



Community Structure of Benthic Macroinvertebrates in Jose Abad Santos, Davao Occidental, Philippines

Jhun Rheil H. Molina^{1*}, Ronilo B. Muda Jr.², Rohaida C. Dela Cruz²

¹Department of Marine Science, College of Science and Mathematics, Mindanao State University, Iligan Institute of Technology (MSU-IIT), Jhun Rheil H. Molina: 0009-0007-9241-6060,

²Department of Marine Biology, Southern Philippines Agri-business and Marine and Aquatic School of Technology (SPAMAST), Ronilo B. Muda Jr.: 0009-0002-2101-9467, Rohaida Dela Cruz: ORCID No. 0009-0002-3052-1352

Submitted: 09 Apr 2024

Revised: 19 May 2025

Accepted: 02 Jun 2025

Published: 20 Jun 2025

*Corresponding author: jhunrheil.molina@g.msuiit.edu.ph

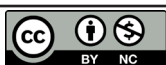


ABSTRACT

Macroinvertebrates play a vital role in energy transfer and nutrient cycling in marine ecosystems and serve as important sources of food and livelihood for coastal communities. However, these critical resources are currently under threat due to uncontrolled harvesting and habitat degradation. This study aimed to provide valuable information on the community structure of benthic macroinvertebrates within the marine protected area (MPA) of Butulan and the open-access area of Balangonan in Jose Abad Santos, Davao Occidental. Sampling was conducted using the belt transect method. A total of 749 individuals, representing 27 species were recorded across the two sites, with gastropods comprising the majority of species. The mean (\pm SE) population density was significantly higher in Butulan, at $3,540 \pm 701.52$ ind ha^{-1} , compared to $1,560 \pm 246.36$ ind ha^{-1} in Balangonan ($t = 3.25$, $P = 0.02$). Diversity index results indicated significantly higher species diversity in Butulan ($H' = 3.04$, $H_{max} = 3.30$) than in Balangonan ($H' = 2.45$, $H_{max} = 2.64$) ($t = 4.65$, $P = 0.001$), with species evenly distributed and no single species dominating both sites. The higher density and diversity of benthic macroinvertebrates in Butulan may be attributed to the strict protection of the MPA by the local government. In contrast, unregulated collection in the open-access area of Balangonan likely contributed to its lower diversity and density. Regulatory measures such as catch limits, size quotas, restrictions on harvesting juveniles and gravid individuals, and stock enhancement should be implemented to ensure the sustainable use of this important resource.

Keywords: Diversity, macroinvertebrate, management, marine protected area, open access.

How to cite: Molina, J. R. H., Muda, R. B. Jr., Dela Cruz, R. C. (2025). Community Structure of Benthic Macroinvertebrates in Jose Abad Santos, Davao Occidental, Philippines. *Davao Research Journal*, 16(2), 130-142. <https://doi.org/10.59120/drj.v16i2.395>



© Molina et al. 2025). **Open Access.** This article published by Davao Research Journal (DRJ) is licensed under a Creative Commons Attribution-NonCommercial 4.0 International (CC BY-NC 4.0). You are free to share (copy and redistribute) the material in any medium or format) and adapt (remix, transform, and build upon the material). Under the following terms, you must give appropriate credit, provide a link to the license, and indicate if changes were made. You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use. You may not use the material for commercial purposes. To view a copy of this license, visit: <https://creativecommons.org/licenses/by-nc/4.0/>

INTRODUCTION

Benthic macroinvertebrates are essential components of benthic ecosystems, playing critical ecological and economic roles. Ecologically, they contribute significantly to the structure and function of aquatic communities. Their roles include the mineralization and decomposition of organic matter, sediment mixing, oxygen flux into sediments, and the overall cycling of nutrients (George et al., 2009). As direct consumers, benthic macroinvertebrates serve as a crucial food source for many aquatic organisms, thereby facilitating energy transfer and nutrient regeneration within aquatic ecosystems (van Houte-Howes et al., 2004).

From an economic standpoint, benthic macroinvertebrates play a vital role in supporting the livelihoods and food security of many coastal communities in the Philippines. They are traditionally harvested through gleaning—a low-cost, small-scale fishing method involving handpicking on reef flats, or wading and raking sediments in shallow-water habitats. This practice contributes significantly to the daily sustenance and income of small-scale fishers (del Norte-Campos et al., 2005; de Guzman et al., 2019). In the Albay side of Lagonoy Gulf, for instance, gleaning activities yield an estimated annual production of 296 metric tons, valued at approximately php 5,920,000. This translates to an average annual income of around php 20,600 per gleaner (Nieves et al., 2010). Similarly, in Banate Bay, located on the eastern side of Panay Island, the annual catch in this area ranges from 20,988.7 to 43,527.6 kilogram (kg), generating an estimated total value of php 421,047.1 when sold in local markets. This value can increase significantly—up to php 897,140.0—when the harvested macroinvertebrates are sold in urban markets, where prices are comparatively higher (del Norte-Campos et al., 2005). Beyond their role as food sources, benthic macroinvertebrates are also collected for various non-traditional uses. These include souvenir items, components of handicrafts and decorative pieces, jewelry, carving tools, and other artisanal products (Jontila et al., 2014; Mecha and Dolorosa, 2020).

Currently, the diversity of benthic macroinvertebrates is in decline due to various anthropogenic activities occurring within intertidal zones. These activities include coastal

housing development, intensive fishing practices, pollution, and unregulated tourism. Such disturbances have a direct impact on macroinvertebrate populations, particularly because their limited mobility within benthic habitats reduces their ability to escape environmental stressors (Sahidin et al., 2019). In open-access areas, overharvesting has emerged as a significant concern. Due to the slow-moving nature of most macroinvertebrate species, they are especially vulnerable to overharvesting, resulting in notable population declines (Nieves et al., 2010; Szabó and Amesbury, 2011). If left unmanaged, the unregulated exploitation of marine macroinvertebrate resources can lead to overexploitation, threatening species sustainability and contributing to the further degradation of their habitats (de Guzman et al., 2016; Maynawang et al., 2023).

Marine Protected Areas (MPAs) are established as a management strategy by local governments and other key stakeholders to safeguard biodiversity and conserve both natural and associated cultural resources (De Guzman and Quiñones 2021). These areas are managed through legal frameworks or other effective governance mechanisms (Edgar et al., 2014). MPAs have been shown to support the recovery and sustainability of marine life, including benthic macroinvertebrates, which often occur in significant numbers within well-protected zones where exploitation is restricted or entirely prohibited particularly in the case of threatened species (Conales et al., 2015; Dolorosa et al., 2016). Several studies have demonstrated that protected sites generally support higher abundance and greater species diversity of benthic macroinvertebrates compared to unprotected or heavily exploited areas (Lumayag et al., 2018; Bantayan et al., 2023; Mahilac et al., 2023; Tuang-tuang, 2022).

In the municipality of Jose Abad Santos, Davao Occidental, the coastal barangays of Balangonan and Butulan are home to ecologically significant marine ecosystems, including extensive coral reefs, seagrass beds, and mangrove forests. In response to increasing conservation concerns, a 24.7-hectare Marine Protected Area (MPA) was established in Barangay Butulan on November 4, 2019, through Barangay Ordinance No. 01, series of 2019, to safeguard these interconnected habitats. In contrast, Barangay Balangonan remains an open-access area, where marine resources

are vulnerable to unregulated exploitation. While MPAs are widely recognized as effective tools for marine conservation, there has been limited scientific research conducted. In particular, the community structure of benthic macroinvertebrates has not been sufficiently studied in either the protected or unprotected areas (Davies, 2021; Prieto-Amador and Palomar-Abesamis, 2024). The absence of such baseline data hinders the ability of local stakeholders and policymakers to assess the current status of marine resources and to identify specific areas requiring enhanced management and protection. This study aims to address this knowledge gap by assessing and comparing the community structure of benthic macroinvertebrates within the MPA of Butulan and the open-access area of Balangonan. The findings are expected to provide valuable insights into the effectiveness of existing conservation measures and to support evidence-based decision-making for the sustainable management of marine resources in Jose Abad Santos.

MATERIALS AND METHODS

Description of the study area

Jose Abad Santos, formerly known as Trinidad, is a coastal municipality in the province of Davao Occidental. It comprises 26 barangays, with 23 located along the coast. Among the 23 barangays, Balangonan is known for its high abundance of macroinvertebrates, which are an important source of food and income for local communities (Molina et al., 2025). However, the area has remained open-access for many years, allowing unrestricted harvesting. This lack of regulation may lead to the overexploitation of macroinvertebrate populations. In contrast, the barangay of Butulan established a 24.7-hectare no-take zone within its marine protected area (MPA) in 2019. This has contributed to the protection and recovery of marine biodiversity, including macroinvertebrates. The two sampling sites were geographically positioned at 5°36'51" N and 125°25'54" E in Butulan and 5°35'50" N and 125°21'49" E in Balangonan (Figure 1).

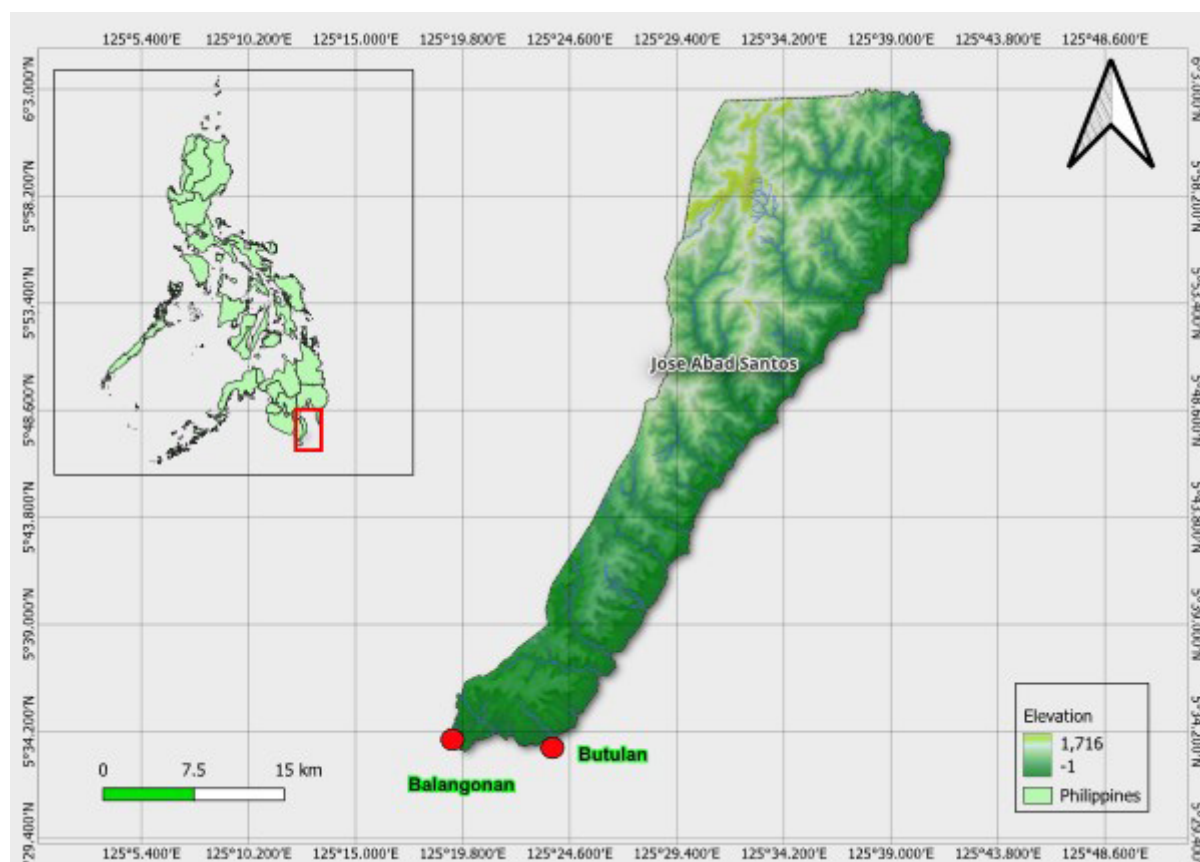


Figure 1. Map showing the two sampling sites in Jose Abad Santos, Davao Occidental.

Sampling procedure

One-shot sampling was conducted on 01 to 04 December 2023 and 06 to 10 January 2024 at the two established sampling sites in Jose Abad Santos, Davao Occidental. Three 50 m x 4 m belt transects, spaced 50 m apart, were laid parallel to the shoreline in the coral reef area and seagrass beds at each study site. For ease of observation, sampling was done by wading or snorkeling in the seagrass beds, and by skin diving with the help of locals in the coral reef area during the daytime, at the lowest low tide. All epifaunal benthic macroinvertebrates encountered within the belt transects were recorded and identified to the lowest possible taxonomic level using identification keys and relevant literature (Schoppe, 2000; Jontila et al., 2014; Dolorosa et al., 2015). Valid scientific names and taxonomic authorities were confirmed through the World Register of Marine Species (WoRMS) and SeaLifeBase databases. No specimens were collected during the survey.

Determination of physicochemical parameters

During the macroinvertebrate assessment along each transect, water temperature, pH, salinity, and dissolved oxygen were determined in situ at the start, middle and end of the transect. Each sampling points was measured in three readings using a YSI ProDSS Multiparameter Digital Water Quality Meter.

Data analyses

Macroinvertebrate density

The density of macroinvertebrates (D_i) was computed using the equation 1:

$$D_i = \frac{Ni}{A}$$

Where Ni is the total number individuals of each species and A is the area of the belt transect. The resulting values were then extrapolated to individuals per 10,000 m² or 1 ha.

Calculation of diversity indices

The Shannon-Wiener Index (H') was computed using the equation 2:

$$H' = - \sum_{i=1}^S p_i \ln(p_i)$$

Where H' was the Shannon-Wiener Index of diversity, S was the total number of species; $p_i = \frac{n_i}{N}$ was the proportion of individuals of benthic macroinvertebrate species i , n_i was the total number of macroinvertebrate species i , $N = \sum_{i=1}^S n_i$ was the total number of all benthic macroinvertebrate species combined; and $\ln(p_i)$ was the natural logarithm of the proportion p_i . The Maximum Shannon-Wiener Index (H_{max}) was calculated using the equation 3:

$$H_{max} = \ln(S)$$

Where H_{max} was the maximum diversity possible given the species richness and S is the total number of benthic macroinvertebrate species; and \ln was the natural logarithm function. The Pielou's Index of evenness (J') was calculated using equation 4:

$$J' = \frac{H'}{H_{max}}$$

Where J' was the Pielou's Evenness Index, H' was the Shannon-Wiener Diversity Index, and H_{max} was the Maximum Shannon-Wiener Diversity Index. The Simpson's Dominance Index (D) was calculated using the equation 5:

$$D = \sum_{i=1}^S p_i^2$$

Statistical analysis

To determine significant differences in macroinvertebrate density, diversity and physicochemical parameters between the two sampling sites, an independent samples t-test was conducted at a 0.05 level of significance. All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS), version 20.

RESULTS

Species composition of benthic macroinvertebrates

A total of 749 individuals from 27 species of benthic macroinvertebrates were recorded across the two sampling sites in Jose Abad Santos, Davao Occidental, Philippines. These species

belong to 3 phyla, 6 classes, and 21 families (Table 1 and 2). The highest number of species recorded was from Phylum Mollusca, Class Gastropoda, which included 11 families and 14 species. Species such as *Filifusus filamentosus*, *Laevistrombus canarium*, *Harpa articularis*, *Tectus pyramis*,

Vasticardium subrugosum, *Protoreaster nodosus*, *Linckia laevigata*, *Spondylus* sp., *Malleus malleus*, *Conus eburneus*, *Lambis millipeda*, *Parribacus* sp. and *Stichopus horrens* were not present in Balangonan (Figure 2).

Table 1. Species composition of benthic macroinvertebrates found in two sites of Jose Abad Santos, Davao Occidental.

| Phylum | Family name | Species name | Butulan | Balangonan |
|---------------|-----------------|--|---------|------------|
| Mollusca | | | | |
| Gastropoda | Pisaniidae | <i>Engina mendicaria</i> (Linnaeus, 1758) | + | + |
| | Mitridae | <i>Strigatella zebra</i> (Lamarck, 1811) | + | + |
| | Fascioliidae | <i>Filifusus filamentosus</i> (Röding, 1798) | + | - |
| | Cymatiidae | <i>Cymatium</i> sp. | + | + |
| | Muricidae | <i>Tylothais aculeata</i> (Deshayes, 1844) | + | + |
| | Strombidae | <i>Laevistrombus canarium</i> (Linnaeus, 1758) | + | - |
| | | <i>Lambis millepeda</i> (Linnaeus, 1758) | + | - |
| | | <i>Canarium</i> sp. | + | + |
| | Neritidae | <i>Nerita polita</i> (Linnaeus, 1758) | + | + |
| | Conidae | <i>Conus eburneus</i> Hwass, 1792 | + | - |
| | | <i>Conus</i> sp. | + | + |
| | Tegulidae | <i>Tectus pyramis</i> (Born, 1778) | + | - |
| | | <i>Tectus fenestratus</i> (Gmelin, 1791) | - | + |
| Bivalvia | Turbinidae | <i>Turbo argyrostomus</i> Linnaeus, 1758 | + | + |
| | Harpidae | <i>Harpa articularis</i> (Lamarck, 1822) | + | - |
| | Cardiidae | <i>Vasticardium subrugosum</i> (G.B. Sowerby II, 1839) | + | - |
| | | <i>Tridacna</i> sp. | + | + |
| | | <i>Spondylus</i> sp. | + | + |
| | Malleidae | <i>Malleus malleus</i> (Linnaeus, 1758) | + | - |
| Echinodermata | | | | |
| Echinoidea | Diadematidae | <i>Diadema setosum</i> (Leeke, 1778) | + | + |
| | Toxopneustidae | <i>Tripneustes gratilla</i> (Linnaeus, 1758) | + | + |
| Asteroidea | Oreasteridae | <i>Protoreaster nodosus</i> (Linnaeus, 1758) | + | - |
| | Ophidiasteridae | <i>Linckia laevigata</i> (Linnaeus, 1758) | + | - |
| Holothuroidea | Holothuriidae | <i>Holothuria leucospilota</i> (Brandt, 1835) | + | + |
| | | <i>Holothuria atra</i> (Jaeger, 1833) | + | + |
| | Stichopodidae | <i>Stichopus horrens</i> (Selenka, 1867) | + | - |
| Arthropoda | | | | |
| Malacostraca | Scyllaridae | <i>Parribacus</i> sp. | + | - |

Note: (+) indicates presence, while (-) indicates absence of each benthic macroinvertebrate species at the surveyed sites.

A greater number of benthic macroinvertebrate species were found in the coral reef areas than in the seagrass areas of both sampling sites. Based on the IUCN Red List, three species are classified as “Least Concern”

(i.e. *C. eburneus*, *H. atra*, and *H. leucospilota*), one species has “Data Deficient” status (*S. horrens*), and the remaining species recorded are classified as “Not Evaluated”.

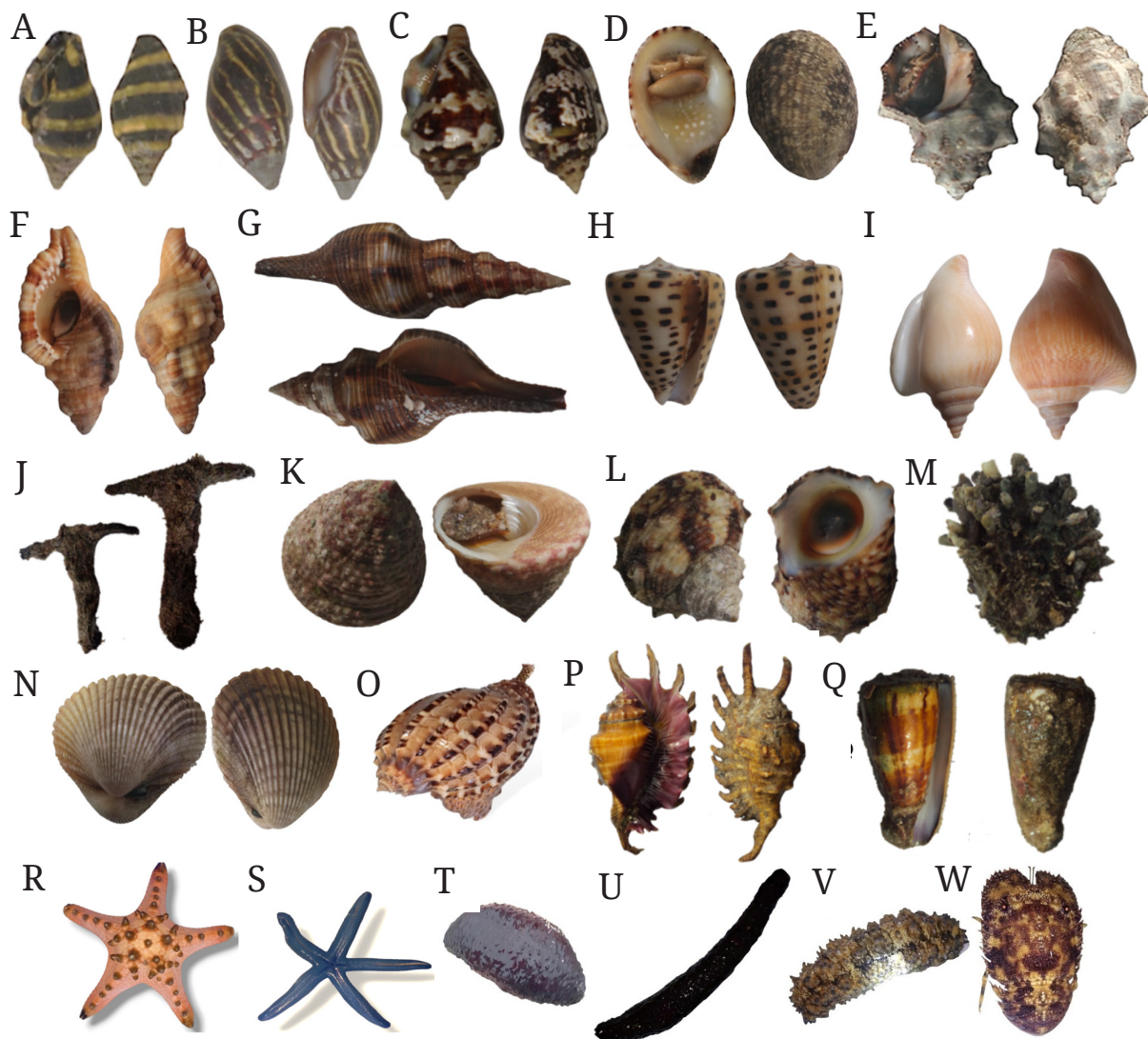


Figure 2. Some of the benthic macroinvertebrates found in Butulan and Balangonan, Jose Abad Santos, Davao Occidental: *Engina mendicaria* (A), *Strigatella zebra* (B), *Canarium* sp. (C), *Nerita polita* (D), *Tylothais aculeata* (E), *Cymatium* sp. (F), *Filifusus filamentosus* (G), *Conuseburneus* (H), *Laevistrombus canarium* (I), *Malleus malleus* (J), *Tectuspyramis* (K), *Turboargyrostomus* (L), *Spondylus* sp. (M), *Vasticardium subrugosum* (N), *Harpa articularis* (O), *Lambis millepeda* (P), *Conus* sp. (Q), *Protoreaster nodosus* (R), *Linckia laevigata* (S), *Holothuria atra* (T), *Holothuria leucospilota* (U), *Stichopus horrens* (V), *Parribacus* sp. (W).

Table 2. Diagnostic characteristics of the recorded benthic macroinvertebrates in the two sampling sites of Jose Abad Santos, Davao Occidental.

| Species name | Diagnostic characteristics |
|---|---|
| <i>Engina mendicaria</i> (Linnaeus, 1758) | The shell has a horizontal color pattern of black and yellow stripes. |
| <i>Strigatella zebra</i> (Lamarck, 1811) | The shell is smooth, with striking zebra-like banding of alternating dark brown and creamy white bands. |
| <i>Filifusus filamentosus</i> (Röding, 1798) | Fusiform and elongated, with an extended siphonal canal. The shell has a hairy outer layer and appears dark brown in color. |
| <i>Cymatium</i> sp. | The fusiform shells exhibit prominent axial ribs and spiral cords, with a vibrant orange coloration marked by darker bands and spots. |
| <i>Tylothais aculeata</i> (Deshayes, 1844) | Fusiform shell with prominent axial ribs and spiral cords. The aperture is ovate, leading into a deep siphonal canal. Shell color ranges from dark gray to brown. |

| | |
|---|---|
| <i>Laevistrombus canarium</i> (Linnaeus, 1758) | High conical spire composed of five furrowed whorls. The outer lip is flared and thickened. The canal is short and straight, with a smooth columella lacking folds. |
| <i>Lambis millepeda</i> (Linnaeus, 1758) | The outer lip has nine digitiform projections. The spire is striated, and the aperture is narrow. |
| <i>Canarium</i> sp. | Ovate-fusiform shell with a short spire. The outer lip is moderately flared, and the aperture is elongate. The siphonal canal is short and open. The shell has white and dark brown bands. |
| <i>Nerita polita</i> (Linnaeus, 1758) | The shell is nearly spherical with a depressed spire. The aperture is crescent-shaped, with a smooth and glossy texture. Shell color varies from gray to creamy white, often marbled. |
| <i>Conus eburneus</i> (Hwass, 1792) | The shell is broadly conical with a low spire. The shell color is white with three yellowish bands marked with black revolving spots. |
| <i>Conus</i> sp. | The shell is conical with a low spire. The aperture is narrow and straight. The shell color is light yellow with two golden brown bands. |
| <i>Tectus pyramis</i> (Born, 1778) | The shell has a pyramid-like shape with prominent spiral ridges and nodules. The whorls are flattened with granulated spiral cords, and the aperture is oval. |
| <i>Tectus fenestratus</i> (Gmelin, 1791) | The shell has a pyramid-like shape but is less steep than <i>T. pyramis</i> . The whorls have window-like depressions. |
| <i>Turbo argyrostomus</i> (Linnaeus, 1758) | The shell is rounded and globose in form, with a rounded spire. It has strong spiral ridges and growth lines. The outer lip of the aperture is silvery. |
| <i>Harpa articularis</i> (Lamarck, 1822) | The shell is ovate to elongate, with a distinctly rounded body whorl and pronounced axial ribs. The ribs are rounded and smooth. Shell color ranges from cream to light brown with darker brown banding. The aperture is wide and ovate, with a smooth inner lip. |
| <i>Vasticardium subrugosum</i> (G.B. Sowerby II, 1839) | The shell is heart-shaped, characterized by numerous radial ribs with fine secondary ridges that give it a wrinkled appearance. The shell color is pale brown with dark streaks. |
| <i>Tridacna</i> sp. | The shell is very large and thick, appearing triangular to ovate in shape. It is prominent with radiating ribs. |
| <i>Spondylus</i> sp. | The shell structure is ovate, with prominent spines on the upper valve and smaller spines on the lower valve. |
| <i>Malleus malleus</i> (Linnaeus, 1758) | The shell is T-shaped. The posterior extension of the shell is long and flat. |
| <i>Diadema setosum</i> (Leeke, 1778) | A visible orange ring surrounds the anus at the center of the aboral surface. The spines are extremely long and slender. |
| <i>Tripneustes gratilla</i> (Linnaeus, 1758) | The spines are short, orange, and white. Some individuals are covered with seagrass and algae. |
| <i>Protoreaster nodosus</i> (Linnaeus, 1758) | Body color varies from pale brown to orange, with distinctive dark brown to black conical tubercles on the dorsal side |
| <i>Linckia laevigata</i> (Linnaeus, 1758) | The central disc is small, and the five-arms are long, cylindrical, and have a vibrant blue coloration. |
| <i>Holothuria leucospilota</i> (Brandt, 1835) | The body is elongated with numerous papillae. It appears black with white spots on the dorsal surface. The body wall is soft. |
| <i>Holothuria atra</i> (Jaeger, 1833) | The body has a leathery texture and a glossy black color. It has a distinct orange ring around the anus. |
| <i>Stichopus horrens</i> (Selenka, 1867) | The body surface has irregular dark blotches, as well as large prominent tubercles and papillae on the dorsal side. |
| <i>Parribacus</i> sp. | The carapace is flattened and broad, with plate-like antennae covering the head |

Diversity of benthic macroinvertebrates

The diversity indices of benthic macroinvertebrates at the two sampling sites are shown in Table 3. The mean Shannon-Wiener diversity index (H') was significantly higher in Butulan ($H' = 3.04$) than in Balangonan ($H' = 2.45$), with a significant difference between the sites ($t = 4.65$, $P = 0.001$). Despite the variation in

diversity values, both sites exhibited H' values close to their respective maximum diversity (H_{max}) values: $H_{max} = 3.30$ in Butulan and $H_{max} = 2.64$ in Balangonan, indicating that the benthic macroinvertebrate communities at both sites were evenly distributed, with no single species dominating. This is further supported by the high Pielou's evenness index and low Simpson's dominance index observed in Butulan ($J' = 0.92$, $D = 0.05$) and Balangonan ($J' = 0.93$, $D = 0.09$).

Table 3. Diversity indices of benthic macroinvertebrates in two sites of Jose Abad Santos, Davao Occidental. Note: Shannon-wiener diversity index (H') was statistically significant between sampling sites with $t = 4.65$, $P = 0.001$.

| Sites | Diversity indices | | | | |
|------------|----------------------|---|---------------------------------|-------------------------------------|--------------------------------------|
| | Species richness (S) | Shannon-Wiener diversity index (H') | Maximum diversity (H_{max}) | Pielou's Index of Evenness (J') | Simpson's Index of Dominance (D) |
| Butulan | 27 | 3.04 | 3.30 | 0.92 | 0.05 |
| Balangonan | 14 | 2.45 | 2.64 | 0.93 | 0.09 |

Population density of benthic macroinvertebrates

The overall mean population density of benthic macroinvertebrates across the two sampling sites was $2,550 \pm 463.09$ ind ha^{-1} . The mean density (\pm SE) was significantly higher in the MPA of Butulan, at $3,540 \pm 701.52$ ind ha^{-1} , compared to $1,560 \pm 246.36$ ind ha^{-1} in the open-access area of Balangonan ($t = 3.25$, $P = 0.016$). In Butulan, the most abundant species recorded was *S. zebra* with a density of 280.00 ± 55.61 ind ha^{-1} , followed by *Cymatium* sp. (260.00 ± 79.16 ind ha^{-1}) and *E. mendicaria* (253.33 ± 53.33 ind ha^{-1}) (Figure 3). In Balangonan, *S. zebra* and *T. gratilla* were the most abundant macroinvertebrates, each with a mean

density of 173.33 ± 69.79 ind ha^{-1} and 173.33 ± 40.88 ind ha^{-1} , respectively. The least abundant species recorded in Balangonan was *Tridacna* sp., with a mean density of 13.33 ± 9.42 ind ha^{-1} (Figure 4). Several commercially important and commonly gleaned benthic macroinvertebrate species were found in Butulan but were absent in Balangonan. These include *L. millipeda* (33.33 ± 26.16 ind ha^{-1}), *V. subrugosum* (26.67 ± 13.33 ind ha^{-1}), *Spondylus* sp. (60.00 ± 22.51 ind ha^{-1}), *F. filamentosus* (140.00 ± 54.40 ind ha^{-1}), *H. articularis* (200.00 ± 30.98 ind ha^{-1}), *M. malleus* (60.00 ± 20.50 ind ha^{-1}), *L. canarium* (200.00 ± 38.64 ind ha^{-1}), *T. pyramis* (53.33 ± 19.78 ind ha^{-1}), *C. eburneus* (33.33 ± 16.05 ind ha^{-1}), *S. horrens* (20.00 ± 13.67 ind ha^{-1}), and *Parribacus* sp. (53.33 ± 26.67 ind ha^{-1}).

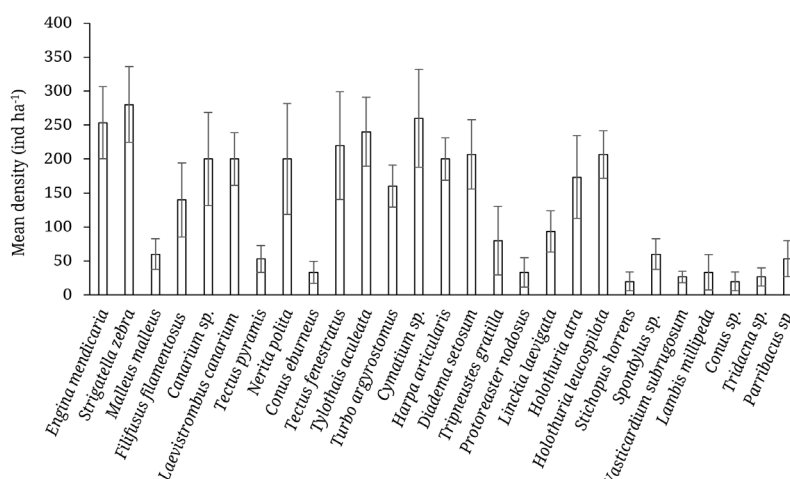


Figure 3. Mean density of benthic macroinvertebrates found Butulan in Jose Abad Santos, Davao Occidental. Vertical bars are the standard error (\pm SE) of means.

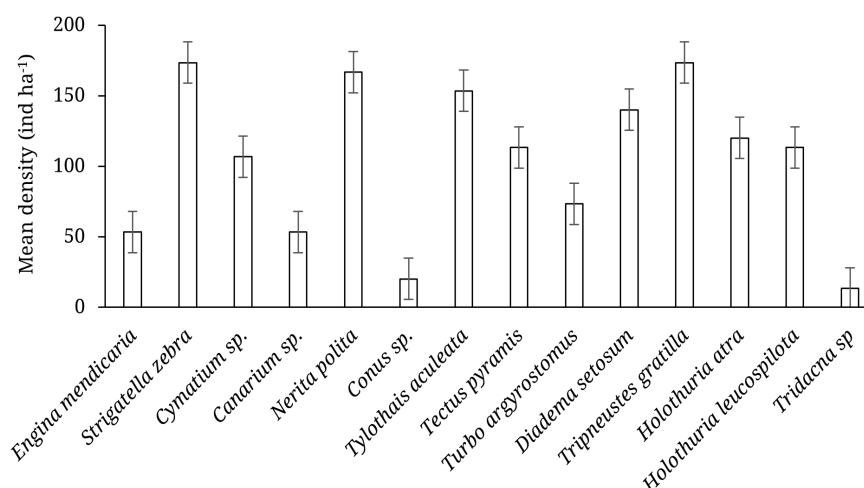


Figure 4. Mean density of benthic macroinvertebrates found in Balangonan in Jose Abad Santos, Davao Occidental. Vertical bars are the standard error (\pm SE) of means.

Physicochemical conditions of the water

The recorded mean values of physicochemical parameters in Butulan were as follows: temperature at $30.8^{\circ}\text{C} \pm 0.17$, pH at 8.1 ± 0.04 , salinity at $30.8 \text{ ppt} \pm 0.11$, and dissolved oxygen at $9.2 \text{ mg L}^{-1} \pm 0.09$. Similarly, in Balangonan, the mean values were $31^{\circ}\text{C} \pm 0.13$ for temperature, 8.1 ± 0.11 for pH, $31 \text{ ppt} \pm 0.10$ for salinity, and $9.2 \text{ mg L}^{-1} \pm 0.05$ for dissolved oxygen. These values fall within the acceptable limits set by the Department of Environment and Natural Resources (DENR) under DAO 2016-08 on the guidelines for water quality and general effluent standards in coastal waters. Statistical test showed no significant difference in temperature ($t = 0.19$, $P = 0.85$), salinity ($t = 0.54$, $P = 0.60$), pH ($t = 0.62$, $P = 0.70$) and dissolved oxygen ($t = 0.32$, $P = 0.76$) between two sites.

DISCUSSION

A total of 749 individuals representing 27 species of benthic macroinvertebrates were recorded across the two sampling sites in Jose Abad Santos, Davao Occidental, Philippines. The most abundant macroinvertebrates in both Butulan and Balangonan belonged to Phylum Mollusca, Class Gastropoda. The dominance of gastropods may be attributed to their high reproductive capacity, allowing them to produce large numbers of offspring (Irma and Sofyatuddin, 2012; Baderan et al., 2019; Tuang-tuang, 2022; Mahilac et al. 2023). Additionally, gastropods are

known for their resilience and adaptability to a wide range of environmental conditions, including fluctuations in salinity and temperature (Baharuddin et al., 2019). Among these, *S. zebra* was the most abundant gastropod species recorded at both sites. This gastropod is commonly found in various marine environments, from brackish waters to fully saline conditions. Its high abundance may also be linked to the fact that it is not typically harvested by local communities for consumption or trade, reducing the anthropogenic pressure on its population and allowing it to proliferate in the area. However, the observed abundance may also be influenced by sampling limitations. The study focused solely on epifaunal macroinvertebrates, potentially underrepresenting infaunal species. Furthermore, since sampling was conducted during daytime, most of the recorded species were diurnal (i.e., active during the day), and nocturnal macroinvertebrates may have been overlooked (Balisco et al., 2022). Therefore, future studies should incorporate infaunal sampling and night time surveys to provide a more comprehensive assessment of macroinvertebrate diversity and abundance in the area.

The mean density of macroinvertebrates was significantly higher in Butulan at $3540 \pm 701.52 \text{ ind ha}^{-1}$ than in Balangonan at $1560 \pm 246.36 \text{ ind ha}^{-1}$ ($t = 3.25$, $P = 0.001$). It is comparably higher than in reef of West Sulu Sea, Palawan at 25.1 ind ha^{-1} (Balisco et al. 2022), in Danjungan Island Marine Reserve and Sanctuaries of Negros

Occidental at 300 ind ha⁻¹ (Prieto-Amador and Palomar-Abesamis 2024), in the Tubbataha Reef National Marine Park at 730 ind ha⁻¹ (Dolorosa and Schoppe 2005). The results of the diversity index showed a significantly higher value in Butulan ($H' = 3.04$, $H_{max} = 3.30$) compared to Balangonan ($H' = 2.45$, $H_{max} = 2.64$) ($t = 4.65$, $P = 0.001$), indicating that macroinvertebrates in these sites were evenly distributed, with no dominant species. This is further supported by the high evenness index values, which are close to 1, indicating that most macroinvertebrate species had similar abundances, resulting in a higher H' value. However, the significant difference in diversity between the sites, along with the lower diversity value in Balangonan, may reflect a decline in species richness and diversity. Moreover, the diversity value in the MPA of Butulan is also higher than that of the protected area of Ban-ao, Baganga, Davao Oriental ($H' = 0.81$) (Bantayan et al. 2023), the Danjungan Island Marine Reserve and Sanctuaries of Negros Occidental ($H' = 1.79$) (Prieto-Amador and Palomar-Abesamis 2024), in Libertad, Sinacaban, Misamis Occidental ($H' = 2.92$) (Mahilac et al. 2023) and in Tinabilan Marine Protected Area, Northwest Leyte ($H' = 2.75$) (Tuang-tuang 2022). The higher density and greater diversity of macroinvertebrates in Butulan can be attributed to the strict protection of the MPA by the “Bantay Dagat”, a coastal law enforcement team designated by the local government. As noted in several studies, protected sites tend to have more individuals and greater diversity compared to exposed or unprotected sites (Lumayag et al., 2018; Bantayan et al., 2023; Mahilac et al., 2023; Tuang-tuang 2022). These findings underscore the critical role of MPAs in supporting the recovery, conservation, and sustainability of marine ecosystems, including benthic macroinvertebrate communities.

The habitat complexity of coral reefs and seagrass beds at the sampled sites may also contribute to the observed high abundance and species diversity of benthic macroinvertebrates. As highlighted by Attrill et al. (2000), the structural complexity of a habitat is often considered a key factor influencing the diversity and abundance of associated communities. Variations in both biotic and abiotic characteristics promote the formation of diverse niches and habitats for macrofauna within the intertidal zone (Gondal et al., 2012). These biotic and abiotic factors such as

salinity, pH, dissolved oxygen, temperature, and substrate type strongly influenced the community structure and diversity of benthic macroinvertebrate (Libres, 2015; Nurhasballah et al., 2019; Onwona Kwakye et al. 2021; Li et al., 2022). Although the physicochemical conditions in both study sites fall within the acceptable ranges set by DENR-DAO 2016-08 and showed no significant differences, further investigation of other biotic and abiotic parameters is recommended. These include nutrient concentrations (e.g., nitrate, nitrite, and phosphate), total suspended solids, substrate type as well as seagrass and coral cover, to provide a more comprehensive understanding of habitat characteristics in the area.

In contrast to the MPA of Butulan, the open-access nature of Balangonan has facilitated unregulated gleaning activities by coastal residents, who view gleaning as both a source of alternative income and a recreational activity (Bantayan et al., 2023). As mentioned by Mahilac et al. (2023) that gleaning impacts macroinvertebrate diversity in Sinacaban, Misamis Occidental, as the intensive collection of organisms poses a threat to species abundance and may lead to reduced reproductive output and population decline. Similarly, this has contributed to the lower macroinvertebrate density and reduced species richness observed at the study site. In addition to gleaning, other anthropogenic pressures including the construction of coastal homes, boat docking areas, swimming zones, beach resorts, ecotourism facilities, and the discharge of domestic waste may also adversely affect benthic macroinvertebrate communities (Mahilac et al., 2023). These disturbances have been widely linked to declining species richness and diversity in coastal ecosystems (Sun et al., 2018). It is also noteworthy, the consequences of these human activities are reflected in the absence of several ecologically and economically important macroinvertebrate species in Balangonan such as *C. eburneus*, *L. millipeda*, and *S. horrens* locally known as “kibul,” “Saang” and “bat mani-mani” respectively, which local communities recall as previously abundant in the area’s coral reefs. Moreover, the increasing market value of many gleaned species, particularly top shells and giant clams, has raised concerns over potential overexploitation, as elevated prices drive small-scale fishers to intensify harvesting efforts (Balisco et al. 2022; Aldea, 2023). For instance, *Tripneustes gratilla*, the second most

abundant macroinvertebrate species in Balangonan, has begun to decline in number and size due to excessive fishing driven by local demand, where the species is commonly sold in bottles to the local market (Molina et al., 2025).

Notably, the presence of *Tridacna* spp. and other high-value benthic macroinvertebrates such as *T. argyrostomus*, *T. pyramis*, and the abundance of *T. gratilla* during the survey in Balangonan underscores the urgency of implementing appropriate management interventions. If left unmanaged, continued unregulated exploitation of marine macroinvertebrate resources may lead to overharvesting, threatening species sustainability and accelerating habitat degradation (de Guzman et al., 2016).

CONCLUSION

A total of 749 individuals representing 27 species of benthic macroinvertebrates were recorded across two sampling sites in Jose Abad Santos, Davao Occidental, Philippines. The most abundant macroinvertebrates in both Butulan and Balangonan belonged to the phylum Mollusca, class Gastropoda. The mean density and diversity of benthic macroinvertebrates were higher in the MPA of Butulan compared to the open-access area of Balangonan, underscoring the critical role of MPAs in protecting and conserving macroinvertebrate resources. Conversely, the open-access status of Balangonan highlights the potential for overharvesting, which can lead to declining wild stock populations and reduced species diversity. Thus, it is recommended that local stakeholders implement regulatory measures to ensure the sustainable use of this important resource in Balangonan. These measures may include catch limits (e.g., no more than 20 pounds per day, including shells), size quotas (which may vary by species; for example, *T. gratilla* with a test diameter greater than 60 mm, and shellfish such as *Trochus* species with a base diameter of at least four inches), restrictions on the harvesting of juveniles and gravid individuals, and stock enhancement. Community-based resource management, combined with continuous ecological monitoring, is essential to maintain the long-term ecological integrity and socioeconomic sustainability of these marine ecosystems.

ACKNOWLEDGMENT

The authors would like to thank the following individuals for the technical support to make this study possible: Mr. Jopy Caneda, Mr. Michael Jeriel Bersaldo, and Ms. Junarie Joy Tuba. We would also like to acknowledge the local government unit of Barangay Butulan and Balangonan, for their assistance in the conduct of the study.

FUNDING SOURCE

The authors did not receive support from any organization for the submitted work.

CONFLICT OF INTEREST

No potential conflict of interest was reported by the authors

AUTHOR CONTRIBUTIONS

Molina, J. R.: Conceptualization, methodology, supervision, data validation, writing-original draft and revising manuscript; Muda, R. and Dela Cruz, R.: Data collection and data analyses. All authors read and approved the final manuscript.

REFERENCES

- Aldea K.Q. (2023). Macroinvertebrate gleaning in coastal ecosystems: Utilization, pressures, and implications for conservation. *AACL Bioflux* 16 (3): 1331-1345.
- Attrill, M. J., Strong, J. A., and Rowden, A. A. (2000). Are macroinvertebrate communities influenced by seagrass structural complexity? *Ecography*, 23(1), 114-121. <https://doi.org/10.1111/j.1600-0587.2000.tb00266.x>
- Baderan, D. W. K., Hamidun, M. S., Utina, R., Rahim, S., and Dali, R. (2019). The abundance and diversity of mollusks in mangrove ecosystem at coastal area of North Sulawesi, Indonesia. *Biodiversitas*, 20(4), 987-993. <https://doi.org/10.13057/biodiv/d200408>
- Baharuddin N, Basir N.H.M, and Zainuddin S.N.H. (2019). Tropical intertidal gastropods: Insights on diversity, abundance, distribution and shell morphometrics of Pulau Bidong, Malaysia. *AACL Bioflux* 12: 1375- 1387.
- Balisco, R.A.T., Gonzales, B.J., and Dolorosa, R.G. (2022). Economically Important Benthic

- Macroinvertebrates in the Reefs of West Sulu Sea, Palawan, Philippines. *Philippine Journal of Science* 151(3).
- 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>
- Conales, S.F., Bundal, N.A., and Dolorosa R.G. (2015). High density of *Tridacna crocea* in exposed massive corals proximate the Ranger Station of Tubbataha Reefs Natural Park, Cagayancillo, Palawan, Philippines. *The Palawan Scientist* 7: 36–39.
- Davies, C.E. (2021). Invertebrate health in marine protected areas (MPAs). *Journal of Invertebrate Pathology*, 186, 107524.
- 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 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., 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/msun-jear.2021.06.04>
- Del Norte-Campos, A.G.C., Campos, W.L., Villarta, K.A. (2005). A Survey of Macroinvertebrate Gleaning in the Banate Bay Intertidal Area, Eastern Panay Island. *Science Diliman*.
- Dolorosa R.G., Grant, A. and Gill J.A. (2016). Spatial and Temporal Abundance of the reef gastropod *Tectus niloticus* (Gastropoda: Tegulidae) in Marine Protected Areas in Palawan, Philippines: Prospects for Conservation. (2016). *Iranica Journal of Energy and Environment*. <https://doi.org/10.5829/idosi.ijee.2016.07.02.16>
- Dolorosa, R.G. and Schoppe S. (2005). Focal benthic mollusks (Mollusca: Bivalvia and Gastropoda) of selected sites in Tubbataha Reef National Marine Park, Palawan, Philippines. *Science Diliman* 17(2): 1–8.
- Edgar, G. J., Stuart-Smith, R. D., Willis, T. J., Kininmonth, S., Baker, S. C., Banks, S., and Thomson, R. J. (2014). Global conservation outcomes depend on marine protected areas with five key features. *Nature*, 506(7487), 216–220. <https://doi.org/10.1038/nature13022>
- George, A.D.I., Abowei, J.F.N. and Daka, E.R. (2009). Benthic macroinvertebrate fauna and Physico-chemical parameters in Okpoka Creek sediments, Niger Delta, Nigeria. *International Journal of Animal and Veterinary Advances*, 1: 59-65.
- Gondal, M., Saher, N., and Qureshi, N. (2012). Diversity and biomass distribution of intertidal fauna in sonmiani bay (Miani Hor), balochistan (pakistan). *Egyptian Academic Journal of Biological Sciences, B. Zoology*, 4(1), 219–234. <https://doi.org/10.21608/ea-jbsz.2012.14304>
- Irma D, and Sofyatuddin K. (2012). Diversity of Gastropods and Bivalves in mangrove ecosystem rehabilitation areas in Aceh Besar and Banda Aceh districts, Indonesia. *AACL Bioflux* 5(2): 55-59.
- Jontila, J. B. S., Balisco, R. A. T, and Matillano J. A. (2014). The sea cucumbers (Holothuroidea) of Palawan, Philippines. *AACL Bioflux* 7(3): 194–206.
- Libres, M.C. (2015). Species diversity of macrobenthic invertebrates in mangrove and seagrass ecosystems of Eastern Bohol, Philippines. *Asia Pacific Journal of Multidisciplinary Research* 3(5): 128–134.
- Li, F., Ma, Y., Song, X., Li, S., Zhang, X., Wang, X., and Sun, Z. (2022). Community structure and ecological quality assessment of macrobenthos in the coastal sea areas of Northern Yantai, China. *Frontiers in Marine Science*, 9. <https://doi.org/10.3389/fmars.2022.989034>
- Lumayag, K. J, Ronaldo, R., Orbita, M. L. S., and Lacuna, M.L.D. (2018). Benthic mollusks in seagrass beds of barangay Liangan East and barangay Esperanza, Bacolod, Lanao del Norte, Northern Mindanao, Philippines. *International Journal of Biosciences*, 13(3), 121-131.
- Mahilac, H. M. O., Tandingan, J. P., Torres, A. G., Amparado, R. J., and Roa-Quiaoit, H. A. (2023). Macroinvertebrate assessment in seagrass ecosystem in Sinacaban Municipality, Misamis Occidental, Philippines. *Biodiversitas*, 24(10), 5586–5597. <https://doi.org/10.13057/biodiv/d241040>

- Maynawang, I. S., Macusi, E. D., Fadli, N., and Nallos, I. M. (2024). Diversity of Harvested Gastropods in Guang-Guang, Mati City, Davao Oriental, Philippines. *HAYATI Journal of Biosciences*, 31(1), 153-160.
- Mecha, N. J. M. F., and Dolorosa, R. G. (2020). Searching the Virtually Extinct *Tridacna gigas* (Linnaeus, 1758) in the Reefs of Palawan, Philippines. *Philippine Journal of Fisheries*, 27(1), 1–18. <https://doi.org/10.31398/tpjf/27.1.2019-0005>
- Molina, J. R., Sumondong Jr. M. G., Tigaldao, J. M., Melindo, H. G. A., Padayag, S. and Bersaldo, M. J. I. (2025). Population status and lunar periodicity of spawning of *Tripneustes gratilla* (Echinodermata: Echinoidea), in Jose Abad Santos, Davao Occidental, Philippines. *The Palawan Scientist*, 17(2), 1-12.
- Nieves, P.M.S., de Jesus, C., Macale, A.M.B., and 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).
- Nurhasballah, Rizki, A., and Suwarno. (2019). Diversity of gastropods epifauna based on substrate in littoral zone in Mesjid Raya, District of Aceh Besar, Indonesia. In IOP Conference Series: Earth and Environmental Science (Vol. 364). *Institute of Physics Publishing*. <https://doi.org/10.1088/1755-1315/364/1/012028>
- Onwona Kwakye, M., Peng, F. J., Hogarh, J. N., and Van den Brink, P. J. (2021). Linking Macroinvertebrates and Physicochemical Parameters for Water Quality Assessment in the Lower Basin of the Volta River in Ghana. *Environmental Management*, 68(6), 928–936. <https://doi.org/10.1007/s00267-021-01535-1>
- Prieto-Amador and Palomar-Abesamis. (2024). Insights on Evaluating Commercially Important Macroinvertebrate Species in Danjugan Island Marine Reserve, Philippines. *Philippine Journal of Science*, 153(3).
- Sahidin, A., Wardiatno, Y. and Setyobudiandi, I. (2019). Biodiversity and special distribution of molluscs in Tangerang coastal waters, Indonesia. *AACL Bioflux*, 12(6): 2051-2061.
- Schoppe, S. (2000). Echinoderms of the Philippines: a guide to common shallow water sea stars, brittle stars, sea urchins, sea cucumbers and feather stars. VISCA-GTZ Program on Applied Tropical Ecology, Visayas State College of Agriculture. 144p.
- Sun, R., Sun, Y., Li, Q. X., Zheng, X., Luo, X., and Mai, B. (2018). Polycyclic aromatic hydrocarbons in sediments and marine organisms: Implications of anthropogenic effects on the coastal environment. *Science of the Total Environment*, 640–641, 264–272. <https://doi.org/10.1016/j.scitotenv.2018.05.320>
- Szabó, K., and Amesbury, J.R. (2011). Molluscs in a word of islands: the use of shellfish as a food resource in the tropical island Asia-Pacific region. *Quaternary International* 239: 8–18. <https://doi.org/10.1016/j.quaint.2011.02.033>
- Tuang-tuang, J. (2022). Baseline information of the benthic macroinvertebrates in the Tinabulan Marine Protected Area, Northwest Leyte as Bioindicators of Reef Health. *International Journal of Biosciences* 21(5) 12-17, <http://dx.doi.org/10.12692/ijb/21.5.12-17>
- Van Houte-Howes, K. S. S., Turner, S. J., and Pilditch, C. A. (2004). Spatial differences in macroinvertebrate communities in intertidal seagrass habitats and unvegetated sediment in three New Zealand estuaries. *Estuaries*, 27(6), 945–957. <https://doi.org/10.1007/BF02803421>.