations in Mindanao, and the seafood provided for the tourists is caught by local fishermen. This domestic and commercial harvesting was observed to be among the drivers of catch decline. The mollusks gleaned are still juveniles, and this threatens the population, coupled with human-induced disturbance, such as improper waste disposal and coastal clearing for tourism, which displaces macroinvertebrate species, resulting in biodiversity decline (Aldea et al 2015).

As a tropical country, the Philippines experiences monsoonal variations. Between June and October, warm air flows from the southwest, known as the Southwest Monsoon (SWM) or Habagat, while between December and March, cold air moves in from the northeast, referred to as the Northeast Monsoon (NEM) or Amihan (Cabaitan et al 2019). Coastal upwelling, driven by the northeast monsoon, creates biologically rich zones (Villanoy et al 2011). The environmental changes associated with these monsoons may influence the distribution of marine macroinvertebrates in coastal areas (Chen 2021), yet these interactions remain poorly understood. Gaining insight into the relationship between environmental conditions and macroinvertebrate species composition can help recommend effective conservation strategies and management policies. This study aims to assess the diversity of macroinvertebrate species and examine variations in their density and abundance across different monsoonal periods.

Material and Method

Description of the study sites. The study was conducted on the island of Malamawi, Isabela City, Basilan Province, located at the coordinates of 6°43'53.0"N, 121°57'47.9"E. It consists of 6 coastal barangays and is under the jurisdiction of Isabela City, the population center of the province. This island is an emerging tourist spot for its extensive mangrove forest, fine sandy beaches, and viewing platform from its solitary hill. Being one of the marine-rich islands in the province, the communities of Malamawi depend on gleaning fisheries for their sustenance and livelihood.

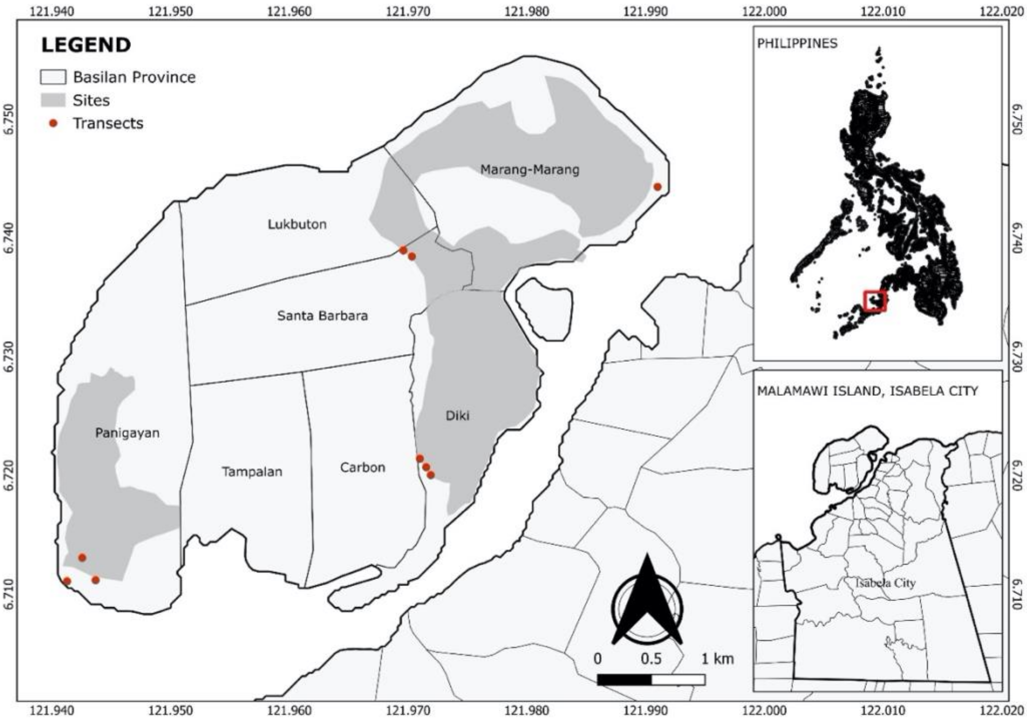

Figure 1. Map of Malamawi Island, Isabela City, Basilan Province showing the three sampling sites.

Three gleaning grounds on the island were selected as sampling sites where the main source of livelihood among the locals in the selected sites is in fisheries. Additionally, most of the locals use these coastal areas for recreational activities (Figure 1). Site 1 (6.743377° N, 121.976064° E) is located at the junction of Barangays Marang-Marang, Lukbuton, and Sta. Barbara, Site 2 (6.720690° N, 121.971541° E) is located in Barangay Diki, and Site 3 (6.711170° N, 121.943700° E) is in Barangay Panigayan. Site 1 encompasses three barangays with a gleaning ground of approximately 217 ha, composed of mangrove forests, reef flats, and seagrass with sandy-muddy substrate. Site 2 measures 156 ha and is situated in one barangay only. This ground is surrounded by mangrove forests and manmade fishponds with muddy substrates. Site 3 in Barangay Panigayan is also covered mainly with mangrove forest, seagrass, and coral reefs at the boundary facing the sea and has an approximate area of 114 ha. Estimates of the gleaning grounds were measured through Google Earth Pro and mapped using QGIS version 3.36.0.

Sample collection and identification. On-site assessment of macroinvertebrate communities in Malamawi Island was conducted from June to August 2024 (SWM) and December to January 2025 (NEM). To determine the density of species in the sites, a transect-quadrat method was employed, modified from the study of Petriki et al (2020). Each transect has a length of 150m laid perpendicular (mangrove forest) and parallel (seagrass meadow) to the shoreline. Three transects were laid in each site. In each transect, three 30 m x 30 m quadrats with a distance of 30 m in between were established. Invertebrate samples were collected by handpicking and the use of simple tools, such as a knife, stick, and pail, and then recorded. The collected samples were measured and photographed, and were returned to the area. However, voucher specimens were collected and preserved using 95% technical-grade ethanol. Gastropods and bivalves with shells were boiled, and soft tissues were removed. Samples were classified to the lowest taxa using key identification guides of Carpenter & Niem (1998), Poppe (2008), and Purcell & Samyn (2012), verified using databases such as World Register of Marine Species (WoRMS), SeaLifeBase, and were further validated by experts.

Physico-chemical assessment. In-situ testing was conducted to determine the water quality parameters, i.e., temperature, pH, salinity, and dissolved oxygen (DO). A portable temperature and pH meter was used for water temperature and pH, a refractometer for salinity, and a DO meter for dissolved oxygen. Standard procedures were followed in reading the values: three replicate readings were done in each transect, with a total of nine readings in each site. The assessment was done once during each monsoon.

Statistical analysis. Descriptive Statistics was used to analyze the data and presented using graphs. The Shannon-Wiener's Diversity Index, Pielou's Evenness Index, and Dominance Index were employed for the species diversity analysis (Magurran 1955; Pielou 1966; Purwanto et al 2021). Shannon Wiener's Diversity Index (H') considers both species richness and distribution of individuals among the species. An H'=0 indicates that there is only one species in a given area. Hence, the higher the H', the higher its diversity (Bautista et al 2017). This was calculated as $H'=-\sum (p_i \ln p_i)$, where p_i is the proportion of individuals in the $_i$th species and ln is the natural log.

Species Evenness (J') was calculated as $J'=H'/\ln S$ where H' is the Shannon-Wiener's Index and S represents species richness.

The Dominance Index (C) was calculated as $C=\Sigma(n_i/N)^2$, where n_i is the individual number of the $_i$th species and N is the total number of individuals of all species.

Diversity, evenness, and dominance indices values were interpreted based on the description shown in Table 1. A t-test was conducted to determine statistically significant differences in the physico-chemical parameters and species abundance between the monsoon seasons. The analyses were done using Paleontological Statistics Software (PAST) version 4.03 and IBM SPSS Software version 30.0.0.

Table 1

Diversity index value interpretation: Shannon Weiner's diversity, evenness, and dominance

Value	Category
Shannon-Wiener's diversity index (H') (Napaldet 2023),	
>3.5	Very high
3.0-3.49	High
2.5-2.9	Moderate
2.0-2.5	Low
<1.9	Very Low
Pielou's evenness index (Napaldet 2023)	
0.96-1.0	Balanced
0.76-0.95	Almost balanced
0.51-0.75	Semi-balanced
0.26-0.50	Less balanced
0.00-0.25	Unbalanced
Species dominance index (Purwanto et al 2021)	
$0<C \leq 0.5$	Low
$0.5<C\leq 0.75$	Moderate
$0.75<C\leq 1$	High

Results and Discussion. A total of 64 macroinvertebrate species were identified, representing 39 families belonging to four phyla, namely Mollusca (n = 42), Echinodermata (n = 13), Cnidaria (n = 1), and Arthropoda (n = 8) as shown in Figure 2. Among the four Phyla, Mollusca obtained 65.63% of the species composition in all monsoons, composed mainly of two Classes: Gastropoda and Bivalvia. This observation was also documented by Marfil (2021) in their study in Davao, Philippines. These classes are composed of marine invertebrates that adhere and mainly live on rocks, mangrove roots, branches, and surface substrates (Cañada 2020). They are typically found in the intertidal zones of coastal areas, hence their numbers during species collection. This was followed by Echinodermata, where they are typically found on seagrass meadows.

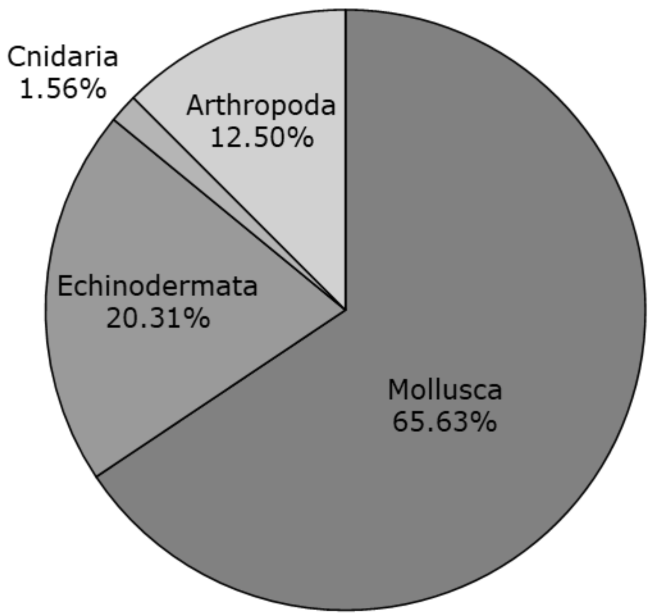

Figure 2. Percentage of total species composition of each Phylum.

As shown in Table 2, sixteen species were identified in the mangrove ecosystems across all sites, consisting mainly of mollusks. Among them, *Terebralia sulcata* (Born, 1778) was the densest in the mangrove ecosystem of all sites during SWM (7.90, 16.41, and 7.72, respectively) and NEM (8.30, 14.57, and 6.85, respectively), and was then followed by *Terebralia palustris* (Linnaeus, 1767). Based on anecdotal evidence, *T. sulcata is* often found anchored on mangrove branches and roots during high tide in the mangrove forests across sites. Meanwhile, *T. palustris* is larger, and they are found on the surface of the mangrove substrate. Since they are detritus feeders, they can grow well in areas with high organic content, such as in mangrove forests with frequent leaf litter (Rahmawati et al 2015). Similarly, Rangan et al (2015) observed that mangrove areas with muddy substrates in Indonesia are predominantly inhabited by Potamididae. Both *T. sulcata* and *T. palustris* are well adapted to environmental changes, a characteristic common among the Potamididae family, which explains their abundance in both seasons (Cañada 2020). Their accessibility and ease of collection make them a preferred species for local gleaners (Merly 2019), unlike members of the Lucinidae family, which require more effort to harvest, as these clams are buried deep within the muddy substrate (Primavera et al 2002).

Nerita histrio Linnaeus, 1758 is present in all sites in the mangrove forest, and it is one of the densest species in Site 3 during SWM (3.83 individuals m^{-2}) and NEM (6.28 individuals m^{-2}). Like *T. sulcata,* they can also adhere to the roots of mangroves, and they prefer to hide in rock and mangrove crevices to avoid direct exposure to the sunlight. They are gleaned for food consumption, and its shell is used for decoration. This species is found beneath rocks; hence, gleaning of this species would involve flipping the rocks, which could become a disturbance.

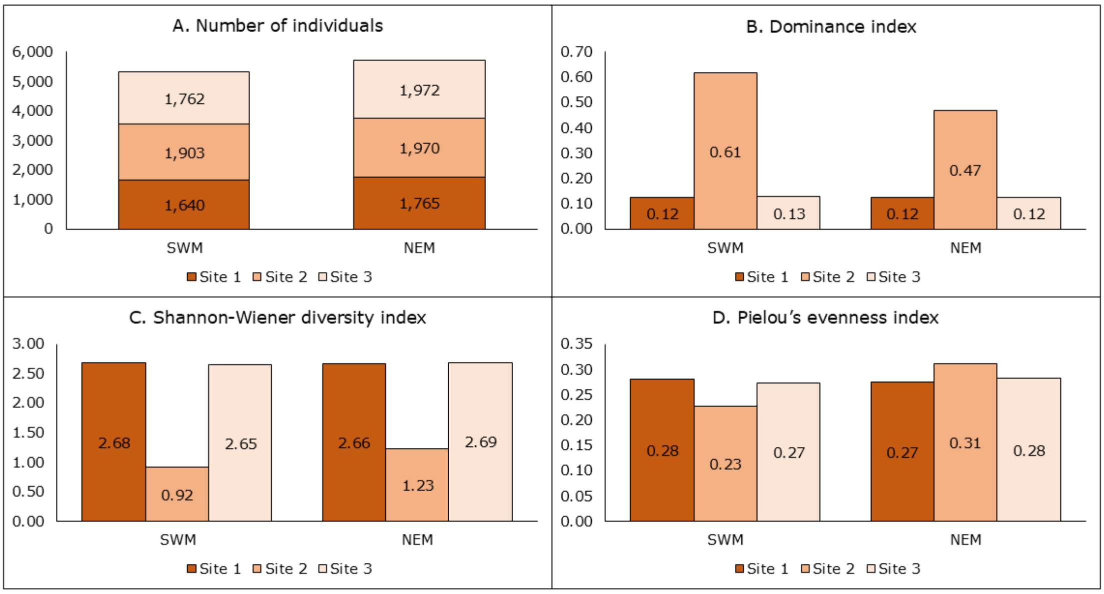

Figure 3. Diversity indices of macroinvertebrates in all sites across monsoons.

Table 2

Mean species density (individuals m^{-2}) of macroinvertebrates in the mangrove ecosystem across the sites

Phylum/Family	*Species*	*Southwest Monsoon* (individuals m^{-2})			*Northeast Monsoon* (individuals m^{-2})			*Local utilization*
		Site 1	*Site 2*	*Site 3*	*Site 1*	*Site 2*	*Site 3*	
				Mollusca				
Cyrenoididae	*Geloina expansa* (Mousson, 1849)	0.03	0.37	0.05	0.05	0.08	0.07	Food
Isognomononidae	*Isognomon alatus* (Gmelin, 1791)	1.65	0.07	0.22	0.82	0.47	0.22	Food
Littorinidae	*Littoraria scabra* (Linnaeus, 1758)	2.62	0.76	0.85	2.75	1.09	1.17	*
Lucinidae	*Pegophysema philippiana* (Reeve, 1850)	0.12	0.04	0.10	0.07	0.06	0.10	Food
Lucinidae	*Anodontia edentula* (Linnaeus, 1758)	0.08	0.02	0.07	0.12	0.01	0.07	Food
Muricidae	*Chicoreus brunneus* (Link, 1807)	0.03	0.00	-	0.05	-	-	Food
Muricidae	*Orania serotina* (A. Adams, 1853)	-	-	0.30	-	-	0.42	Food
Neritidae	*Nerita histrio* Linnaeus, 1758	0.58	0.46	3.83	0.93	1.51	6.28	Food
Neritidae	*Nerita planospira* Anton, 1838	1.10	0.47	0.45	0.88	0.51	0.47	Food
Neritidae	*Nerita albicilla* Linnaeus, 1758	0.10	-	0.30	-	-	-	Food
Potamididae	*Terebralia sulcata* (Born, 1778)	7.90	16.41	7.72	8.30	14.57	6.85	Food
Potamididae	*Terebralia palustris* (Linnaeus, 1767)	3.00	2.06	3.75	3.83	2.44	3.30	Food
Potamididae	*Telescopium telescopium* (Linnaeus, 1758)	0.22	0.51	1.17	0.32	1.06	1.17	Food
Strombidae	*Canarium urceus* (Linnaeus, 1758)	-	-	-	0.10	-	-	Food
Veneridae	*Gafrarium pectinatum* (Linnaeus, 1758)	0.37	-	0.23	0.87	-	0.40	Food
				Arthropoda				
Portunidae	*Thalamita crenata* Rüppell, 1830	0.02	0.09	0.17	0.05	0.09	0.12	Food

(*) Data deficient; (-) Absent.

Table 3

Mean species density of macroinvertebrates in the seagrass ecosystem in two sites

Phylum/Family	*Species*	*Southwest Monsoon* (individuals m^{-2})		*Northeast Monsoon* (individuals m^{-2})		*Local utilization*
		Site 1	*Site 3*	*Site 1*	*Site 3*	
		Mollusca				
Angariidae	*Angaria delphinus* (Linnaeus, 1758)	0.03	0.50	0.03	0.57	Food
Aplysiidae	*Dolabella auricularia* (Lightfoot, 1786)	0.47	-	0.33	-	Food
Arcidae	*Anadara antiquata* (Linnaeus, 1758)	0.13	0.10	0.23	0.10	Food
Cerithiidae	*Rhinoclavis sinensis* (Gmelin, 1791)	0.10	0.47	0.03	0.53	*
Chitonidae	*Acanthopleura granulata* (Gmelin, 1791)	0.37	0.47	0.47	0.70	Food
Conidae	*Conus ebraeus* Linnaeus, 1758	0.20	0.37	0.20	0.17	Food
Cymatiidae	*Gyrineum gyrinum* (Linnaeus, 1758)	-	0.07	-	0.10	Food
Cypraeidae	*Monetaria annulus* (Linnaeus, 1758)	2.93	5.50	5.13	7.13	Decoration
Cypraeidae	*Cypraea tigris* Linnaeus, 1758	0.03	0.03	0.03	0.03	Food; Decoration
Cypraeidae	*Pustularia bistrinotata* M. Schilder & F. A. Schilder, 1937	-	0.03	-	0.07	Decoration
Cypraeidae	*Melicerona felina* (Gmelin, 1791)	-	0.17	0.03	0.30	Decoration
Cypraeidae	*Nucleolaria nucleus* (Linnaeus, 1758)	-	0.03	-	0.03	Decoration
Mactridae	*Mactra maculata* Gmelin, 1791	0.30	0.20	0.37	0.20	Food
Muricidae	*Chicomurex gloriosus* (Shikama, 1977)	0.03	0.20	0.03	0.23	Food
Muricidae	*Chicoreus brunneus* (Link, 1807)	0.13	0.13	0.10	0.20	Food
Nassariidae	*Nassarius coronatus* (Bruguière, 1789)	0.07	0.70	-	0.37	*
Neritidae	*Nerita histrio* Linnaeus, 1758	1.47	1.63	1.33	0.83	Food; Decoration
Neritidae	*Nerita plicata* Linnaeus, 1758	1.13	-	1.63	-	Food; Decoration
Neritidae	*Nerita albicilla* Linnaeus, 1758	3.60	0.97	3.77	1.87	Food
Neritidae	*Nerita polita* Linnaeus, 1758	0.03	0.07	0.07	0.17	Food
Pectinidae	*Decatopecten radula* (Linnaeus, 1758)	0.03	0.07	0.03	0.07	Food
Pinnidae	*Atrina rigida* (Lightfoot, 1786)	0.07	-	0.10	-	Food
Pinnidae	*Pinna muricata* Linnaeus, 1758	-	0.03	-	0.07	Food
Strombidae	*Canarium labiatum* (Röding, 1798)	0.10	0.70	0.10	-	Food
Strombidae	*Canarium urceus* (Linnaeus, 1758)	0.20	-	-	0.07	Food
Strombidae	*Lambis lambis* (Linnaeus, 1758)	0.03	0.07	0.03	0.03	Food; Decoration
Tegulidae	*Tectus fenestratus* (Gmelin, 1791)	0.50	0.37	0.50	0.50	Food
Tegulidae	*Rochia nilotica* (Linnaeus, 1767)	0.03	0.03	0.03	0.03	Food
Turbinidae	*Turbo brunneus* (Röding, 1798)	0.03	0.23	0.20	0.60	Food
Onchidiidae	*Peronia verruculata* (Cuvier, 1830)	0.20	0.37	0.27	0.43	Food
Veneridae	*Perigylpta puerpera* (Linnaeus, 1771)	-	0.13	-	0.13	Food

		Echinodermata				
Archastidae	*Archaster typicus* Müller & Troschel, 1840	0.07	-	-	-	*
Brissidae	*Brissus latecarinatus* (Leske, 1778)	0.07	0.13	0.13	0.17	Food
Clypeasteridae	*Clypeaster reticulatus* (Linnaeus, 1758)	0.40	0.87	0.67	0.40	Decoration
Diadematidae	*Diadema setosum* (Leske, 1778)	0.77	0.17	0.83	0.40	Food
Echinometridae	*Tripneustes gratilla* (Linnaeus, 1758)	0.13	0.00	0.07	0.07	Food
Echinometridae	*Echinometra mathaei* (Blainville, 1825)	1.53	0.57	0.93	0.23	Food
Holothuridae	*Holothuria arenicola* Semper, 1868	0.03	0.00	-	-	Food
Holothuridae	*Holothuria notabilis* Ludwig, 1875	0.07	0.17	-	0.07	Food
Holothuridae	*Holothuria leucospilota* (Brandt, 1835)	-	0.07	-	0.07	Food
Ophiomyxidae	*Ophiocomina nigra* (Abildgaard in O.F. Müller, 1789)	2.60	3.13	2.40	3.20	*
Ophiomyxidae	*Ophiarachna incrassata* (Lamarck, 1816)	-	-	0.03	-	*
Oreasteridae	*Protoreaster nodosus* (Linnaeus, 1758)	0.30	-	0.03	-	*
Temnopleuridae	*Salmacis sphaeroides* (Linnaeus, 1758)	0.07	-	0.03	-	Food
		Cnidaria				
Actiniidae	*Anthopleura artemisia* (Pickering in Dana, 1846)	0.40	0.10	0.17	0.13	Food
		Arthropoda				
Calappidae	*Calappa calappa* (Linnaeus, 1758)	-	0.03	-	-	*
Calappidae	*Calappa hepatica* (Linnaeus, 1758)	-	-	0.03	-	*
Eriphiidae	*Eriphia sebana* (Shaw & Nodder, 1803)	-	0.13	0.03	0.17	*
Oregoniidae	*Hyastenus diacanthus* (De Haan, 1839)	0.10	-	0.07	-	*
Portunidae	*Charybdis natator* (Herbst, 1794)	0.47	0.40	0.67	0.43	Food
Portunidae	*Thalamita crenata* Rüppell, 1830	0.03	0.07	-	0.10	Food
Xanthidae	*Leptodius affinis* (De Haan, 1835)	0.13	0.40	0.20	0.50	*
Xanthidae	*Atergatis floridus* (Linnaeus, 1767)	0.07	0.20	0.17	0.53	*

(*) Data deficient; (-) Absent.

The seagrass ecosystem supports 53 macroinvertebrate species, with *N. albicilla* exhibiting the highest species density in Site 1 (3.60 individuals m^{-2}), while *M. annulus* is the most abundant in Site 2 (5.50 individuals m^{-2}) during SWM (Table 3). However, during NEM, *M. annulus* had the highest density across both sites (Site 1 = 5.13; Site 3 = 7.13). These species are commonly found in rocky shores and seagrass meadows, often adhering to or hiding within rock crevices (Chumchuen & Yamamoto 2015; Zvonareva & Kantor 2016). *N. albicilla* is abundant in these coastal areas, forming dense colonies that are frequently harvested by gleaners for food (Carpenter & Niem 1998). In contrast, *M. annulus* is manually collected for decorative purposes. However, gleaners typically do not harvest live *M. annulus* individuals, as this species often leaves behind empty shells along the shoreline. In tropical climates, *M. annulus* has adapted to high temperatures by seeking shelter in rock crevices, which protect them from direct sunlight and create a more suitable environment for survival (Latupeirissa et al 2020).

The majority (70%) of the gleaned invertebrates in the area were utilized for food by the locals, while 14 % of the composition is used as decoration, specifically in shell craft. This coincides with literature reporting that most macroinvertebrates are generally consumed by people as food, while some species are used as decorations and medicines (Ekin & Sesen 2018). These organisms are commonly preferred by gleaners since they are immobile, which makes harvesting easier with the mere use of simple, traditional tools. They are also highly nutritious and are cost-effective in providing balanced meals for the household (Chakraborty & Joy 2020).

Figure 4. Species with high density: (a) *T. sulcata,* (b) *L. scabra,* (c) *T. palustris,* (d) *M. annulus,* (e) *N. histrio*; and some species with low density: (f) *L. lambis,* (g) *C. hepatica,* (h) *H. arenicola,* (i) *R. nilotica,* (j) *C. calappa*.

A total of 5,305 individuals were counted during SWM and 5,707 individuals during NEM (Figure 3a). Among the sites surveyed, Site 2 has the highest abundance during SWM, while Site 3 ranked first in the number of individuals during NEM. The dominance index highlights the extent to which one or a few species numerically dominate the community (Whittaker 1965). The dominance index of Site 2 during SWM shows moderate dominance (Figure 3b), indicating that a few species, particularly *T. sulcata* and *T. palustris*, dominate over others. The Potamididae family has dominated the mangrove forest of Site 2 (Figures 4a and 4c). The Shannon-Wiener diversity index combines both species richness and the relative abundance of each species, providing a more nuanced view of biodiversity (Omayio et al 2019). Figure 3c illustrates the species diversity across different sites, with Sites 1 and 3 displaying relatively high diversity during SWM and NEM. However, according to H' interpretation, these sites are moderately diverse and could further decline if not properly managed (Ulfah et al 2019).

Seagrass meadows are highly productive ecosystems (Lauritsen 2019), and they are found in shallow coastal waters in tropical zones. It provides support services, such as nursing habitats and shelters for marine species. The seagrass ecosystem boasts the highest density of juvenile species amongst other marine and coastal ecosystems. Observations indicate that juvenile species are more abundant than mature ones in the seagrass meadows, a pattern also recognized by local gleaners. Nevertheless, this study revealed that the seagrass meadows in Sites 1 and 3 displayed moderate diversity, possibly due to overharvesting of these species. A comparable observation was noted by Furkon et al (2019), indicating that an increase in the number of gleaners could also influence the abundance of invertebrates found. *L. lambis* (Figure 4f) are species that are often found on seagrass beds; however, they are becoming rare in seagrass beds as they can be easily harvested by gleaners (Wagey & Bucol 2016). The gradual decline of this species was also reported by Wagey et al (2017) on the island of Siquijor. *L. lambis,* having low abundance in both monsoonal seasons, raises concerns if not mitigated. On the other hand, the abundance of *H. arenicola* (Figure 4h) can be hard to determine since they are difficult to find as they are buried in the sand (Eisapour et al 2022). This was also encountered in the study of Walag et al (2016) in Mindanao, where species that usually burrow or hide in seagrasses or sand have a lower number of individuals collected.

R. nilotica (Figure 14i), also known as the smooth top shell, is an ecologically important mollusk that helps control macroalgae populations in reef flats (Purcell and Ceccarelli 2021). It is also commercially valuable, as it is gleaned for its high-protein meat, while its shell is widely used for crafts and button manufacturing, leading to overexploitation (Wahyudi et al 2023). *R. nilotica* is now considered a threatened species and is listed under Fisheries Administrative Order No. 208, Series of 2001, which prohibits its collection and trade (BFAR 2024).

The species evenness index specifically measures how evenly individuals are distributed among the species present (Heip et al 1998). Figure 3d shows that all sampling sites, across both monsoon seasons, exhibit low evenness values, indicating an unbalanced species distribution across the entire study area. A similar case was also observed in the study of Natan et al (2023) conducted in Indonesia, where the evenness value is low, indicating the dominance of some species in the area. While a lot of macroinvertebrate species were present in Malamawi island, their numbers are low.

The assessment of physico-chemical conditions is important to understand how environmental conditions can influence the composition and diversity of species on the island (Llacuna et al 2016). As shown in Table 4, there are significant differences in the means of pH ($p = 0.041$) and DO ($p=0.016$), but only slightly, indicating that the pH and DO values between SWM and NEM are different. Meanwhile, the temperature ($p < 0.001$) is also significantly different. The pH declined during NEM, while DO increased during the same monsoon. The cold air brought by NEM has changed the water temperature from 30.24°C (SWM) to 21.71°C (NEM). With the decrease in temperature, the dissolved oxygen increased across all sites. An increase in water temperature could affect the breeding and metabolic processes of some gastropods, where the ideal temperature can range from 25 to 31°C (Leiwakabessy & Latupeirissa 2023). On the other hand, a study by Leung et al (2019) shows that some gastropods can tolerate a sudden increase in temperature by adapting. Although the water pH declined during NEM, it is still within normal values where marine macroinvertebrates can survive.

Table 4

T-test analysis of physico-chemical parameters during SWM and NEM

Parameters	*Monsoon*	*Means*	*t-test*	*p-value*
pH	SWM	7.60	1.854	0.041*
	NEM	7.26		
Temperature	SWM	30.24°C	15.292	<0.001*
	NEM	21.71°C		
Salinity	SWM	32.19 ppt	0.073	0.471
	NEM	32.07 ppt		
DO	SWM	6.29 mg L^{-1}	-2.384	0.016*
	NEM	6.86 mg L^{-1}		

*. Significant at the 0.05 level.

Mollusks require a dissolved oxygen concentration of at least 4.5 mg L^{-1} to survive, and levels below this threshold can be fatal. Some arboreal mollusks, like gastropods, can retain sufficient oxygen to function during low tide, which explains their presence across different monsoonal seasons (Tokan et al 2018). Mangrove clams, such as *A. edentula*, are more prevalent in areas with high dissolved oxygen, as lower concentrations negatively impact their survival during early life stages (Bersaldo et al 2022).

Alkaline waters and high salinity are necessary for macroinvertebrates to function properly, especially those species possessing shells. In the study conducted by Susetya et al (2018), intertidal areas with high salinity and high pH are positively correlated with the abundance of bivalves, such as *P. philippiana* and *A. edentula,* across monsoons.

The marine invertebrates are at risk from human and natural disturbances, and their assemblage may be affected by water quality in the island due to changing monsoonal seasons (Cabaitan et al 2019). However, species density does not vary significantly across monsoons, and fluctuations in the density of certain species may be influenced more by social factors than by monsoonal changes. The low species density of economically significant macroinvertebrates, including sea cucumbers, sea urchins, and highly valued mollusks, may be attributed to human-induced disturbances like overharvesting and other drivers. For many local gleaners, collecting these marine invertebrates serves as both a livelihood and a source of sustenance. However, no regulations currently exist to safeguard these resources (De Guzman et al 2016). Overharvesting may lead to negative impacts on both the environment and the well-being of local communities over time. Consequently, the local government needs to take proactive steps in managing these marine resources.

Conclusions. A total of 64 marine macroinvertebrates from four Phyla were identified, with the seagrass ecosystem having the highest species composition. However, the dominance of certain species has led to Malamawi Island having poorly diverse communities. Species composition does not show significant variation with environmental conditions, and fluctuations in species density across monsoon seasons may be influenced more by human activities than by natural environmental factors. The continuous decline of macroinvertebrate species will have repercussions that will affect the natural structure and resilience of the coastal ecosystems. Due to the limited sampling period, it is recommended to use catch per unit effort and incorporate ecological knowledge from local communities, including secondhand observations of monsoonal variations, for a more comprehensive understanding of changes in macroinvertebrate composition and environmental influences. This approach aims to support the development of effective policies to mitigate the decline of these resources.

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References

Aldea K. Q., 2023 Macroinvertebrate gleaning in coastal ecosystems: utilization, pressures, and implications for conservation. AACL Bioflux 16(3):1331-1345.
Aldea K. Q., Morales M. I., Araojo A. E., Masagca J. T., 2015 Biodiversity in the Kuroshio Region: Challenges and Trends in the Upstream. Kuroshio Science 9(1):45-56.
Bautista L., Capinpin E., Argente F. A., 2017 Assessment of commercially important marine invertebrates in selected areas of Anda, Pangasinan, Northern Philippines. PSU Journal of Natural and Allied Sciences 1(1):12-16.
Bersaldo M. J., Lacuna M. L., Macusi E., 2022 Status of mangrove clam (*Anodontia philippiana* Reeve, 1850) in Bagana, Davao Oriental, Philippines. ABAH Bioflux 14(2):55-66.
Cabaitan P. C., Quimpo T. J. R., Dumalagan E. E., Munar J., Calleja M. A. C., Olavides R. D. D., Go K., Albelda R., Cabactulan D., Tinacba E. J. C., Doctor M. A. A., Villanoy C. L., Siringan, F. P., 2019 The Philippines. Mesophotic Coral Ecosystems. pp. 265-284.
Cabanban A. S., Tajonera I. J., Palomares M .L. D., 2014 A short history of gleaning in Negros and Panay Islands, Visayas, Philippines8889. Fisheries Centre Research Reports 22:105.
Cañada M. C. B., 2020 Species Richness and Abundance of Bivalves and Gastropods in Mangrove Forests of Casiguran, Aurora, Philippines. Open Journal of Ecology 10:778-787.
Carpenter K. E., Niem V. H., 1998 FAO species identification guide for fishery purposes.The living marine resources of the Western Central Pacific. Volume 2. Cephalopods, crustaceans, holothurians and sharks. pp. 687-1396.
Chakraborty K., Joy M., 2020 High-value compounds from the molluscs of marine and estuarine ecosystems as prospective functional food ingredients: An overview. Food Research International 137:109637.
Chen E. Y. S., 2021 Often overlooked: Understanding and meeting the current challenges of Marine Invertebrate Conservation. Frontiers in Marine Science 8:690704.
Chumchuen S., Yamamoto T., 2015 Population characteristics of *Monetaria annulus* (Linnaeus, 1758) (Gastropoda: Cypraeidae) from temperate to tropical areas. Aquaculture Science 63(3):273-282.
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 Fisheries Bull 29:34-40.
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: impacts on the coastal environment, household economy and nutrition, 39 pp.
Eisapour M., Salari A. M. A., Salamat M., Nafisi B., Salati A., 2022 Identification and taxonomy of sea cucumbers (*Holothuria*) in Persian Gulf. Iranian Journal of Fisheries Sciences 21(1):63-81.
Ekin I., Sesen R., 2018 Molluscs: Their usage as nutrition, medicine, aphrodisiac, cosmetic, jewelry, cowry, pearl, accesory and so on from the history to today. Middle East Journal of Science 4(1):45-51.
Furkon N. N., Ambo-Rappe R., Cullen-Unsworth L. C., Unsworth R. K. F., 2019 Social-ecological drivers and dynamics of seagrass gleaning fisheries. Ambio 49(7):1271-1281.
Heip C. H., Herman P. M., Soetaert K., 1998 Indices of diversity and evenness. Oceanis 24(4):61-88.

Latupeirissa L. N., Leiwakabessy F., Rumahlatu D., 2020 Species density and shell morphology of gold ring cowry (*Monetaria annulus*, Linnaeus, 1758) (Mollusca: Gastropoda: Cypraeidae) in the coastal waters of Ambon Island, Indonesia. Biodiversitas Journal of Biological Diversity 21(4):1391-1400.

Lauritsen J., 2019 The declining significance of seagrass-associated invertebrate gleaning for providing food security in Kaole, Tanzania, 51 pp.

Leiwakabessy F., Latupeirissa L. N., 2023 Morphometric variation and species density of Nerita (Neritidae: Gastropoda) in the coastal waters of Ambon Island, Indonesia. Bioedupat: Pattimura Journal of Biology and Learning 3(2):129-136.

Leung J. Y., Russell B. D., Connell S. D. 2019 Adaptive responses of marine gastropods to heatwaves. One Earth 1(3):374-381.

Llacuna M. E. J., Walag A. M. P., Villaluz E. A., 2016 Diversity and dispersion patterns of echinoderms in Babanlagan, Talisayan, Misamis Oriental, Philippines. Environmental & Experimental Biology 14:213-217.

Magurran A. E., 2004 Measuring biological diversity. Blackwells. Mason, NWH et al.(2005). Functional richness, functional.

Marfil F. J. C., 2021 Gleaning fisheries in selected intertidal areas of Sta. Cruz and Digos City, Davao Del Sur, 46 pp.

Merly S. L., 2019 Study of abundance and edible parts (Bydd) of the Sea Snail (Gastropods) in mangrove ecosystem at Lampu Satu Beach and Payum Beach, Merauke District. International Conference on Science and Technology 1(1):28-35.

Napaldet J. T., 2023 Plant species and ecosystem diversity along national road in mountain sites: the case of Kennon Road in Cordillera Central Range, Philippines. Taiwania 68(3):339-348

Natan J., Limmon G. V., Hendrika N., Rahman, 2023 Correlation of some water quality parameters and Pb in sediment to gastropod diversity in Ambon Island Waters. JPSL 13(4):656-670.

Omayio, D., Mzungu, E., Kakamega, K., 2019 Modification of Shannon-Wiener diversity index towards quantitative estimation of environmental wellness and biodiversity levels under a non-comparative Scenario. Journal of Environment and Earth Science 9(9):46-57.

Palomares M. L. D., Espedido J. C., Parducho V. A., Saniano M. P., Urriquia L. P., Yap P. M. S., 2014 A short history of gleaning in Mabini, Batangas (Region IV, Subzone B, Philippines). In: Palomares M. L. D., Pauly D. (eds.), Philippine Marine Fisheries Catches: A Bottom-up Reconstruction, 1950 to 2010. pp 118-128.

Patria M. P., Putri S. A., 2017 The role of *Terebralia* (Gastropoda: Potamididae) in carbon deposits at mangrove forest Pulau Panjang, Serang-Banten. In AIP Conference Proceedings 1844(1):040002.

Petriki O., Zervas D., Doulgeris C., Bobori D., 2020 Assessing the ecological water level: the case of four Mediterranean Lakes. Water 12(11):2977.

Pielou E. C., 1966 The measurement of diversity in different types of biological collections. Journal of Theoretical Biology 13:131-144.

Poppe G. T., 2008 Philippine marine mollusks. Vol. 1 (Gastropoda - Part 1). ConchBooks, 766 pp.

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(5):363-370.

Purcell S. W., Ceccarelli D. M., 2021 Population colonization of introduced trochus (Gastropoda) on coral reefs in Samoa. Restoration ecology 29(1):e13312.

Purcell S. W., Samyn Y., Conand C., 2012 Commercially important sea cucumbers of the world. FAO.

Purwanto Y., Santoso H., Manohas J., Zaini M., Tumiwa J. H., Nugraha E., 2021 Analysis of the diversity index and dominance of bottom gillnet catches in Kulu waters, North Minahasa Regency, Indonesia. AACL Bioflux 14(5):2639-2649.

Rahmawati R., Sarong M. A., Muchlisin Z. A., Sugianto S., 2015 Diversity of gastropods in mangrove ecosytem of western coast of Aceh Besar District, Indonesia. AACL Bioflux 8(3):265-271.

Rangan K. K., Mahmudi M., Arfiati D., 2015 Density and habitat preference of *Telescopium telescopium* (Gastropoda: Potamididae) population in mangrove forest of likupang waters, North Sulawesi, Indonesia. Journal Biodiversity and Environmental Sciences 7(1):291-301.
Stiepani J., Jiddawi N., Mtwana Nordlund L., 2022 Social-ecological system analysis of an invertebrate gleaning fishery on the island of Unguja, Zanzibar. Ambio 52(1):140-154
Susetya I. E., Desrita D., Ginting E. D. D., Fauzan M., Yusni E., Saridu S. A., 2018 Diversity of bivalves in Tanjung Balai Asahan Waters, North Sumatra, Indonesia. Biodiversitas Journal of Biological Diversity 19(3):1147-1153.
Tokan M. K., Imakulata M. M., Neolaka Y. A. B., Kusuma H. S., 2018 Species diversity and vertical distribution of arboreal organisms on the Paradiso Mangrove environment of Kupang Bay, East Nusa Tenggara, Indonesia. Asian Journal of Agriculture and Biology 6(4):535-542.
Ulfah M., Fajri S. N., Nasir M., Hamsah K., Purnawan S., 2019 Diversity, evenness and dominance index reef fish in Krueng Raya Water, Aceh Besar. IOP Conference Series: Earth and Environmental Science 348(1):012074.
Villanoy C. L., Cabrera O., Yniguez A., Camoying M., De Guzman A., David L., Flament P., 2011 Monsoon-driven coastal upwelling off Zamboanga Peninsula, Philippines. Oceanography 24(1):156-165.
Wagey B., Bucol A., 2016 Indigenous Ecological Knowledge (IEK) on the utilization and conservation of coastal resources in Siquijor island, central Philippines. Ecology, Environment and Conservation 22(3):111-118.
Wagey B., Kreckhodd R. L., Bucol A., 2017 Comparison of abundance and diversity of benthic macroinvertebrates between disturbed and nondisturbed seagrass-algal beds in central Philippines. AACL Bioflux 10(4):882-893.
Wahyudi N. D., Hidayati D., Arbi U. Y., Ismail A., 2023 Morphometric study of Lola *Rochia nilotica* (Linnaeus 1767) shells from natural harvest found in Indonesian. Biodiversitas Journal of Biological Diversity 24(9):4711-4722.
Whittaker R. H., 1965 Dominance and diversity in land plant communities: numerical relations of species express the importance of competition in community function and evolution. Science 147(3655):250-260.
Zvonareva S., Kantor Y., 2016 Checklist of gastropod molluscs in mangroves of Khanh Hoa province, Vietnam. Zootaxa 4162(3):401-437.
***BFAR (Bureau of Fisheries and Aquatic Resources), 2024 Amendment to fisheries administrative order No. 208, Series of 2001 on the Conservation of Rare, Threatened and Endangered Fishery Species.

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Authors:
Nur Inih Urot Sahidjan, Department of Environmental Science, School of Interdisciplinary Studies, Mindanao State University-Iligan Institute of Technology, 9200 Iligan City, Lanao del Norte, Philippines, e-mail: nurinih.sahidjan@g.msuiit.edu.ph
Ivane Pedrosa Gerasmio, Department of Marine Science, College of Science and Mathematics, Mindanao State University-Iligan Institute of Technology, 9200 Iligan City, Lanao del Norte, Philippines, e-mail: ivane.gerasmio@g.msuiit.edu.ph
Wella Tiu Tatil, Department of Environmental Science, School of Interdisciplinary Studies, Mindanao State University-Iligan Institute of Technology, 9200 Iligan City, Lanao del Norte, Philippines, e-mail: wella.tatil@g.msuiit.edu.ph
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