HAYATI
Journal of Biosciences

Vol. 33 No. 2, March 2026 540-555
DOI:10.4308/hjb.33.2.540-555
ISSN: 1978-3019
EISSN: 2086-4094

Research Article

Assessment of Macrobenthos Assemblages Along the Seabed Characteristic in the Cempi Bay, West Nusa Tenggara, Indonesia: A Case Study in the Dry Season

Karizma Fahlevy[1*], Agustinus Sembiring[2], Rias Kaessari Magenta[2], Muchammad Iqbal Havis[2], Adi Suroso[2], Rahmat Nauval[3], Charles P. H. Simanjuntak[4]

[1]*Independent Researcher, Jakarta 12270, Indonesia*
[2]*PT Lorax Indonesia, Jakarta 12950, Indonesia*
[3]*Fisheries Diving Club (FishDic), Brawijaya University, Malang 65145, Indonesia*
[4]*Department of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, IPB University, Bogor16680, Indonesia*

ARTICLE INFO

Article history:
Received July 3, 2025
Received in revised form October 4, 2025
Accepted December 5, 2025
Available Online December 11, 2025

KEYWORDS:
Bivalvia,
Gastropoda,
Habitat category,
Polychaeta,
Sediment gradient

ABSTRACT

The ecosystem in Cempi Bay, Indonesia, is known for its diverse coastal ecosystems. Gathering baseline data to understand the habitat and its fauna is essential. The study aims to update macrobenthos data and identify natural patterns across sediment gradients, specifically in the dry season. Cempi Bay has three distinct areas: the lower reach (open sea), the middle reach (mixing water), and the upper reach (influenced by freshwater). The most dominant classes in the macrobenthic assemblages were Gastropoda, Bivalvia, and Polychaeta, especially in the lower and middle reaches with sand and silty sand seabed textures. However, the upper reach area with sandy silt textures showed a different pattern of macrobenthic assemblages, with fewer classes, leaving only Gastropoda and Bivalvia. The feeding habits of macrobenthos also varied, with carnivores, deposit feeders, and suspension feeders dominating the lower and middle reach areas. It is important to continue monitoring macrobenthos to understand if these patterns are natural or caused by environmental changes.

1. Introduction

Coastal ecosystems are among the most diverse marine ecosystems and play a vital role in supporting global biodiversity and ecological processes (Klemas 2011; Laksmi 2021). These transitional zones between land and sea include habitats along the shoreline and nearby waters (Murthy and Reddy 2014) and are shaped by dynamic processes such as waves, tides, sediment supply, and river dynamics (Chandramohan *et al.* 1993; Kumar *et al.* 2002). This natural process maintains the stability of the coastal seabed, which is mainly covered with sediments ranging from gravel to fine mud (Snelgrove 1997). Sediments, ranging from gravel to fine mud, may originate locally (autochthonous) or from other locations (allochthonous) and provide habitats for benthic communities (Commey *et al.* 2021). Marine sediments cover 70% of the Earth's surface and support diverse organisms (Baker *et al.* 2021). Macrobenthos, benthic organisms between 0.1 and >3 mm, play key roles in nutrient cycling, sediment dynamics, and food webs (Blackwell 2013; Vanden Eede *et al.* 2014; Szczepanek *et al.* 2021; Hale *et al.* 2024).

Sediment deposition in coastal zones influences macrobenthos abundance, biodiversity, and assemblage distribution (Commey *et al.* 2021). This deposition is strongly affected by seasonal variations, with higher precipitation and river runoff during the wet season and lower discharge in the dry season (Sukartaatmadja *et al.* 2003; Lowe *et al.* 2022). These seasonal changes can

---

*Corresponding Author
E-mail Address: karizmafahlevy@yahoo.com

alter macrobenthos assemblages by affecting the habitats they occupy, the taxa present, and their density (Lamptey and Armah 2008; Yu *et al.* 2020; Lowe *et al.* 2022). Different habitats, in turn, host distinct macrobenthos assemblages, shaped by feeding habits that determine ecological roles and species interactions (Valentine *et al.* 2002; Kanaya *et al.* 2005; Ieno *et al.* 2006). Functional traits such as life form, life history, feeding habits, and size provide better predictions of ecosystem functioning than taxonomic richness alone (Micheli *et al.* 2014; Laureto *et al.* 2015 Gagic *et al.* 2015; Chen *et al.* 2022). Feeding habits, in particular, help identify how macrobenthos contribute to food webs and ecosystem processes (Nasi *et al.* 2017; Jayachandran *et al.* 2019; Chen *et al.* 2022; Pratiwi *et al.* 2024). Despite numerous studies on coastal macrobenthos in Indonesia, most focus solely on taxonomic richness and biodiversity, while investigations of habitat preferences based on feeding traits remain lacking (Pratiwi *et al.* 2024).

Cempi Bay, on the northern coast of West Sumbawa Island, West Nusa Tenggara Province, is an important region in Indonesia (Yulianto *et al.* 2016). Cempi Bay exhibits high habitat heterogeneity, including mangroves (Sentosa and Nastiti 2012), seagrass beds (Lestariningsih *et al.* 2023), and coral reef ecosystems (Yulianto *et al.* 2016). Despite this, studies on macrobenthos in the area, including their taxonomic abundance, diversity, and feeding habits, remain limited. Most existing research on fauna has focused on specific species, such as shrimp, in the mangrove zones of the inner bay (Putri and Nastiti 2017; Taufani *et al.* 2019), and comprehensive assessments of the bay's environmental conditions or aquatic fauna are scarce. Unfortunately, so few studies have been conducted on macrobenthos in Cempi Bay, even though the bay receives sediments from multiple rivers, which contribute to macrobenthos habitat diversity (Sentosa and Nastiti 2012; Nakano *et al.* 2025). Understanding macrobenthos distribution, assemblages, and habitat preferences is essential for evaluating their role in ecosystem services (Ji *et al.* 2024). This preliminary study aims to characterize sediment grain size as a habitat for macrobenthos, analyze macrobenthos composition across habitat types, identify the dominant macrobenthos groups within each habitat, and assess habitat preferences based on macrobenthos traits.

2. Materials and Methods

2.1. Sample Collection

Sampling focused on the dry season, as studies on coastal macrobenthos in Indonesia reported higher abundance during this period (Sharani *et al.* 2018; Muskananfola *et al.* 2020). The wet season, characterized by rainfall and runoff, may have short-term effects on macrobenthos density and sediment distribution. Accordingly, sampling was conducted in July 2023, representing the dry season in the Cempi Bay area. Seabed sediment and macrobenthos samples were collected from 15 locations (MWQ-01 to MWQ-15) in Cempi Bay, West Sumbawa Island, West Nusa Tenggara Province, Indonesia (Figure 1, Table 1). While the upstream inner bay was inaccessible due to shallow depth (2–3 m), the closest accessible sites were selected. MWQ-01–04 were in the inner bay, MWQ-05–12 at the bay entrance, and MWQ-13–15 outside the bay (Figure 1). Depths at each site, measured with an Echosounder GP-3700F (Furuno), ranged from 5.5 to 241 m (Table 1).

Replications were not possible due to environmental and time constraints. Sediment samples were collected using a 130 kg Van Veen grab sampler (28 L volume, 0.228 × 0.357 × 0.35 m). Multiple grabs were required at MWQ-06, 09, 10, 12–15 due to rough substrate and bedrock. Sediments were homogenized, placed in pre-labelled, sealed bottles, chilled at 4°C, and sent to Intertek Laboratory, Jakarta, for grain-size analysis using the modified APHA 9223-B hydrometer method (APHA 2017). Macrobenthos samples were collected from similar sediment substrates, sieved through a 500 µm mesh, preserved in 10% formaldehyde (diluted with filtered seawater), and delivered to the Macro Eco-biology Laboratory, Bogor Agricultural University (IPB, Bogor) for identification. Samples were examined under a stereomicroscope as described by Rachman *et al.* (2016). Macrobenthos density was expressed as individuals per square meter (Ind./m^2). Organisms were identified to the lowest possible taxonomic level, classified primarily by class, or by infraorder when taxonomic information was insufficient (e.g., Sipunculidea). Taxonomic names were confirmed according to Pennak (1953), Gosner (1971), Fauschald (1977), Lovett (1981), Beesley *et al.* (2000), and Dharma (2005), and cross-checked against the World Register of Marine Species (WoRMS 2024).

2.2. Sediment Classification

The Shepard's diagram is commonly used to classify sediments and identify sedimentary characteristics in coastal-estuarine environments (Romano *et al.* 2017). In this study, sediment grain size served as a proxy for macrobenthos habitat at each location. Sediments were classified into sand, silt, and clay proportions and plotted on the sediment distribution triangle (Shepard

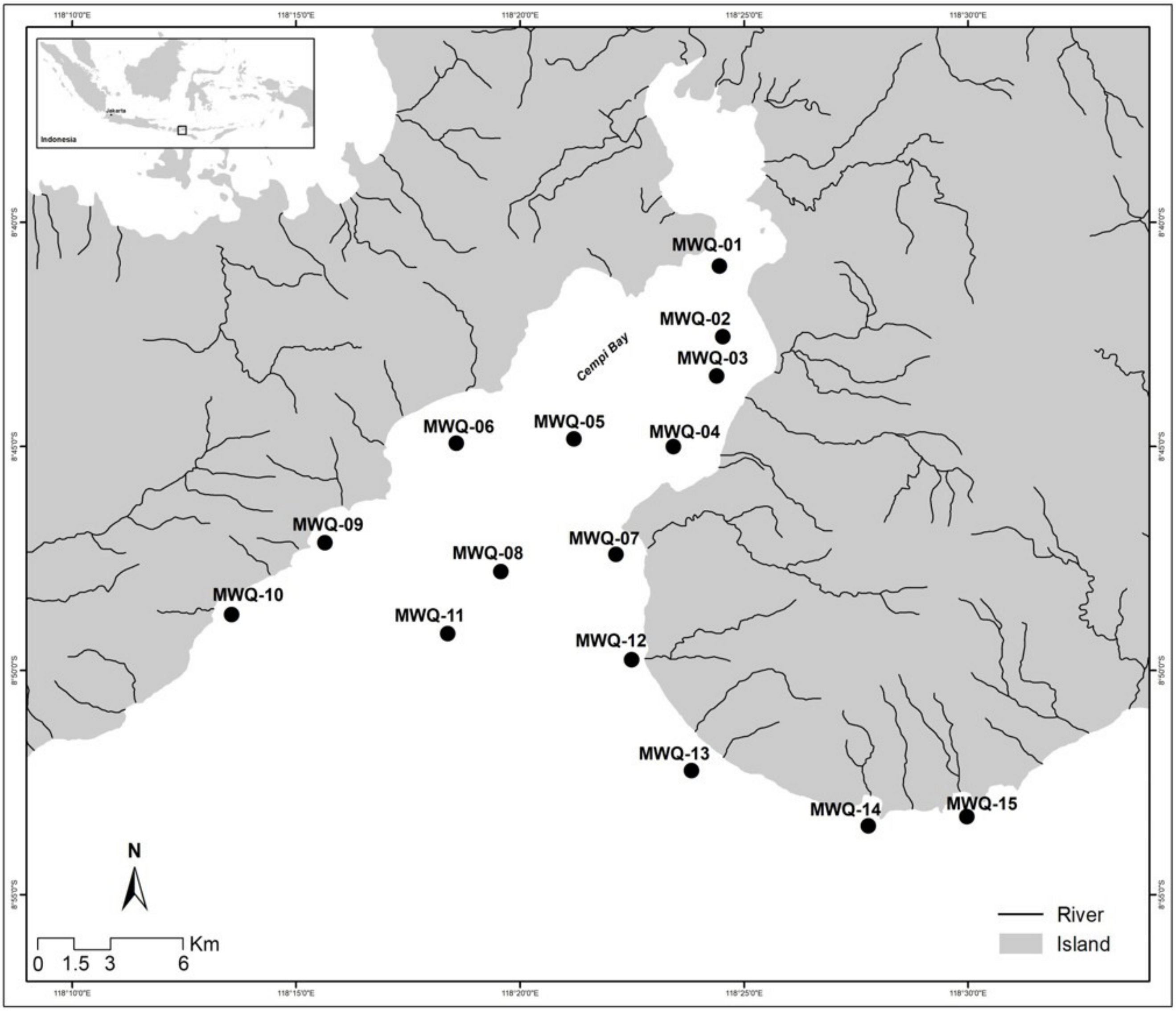

Figure 1. Sampling locations of sediment and macrobenthos in Cempi Bay

Table 1. Sediment and Macrobenthos Sampling Locations in Cempi Bay

Location ID	Coordinates		Depth (m)
	Lattitude	Longitude	
MWQ-01	118° 24’ 27.443” E	8° 40’ 58.483” S	5.5
MWQ-02	118° 24’ 31.964” E	8° 42’ 32.814” S	5.5
MWQ-03	118° 24’ 23.674” E	8° 43’ 25.673” S	5.9
MWQ-04	118° 23’ 25.426” E	8° 45’ 00.014” S	7.1
MWQ-05	118° 21’ 12.612” E	8° 44’ 49.914” S	17
MWQ-06	118° 18’ 35.039” E	8° 44’ 55.446” S	18
MWQ-07	118° 22’ 08.836” E	8° 47’ 24.443” S	30
MWQ-08	118° 19’ 34.459” E	8° 47’ 47.177” S	109
MWQ-09	118° 15’ 38.855” E	8° 47’ 08.696” S	34.35
MWQ-10	118° 13’ 34.085” E	8° 48’ 45.063” S	14
MWQ-11	118° 18’ 23.630” E	8° 49’ 10.294” S	241
MWQ-12	118° 22’ 29.621” E	8° 49’ 45.476” S	42
MWQ-13	118° 23’ 49.740” E	8° 52’ 13.831” S	86
MWQ-14	118° 27’ 46.550” E	8° 53’ 27.633” S	37
MWQ-15	118° 29’ 58.478” E	8° 53’ 15.508” S	87

1954) and on hydrodynamic and substrate-dominant triangle diagrams (Pejrup 1988). Triangle dimensions were adjusted using MS Excel v.365. The sediment triangle included 10 classes: silt, sandy silt, silty sand, sand, clayey silt, clayey sand, silty clay, sandy clay, clay, and sand-silt-clay (Jones *et al.* 2011). The hydrodynamic and substrate-dominant triangle assigned hydrodynamic classes I–IV (low to high energy) and sediment-dominant classes A–D (reflecting sediment proportions). These classifications provide a basis for categorizing benthic habitats in coastal estuaries based on sediment characteristics (Sutherland *et al.* 2018).

2.3. Macrobenthos Trait

The species trait used during this study was based on their feeding habit. This trait reflects their primary food sources, offering valuable insight into their dietary preferences and ecological role within their habitat (De Raedemaecker *et al.* 2011; Nasi *et al.* 2017). It also determines their trophic level (food chain), distinguishing among omnivores, herbivores, carnivores, and deposit- and suspension-feeding organisms. We compiled this trait from online literature (BIOTIC: MarLIN 2006; polytraits: Polytraits Team 2024; SeaLifeBase: Palomares and Pauly 2024) and scientific publications (Gaudêncio & Cabral 2007; Floyd *et al.* 2020; Chen *et al.* 2022).

2.4. Data Analysis

2.4.1. Habitat Classification

Since none of the locations had replicates, direct statistical comparisons were not possible. To address this, locations were categorized based on Shepard's sediment texture classification. Previous studies have shown a strong relationship between macrobenthos communities and sediment texture (silt and sand) (Arrighetti and Penchaszadeh 2010; Farsi *et al.* 2015; Steffani *et al.* 2015), allowing sediment classification to serve as a proxy for macrobenthos habitat in this study. A similar approach has been used when multiple grab replicates were not feasible, by grouping locations based on environmental characteristics (Hashim *et al.* 2024).

Correlations between sediment composition and macrobenthos taxa-density were analyzed using BEST (BIO-ENV) and DistLM (Distance-based linear models) in PRIMER v7 (Clarke and Gorley 2015). Macrobenthos data were square-root transformed to reduce differences between common and rare species (Fahlevy *et al.* 2018), and sediment data were normalized. Bray-Curtis similarity and Euclidean distance were used for macrobenthos and sediment distance matrices, respectively. BEST analysis indicated that the sand-silt combination correlated with taxa-density (0.510; Supplementary Table 1), while silt alone had the highest correlation (0.525; Supplementary Table 1). DistLM showed that all three variables (clay, sand, and silt) significantly explained variation in macrobenthos data (marginal test: clay $p = 0.013$, sand $p = 0.002$, silt $p = 0.001$; Supplementary Table 2), with silt being the most significant variable in stepwise selection (Supplementary Table 2). These results support the use of sediment grain size composition as a key determinant of macrobenthos assemblages.

2.4.2. Macrobenthos Assemblages and Trait Composition

Macrobenthos density and taxonomic composition were calculated for each class and visualized using chord diagrams. The chord diagrams were generated using the 'circlize' package in R version 0.4.16 (Gu *et al.* 2014). Taxon distribution (species or genera) was also shown using a heatmap created with the 'ggplot2' package in R (version 3.5.1; Wickham 2016). Non-metric multidimensional scaling (nMDS) was performed using the 'vegan' package (version 2.6-6.1; Oksanen *et al.* 2024) to examine variation among habitat categories based on macrobenthos density and taxa number. Before nMDS, data were square-root transformed, and Bray–Curtis similarity was used as the distance matrix. nMDS plots were created with 'ggplot2', and locations within each category were subsetted to visualize hulls. A Similarity Percentage (SIMPER) analysis was conducted in PRIMER V.7 (Clarke and Gorley 2015) on the Bray–Curtis matrix to determine the contribution of each macrobenthos class (Fahlevy *et al.* 2024).

To analyze feeding habit composition across locations classified by sediment attributes (grain size), we calculated community-weighted means (CWM) using the 'FD' package (version 1.0-12; Laliberté *et al.* 2014). Two matrices were prepared: a trait matrix and a taxa (species/genera)-density matrix. For categorical traits (e.g., carnivore, omnivore), we applied "fuzzy coding," assigning scores from 0 to 1 for each feeding habit (Darr *et al.* 2014). This ensures that scores sum to 1 for each species, reducing bias in subsequent analyses (Bremner *et al.* 2003; Darr *et al.* 2014). Species with dual feeding habits were assigned proportional scores based on available information (e.g., suspension feeders as larvae and carnivores as adults scored 0.2 and 0.8, respectively; Hewitt *et al.* 2008).

CWM values for each location were calculated using the 'dbFD' function, combining trait and species density matrices (Laliberté *et al.* 2014). Similar nMDS analyses were performed using CWM results to examine assemblage differences between habitat categories based on feeding habits, without square-root transformation.

3. Results

3.1. Sediment Grain Size Classification

The respective sand, silt, and clay ranges were 23.47-98.8%, 1.3-71.22%, and 0.2-6.1% (Figure 2). The triangular plots based on sand, silt, and clay proportions (Shepard diagrams) revealed clay-free sediment texture classifications for all 15 locations in Cempi Bay during this dry season (Figures 3 and 5). Within the ten available texture classes, our results fall into three class outlines in the triangular plot: sand (MWQ-06, 07, 09, 10, 12-15), silty sand (MWQ-05, 08, and 11), and sandy silt (MWQ-01–04).

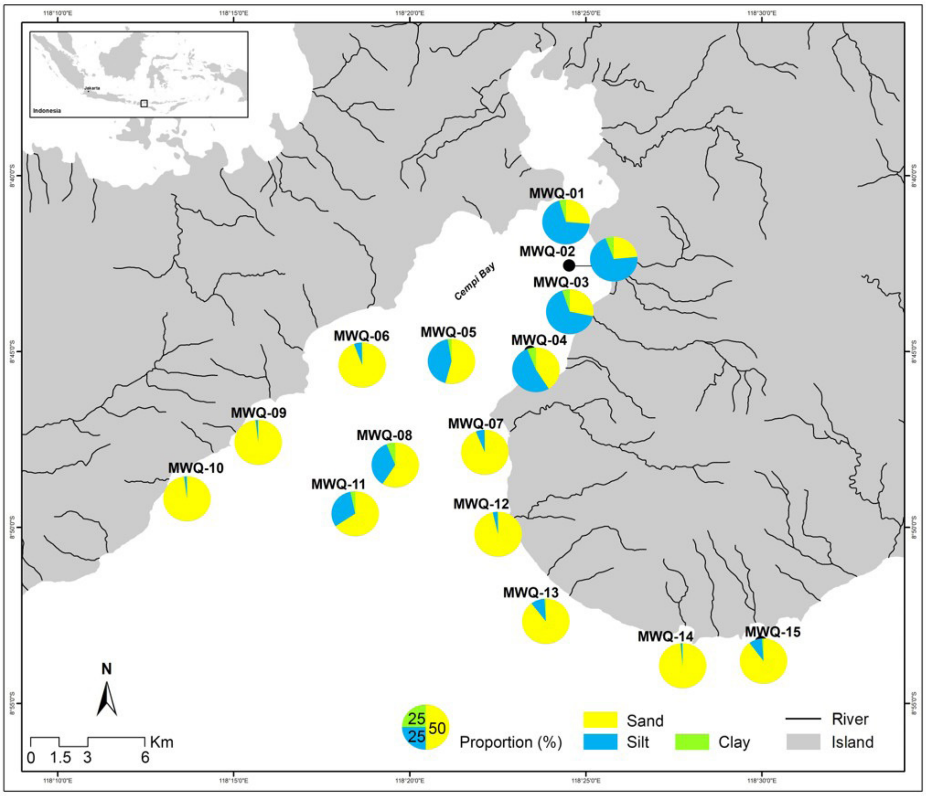

Figure 2. Sediment grain size distribution in the Cempi Bay during dry season

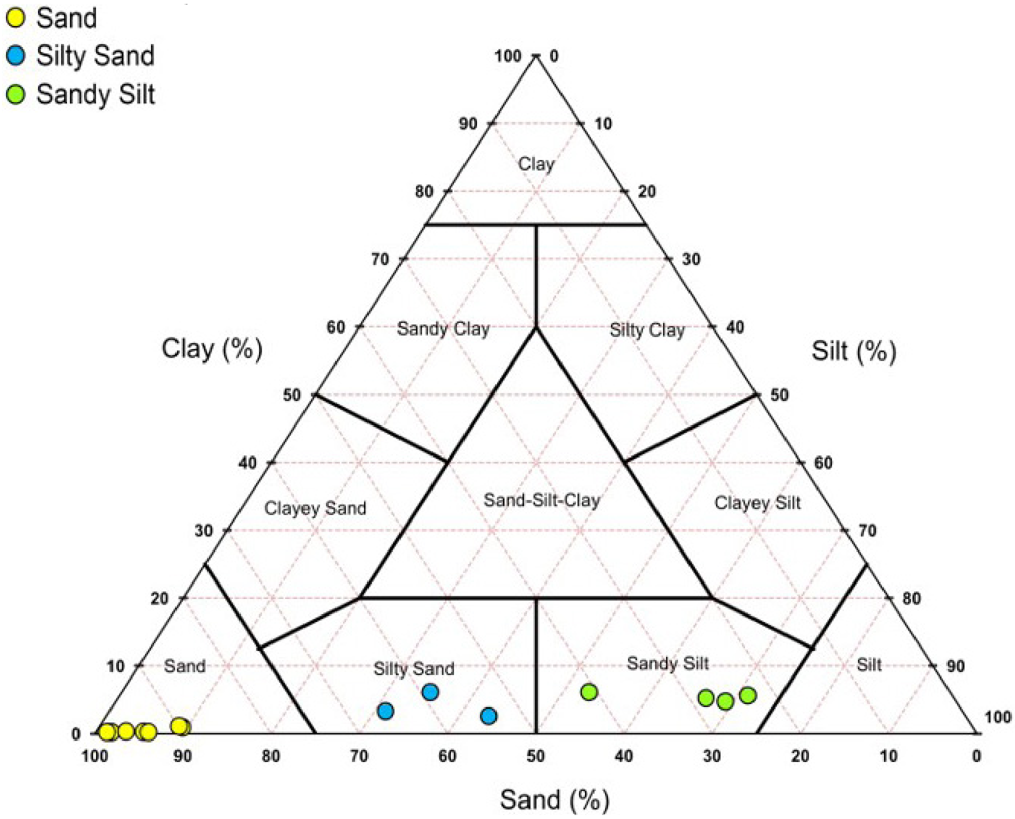

Figure 3. Sediment grain size texture classification. Sand: MWQ-06, 07, 09, 10, 12–15; Silty Sand: MWQ-05, 08, 11; Sandy Silt: MWQ-01–04

During this dry season, a noticeable textural gradient was identified in Cempi Bay, with sand dominating the outer bay and fine sediment prevailing in the inner bay. Based on the Shepard triangular plot, the sediment samples (sand, silt, and clay ratios) of the study locations during the dry season primarily fall within hydrodynamic classifications IV, suggesting highly energetic depositional conditions that favor a silt-dominated texture along the sand gradient rather than a clay-dominated texture (Figure 4). This range of sediment composition indicates a strong hydrodynamic-depositional gradient in the area.

The study locations (Figure 5) can be split into three groups based on the triangular texture class: (1) nearshore locations within the outer bay (MWQ-13–15) and bay mouth (MWQ-06, 07, 09, 10, and 12) with sand classification, (2) subtidal central axis locations: within the bay mouth (MWQ-05, 08, and 11) with silty sand, and (3) upper bay locations: within the inner bay with sandy silt classification (MWQ-01–04). These sediment classifications (sand, silty sand, and sandy silt) were represented for the macrobenthos habitat category.

3.2. Macrobenthos Composition

A total of 25 species and 21 genera of macrobenthos from seven classes (Bivalvia, Echinoidea, Gastropoda, Holothuroidea, Malacostraca, Ophiuroidea, and Polychaeta) and one infraorder (Sipunculidea) were identified at the sampling locations (Figure 6). The highest to the lowest density and taxa composition of macrobenthos were Gastropoda (density: 47%, taxa: 46%), Polychaeta (density: 31%, taxa: 29%), Bivalvia (density: 13%, taxa: 11%), Malacostraca (density: 8%, taxa: 10%), and the four taxa with similar portions (density and taxa: 1%), included Echinoidea, Holothuroidea, Ophiuroidea and Sipunculidea (Figure 6).

The number of taxa varied from 3 taxa (MWQ-02) to 12 taxa (MWQ-11), and the density of macrobenthos ranged from 24 individuals/m^2 at MWQ-02 and MWQ-15 to 144 individuals/m^2 at MWQ-11 (Figure 7). Among all organisms, none of the genera or species were found at any of the locations during this dry-season study. The most macrobenthos taxa found were *Nereis* sp. and *Paraonis* sp. from the Polychaeta class, which were found at 6 locations. The *Nereis* sp. were discovered at locations MWQ-05, MWQ-06, MWQ-07, MWQ-08, MWQ-09, and MWQ-13, while the *Paraonis* sp. were found at MWQ-06, MWQ-07, MWQ-08, MWQ-09, MWQ-10, and MWQ-13 (Figure 7). According to the habitat category, only *Conasprella viminea* and *Monilea callifera* from the Gastropoda class were found in all habitat categories (Figure 7).

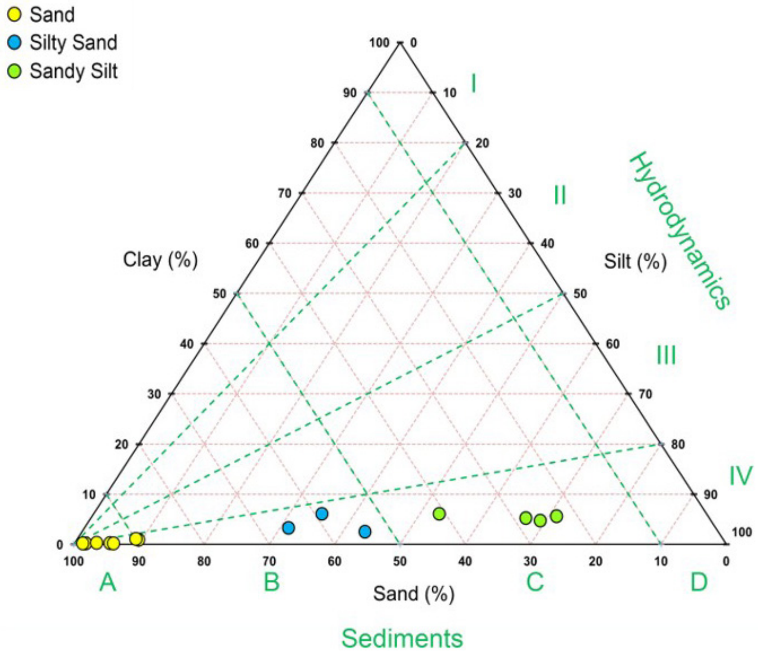

Figure 4. Sediment grain size–hydrodynamic classification. Sand: MWQ-06, 07, 09, 10, 12 – 15; Silty Sand: MWQ-05, 08, 11; Sandy Silt: MWQ-01–04

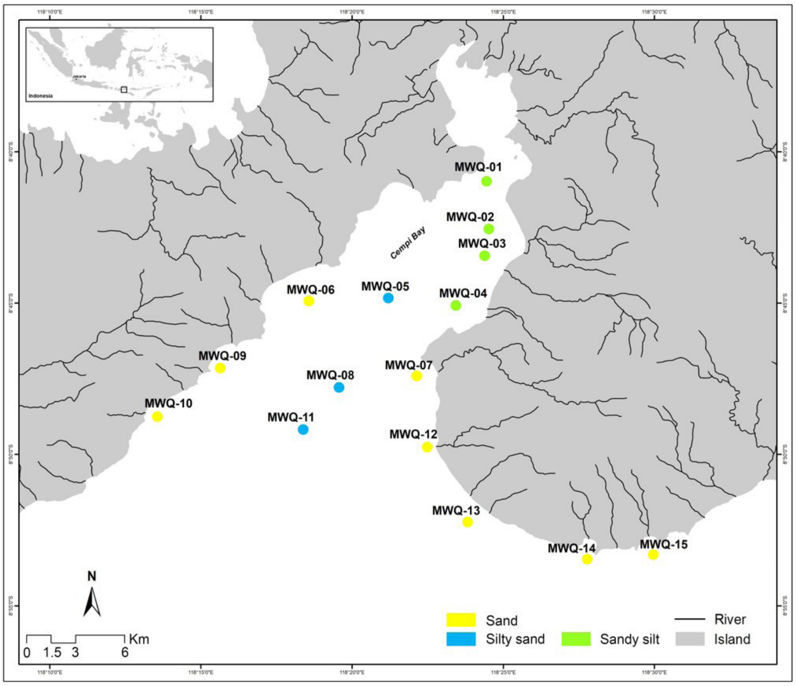

Figure 5. Sediment classification distribution in Cempi Bay during dry season. All locations fall within hydrodynamic and sediment-dominant class IV (high energy). Nearshore bay mouth-outer locations: sand (yellow), subtidal central axis locations: silty sand (blue), and nearshore inner bay locations: sandy silt (green)

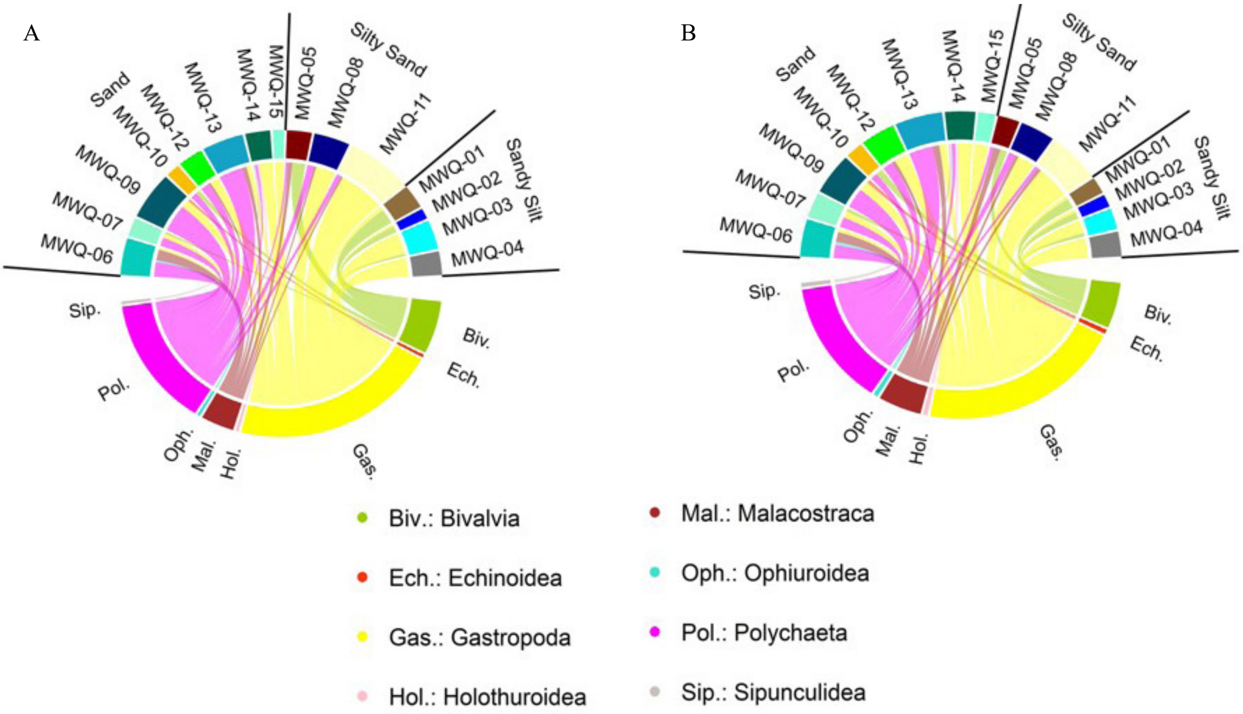

Figure 6. Macrobenthos composition in Cempy Bay during the dry season. (A) Density composition, (B) taxa composition

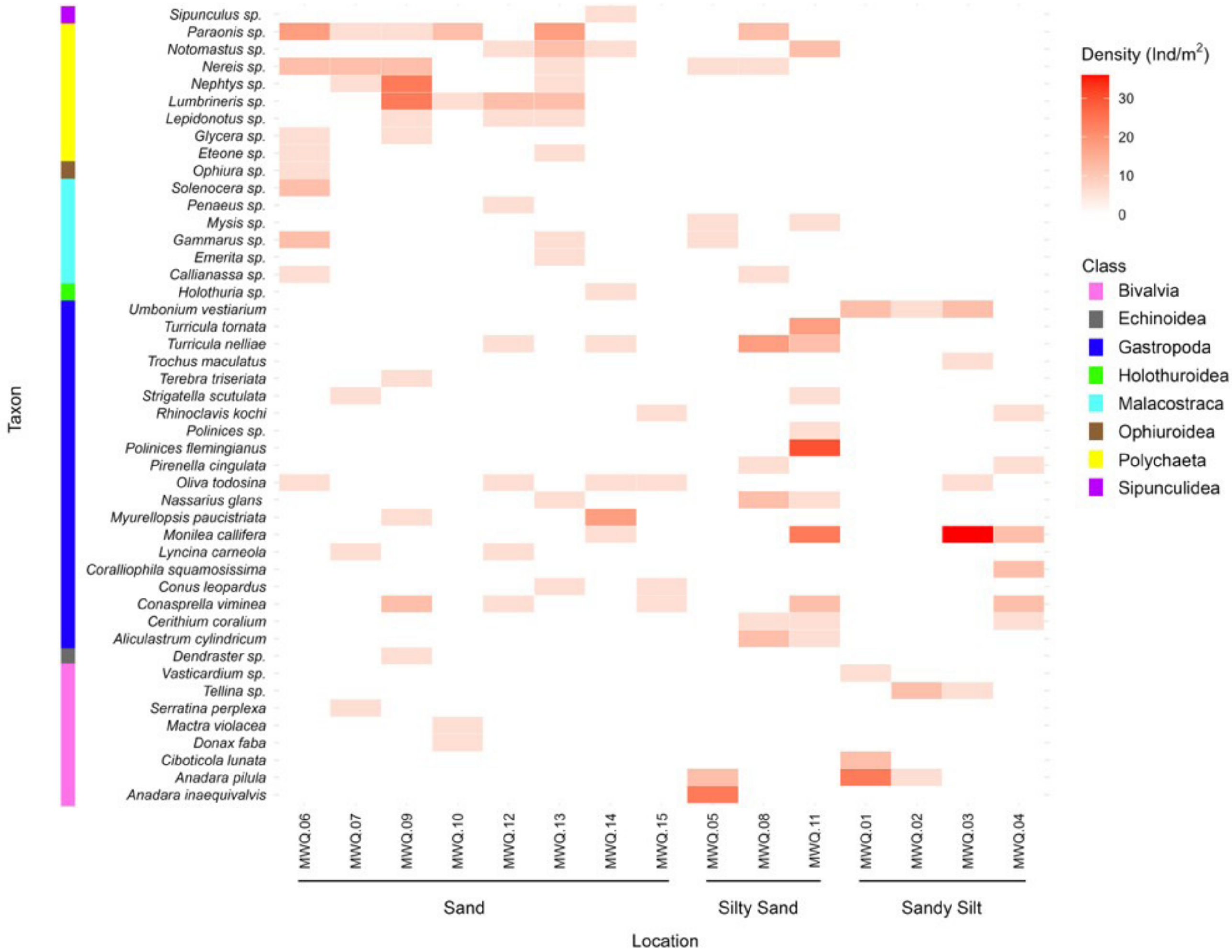

Figure 7. Macrobenthos occurrence and distribution in Cempi Bay during the dry season

3.3. Major Drivers of Community Assemblages

The macrobenthos assemblages showed clear clustering between habitat categories in terms of density and taxonomic richness (Figure 8). The sand and silty sand categories had similar macrobenthos assemblages, whereas the sandy silt category formed a distinct cluster (see Figure 8). The direction and length of arrows on the nMDS plot closely matched the macrobenthos contributions to group similarity as determined by SIMPER analysis (Figure 8; Table 2). According to the SIMPER analysis, the similarity within the sand and silty sand habitats was primarily driven by the habitat preferences of Polychaeta and Gastropoda. In contrast, the similarity in sandy silt habitat was mainly driven by Bivalvia and Gastropoda (Table 2).

3.4. Feeding Habits and Habitat Preferences

The nMDS result based on feeding habits also showed a pattern similar to that of the density and taxa clusters, with a distinct group of sandy silt (Figure 9). Based on the SIMPER analysis (Table 3), carnivores and deposit feeders generally contributed to the similarity matrix across all habitats, with their influence most evident in the sand habitat, accounting for up to 71% and 22%, respectively. The suspension feeders notably contributed to the sandy silt habitat (up to 44%; Table 3).

4. Discussion

Our study approach involves grouping locations by sediment texture classification, which provides an initial understanding of macrobenthos assemblages and sediment in Cempi Bay during the dry season. The sediment in Cempi Bay is mainly composed of sand in nearshore locations at the bay mouth and in the outer bay. In contrast, the nearshore locations within the inner bay are predominantly made up of silt. In addition, the subtidal central axis locations within the

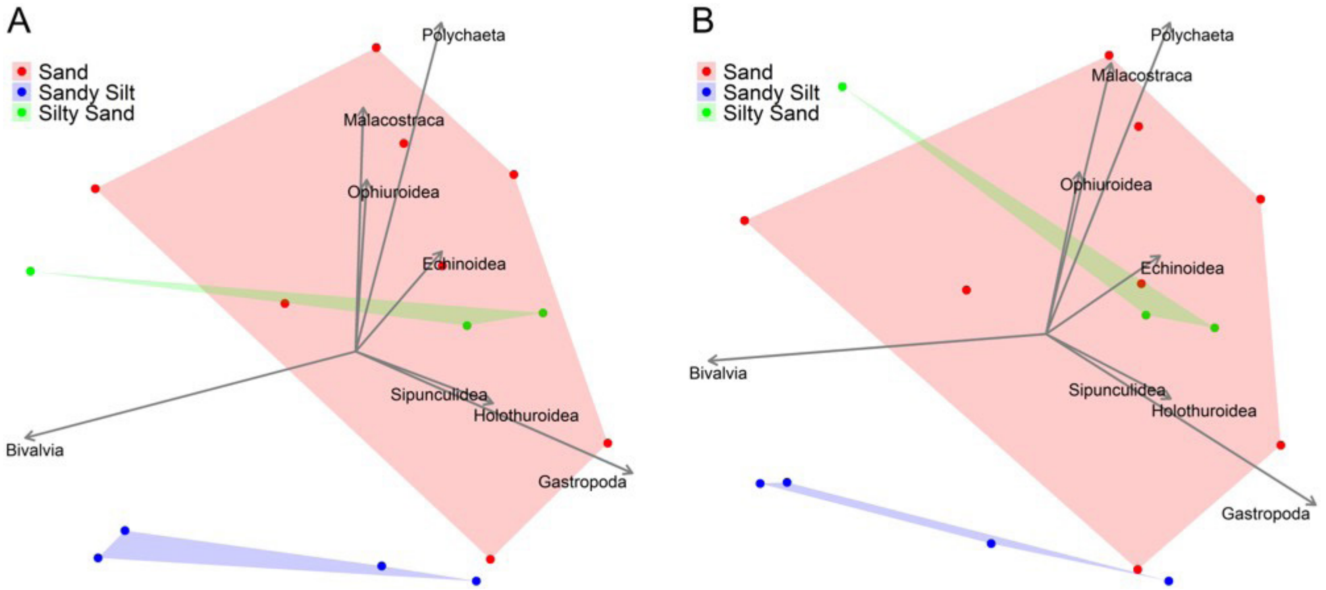

Figure 8. Non-metric multidimensional scaling (nMDS) analysis of macrobenthos assemblages. (A) Macrobenthos density, B) number of taxa. The vectors represent the class that have a Pearson's correlation of greater than 0.2 with either of the nMDS axes

Table 2. Similarity percentage (SIMPER) analysis showing the contribution of the top macrobenthos classes based on density and number of taxa to the Bray Curtis Similarity matrix

Category/class	Avg. abundance	Avg. similarity	% contribution	% cumulative
1. Density				
1.1 Sand, average similarity: 50.29				
Polychaeta	4.99	24.87	49.46	49.46
Gastropoda	3.76	22.45	44.65	94.11
Malacostraca	1.42	2.02	4.01	98.12
1.2 Silty sand, average similarity: 52.18				
Polychaeta	3.39	19.32	37.02	37.02
Malacostraca	2.79	17.15	32.87	69.89
Gastropoda	6.19	15.71	30.11	100
1.3 Sandy silt, average similarity: 59.32				
Gastropoda	5.25	41.93	70.69	70.69
Bivalvia	3.29	17.39	29.31	100
2. Number of taxa				
2.1 Sand, average similarity: 51.73				
Gastropoda	1.45	24.38	47.12	47.12
Polychaeta	1.62	24.05	46.48	93.61
Malacostraca	0.52	2.28	4.42	98.02
2.2 Silty sand, average similarity: 59.34				
Malacostraca	1.14	22.07	37.2	37.2
Polychaeta	1.14	22.07	37.2	74.4
Gastropoda	1.8	15.19	25.6	100
2.3 Sandy silt, average similarity: 65.10				
Gastropoda	1.61	43.97	67.54	67.54
Bivalvia	1.04	21.13	32.46	100

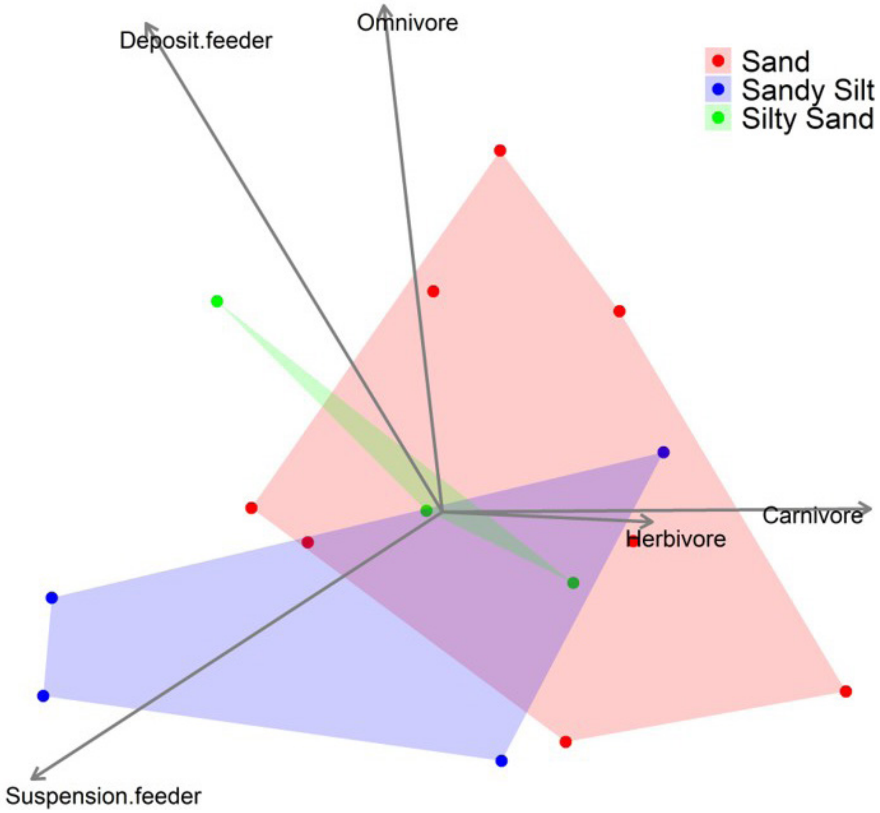

Figure 9. Non-metric multidimensional scaling (nMDS) result for the macrobenthos feeding habits. The vectors depict feeding habits with a Pearson correlation greater than 0.2 with nMDS axes

Table 3. Similarity percentage (SIMPER) analysis showing the contribution of the top feeding habits group based on the Bray Curtis Similarity matrix

Category/class	Avg. abundance	Avg. similarity	% contribution	% cumulative
1. Sand, average similarity: 60.76				
Carnivore	0.59	43.19	71.08	71.08
Deposit feeder	0.23	13.67	22.5	93.58
Suspension feeder	0.12	3.27	5.37	98.96
2. Silty sand, average similarity: 51.53				
Carnivore	0.45	22.79	44.23	44.23
Deposit feeder	0.26	18.06	35.04	79.27
Suspension feeder	0.20	9.29	18.04	97.3
3. Sandy silt, average similarity: 41.06				
Suspension feeder	0.41	17.99	43.82	43.82
Deposit feeder	0.2	11.53	28.09	71.91
Carnivore	0.35	10.61	25.83	97.74

bay mouth appeared to have a combination of high sand and silt content, with silt slightly more prevalent than sand. In general, Cempi Bay has shown typical characteristics of the typical tidal estuary (Wells 1995), with three distinct sections of typically estuarine area, as identified by Pickard (1961) and Sutherland *et al.* (2018): (1) a lower reach that characterized by marine conditions and connected to the open sea, (2) a middle reach characterized by intense mixing of marine and freshwater, and (3) an upper reach with higher freshwater outflows. These findings were aligned with our results during the dry season, where we observed (1) the lower reach dominated by sand, (2) the middle reach consisting of sand to silty sand, and (3) the upper reach characterized by sandy silt (Figure 5).

According to Pejrup (1988), the sediments in Cempi Bay during the dry season were deposited under intense hydrodynamic conditions (Category IV). In assessing the textural composition of estuarine sediment, it is essential to consider the flocculation process and the turbidity of estuarine waters (Pejrup 1981, 1988). The suspended flocs in the water settle more slowly than larger fractions, such as sand, which tend to settle relatively quickly due to their weight (Pejrup 1988; Sutherland *et al.* 2015). As a result, sediments deposited under intense hydrodynamic conditions contain fewer silt and clay particles and flocculated particles (Pejrup 1988; Sutherland *et al.* 2018). In addition, Hidayat *et al.* (2025) showed that offshore waves exceeding 2 m dissipate to below 0.5 m inside the bay, demonstrating the strong sheltering effect of Cempi Bay's semi-enclosed geomorphology and bathymetry, which further influences the energy available for sediment transport and deposition. This supports the deposition of sand in the nearshore locations of lower reach (outer bay) and middle reach (bay mouth), the deposition of sand and dominant sand-silt (silty sand) in the middle reach (bay mouth), and lastly the deposition of dominant silt-sand (sandy silt) in the upper reach (inner bay), as shown in Figure 4 and Figure 5.

Our results highlighted a variation of macrobenthos assemblages in Cempi Bay across different habitat categories during the dry season. The macrobenthos assemblages in subtidal central-axis locations with silty-sand habitats were similar to those in nearshore locations with sand habitats (Figures 8 and 9). In contrast, nearshore locations in the inner bay with silty sand showed a distinct pattern (Figures 8 and 9). During this dry season, Gastropoda, Bivalvia, and Polychaeta were the dominant classes found in Cempi Bay. This result was consistent with other macrobenthos findings in seabed ecosystems in Indonesia (Sharani *et al.* 2018; Muskananfola *et al.* 2020; Almaniar *et al.* 2021) and other tropical/subtropical regions (Arrighetti *et al.* 2010; Lipi *et al.* 2020; Sukumaran *et al.* 2021).

During the dry season, we found fewer classes of macrobenthos within the nearshore of inner bay locations, which have a sandy silt habitat, comprised of Bivalvia and Gastropoda. These two classes were also found in the sand and silty sand habitat category. This finding aligns with other studies showing a broad distribution of bivalves and gastropods in sediment, as they can thrive in both soft and hard substrates (Pridmore *et al.* 1990; Wang *et al.* 2009; Sivadas *et al.* 2012). In our findings, we identified *Conasprella viminea* and *Monilea callifera* in all habitat categories. These characteristics may correspond to the exceptional adaptability and flexible feeding approaches of gastropod snails (Sukumaran *et al.* 2021). Gastropod snails possess strong muscular feet that facilitate movement across different types of substrate (Pyron and Brown 2015). This ability to move efficiently enables them to search for food and avoid predators on both soft and hard bottoms (Rochette and Dill 2000).

The other dominant class observed was Polychaeta, commonly known as polychaete worms. The composition of this class was mainly due to the density of *Paraonis* sp., *Nephtys* sp., and *Nereis* sp. (Figure 7). During this dry season, these worms preferred hard substrates over soft bottoms, as none of the species in this class were found in nearshore inner-bay locations characterized by sandy silt sediment. Hard substrates may provide greater feeding opportunities, as carnivorous polychaetes could prey on organisms incapable of burrowing into the seabed to escape (Kanhai 2022). Our findings also showed that most of the polychaetes observed during this dry season in Cempi Bay were carnivorous (Supplementary Table 3). Other factors observed to correlate with polychaete distribution on hard substrates included salinity, substrate type, and organic matter (Díaz-Castañeda and Reish 2009).

Macrobenthos assemblages in the nearshore locations of the lower and middle reaches, characterized by sand and silty sand, comprised carnivores, suspension feeders, and deposit feeders as the main contributors (Figure 9 and Table 3). Meanwhile, the upper reach, characterized by sandy silt, was dominated by suspension feeders, with carnivores and deposit feeders present in smaller proportions (Figure 9 and Table 3). The structures of macrobenthos' feeding habits often vary between ecosystems (Chen *et al.* 2022). The availability of food sources, such as organic matter and plankton (Lessin *et al.* 2019), within the inner bay is likely to have contributed to the occurrence of these types of macrobenthos. In muddy areas with soft bottoms, suspension feeders and deposit feeders are among the most common feeding strategies (Gilia *et al.* 2006). However, it is also noted that the suspension feeders were restricted to the upper layer of sediment due to their dependence on moving water over the sediment for feeding (Wilson and Kritmanson 1979; Pan 2022).

Although our study provides valuable insights, our valuations may be conservative for a several factors: as (1) our initial evaluation assumed that the wet season would impact macrobenthos and sediment composition, which may not be entirely accurate; (2) macrobenthos-sediment relationships are complex, while we solely focused on the physical aspect of grain size of sedment that may neglecting other properties that could influence macrobenthos communities e.g. organic matter, dissolve oxygen, porosity (Sinu 2022); and (3) the upstream areas of the inner bay could display distinct assemblage patterns considering its characteristic of semi-enclosed bay with potentially finer sediment were not evaluated due to limited access. Further, this study has limitations since it lacked a replicate sample. A lack of replicates may mask genuine effects or lead of misleading conclusions (Hurlbert 1984). However, we have addressed this constraint by using a grouping approach that categorizes samples by sediment grain size. We assumed that this method enhanced our analysis and mitigated the effects of limited replication. In addition, as it was primarily a preliminary assessment, extensive statistical analysis was not required. Our focus was not on comparing locations but rather on obtaining an initial understanding of the current community structure of macrobenthos assemblages, including their feeding habits and sediment characteristics (grain size), especially during the dry season. Therefore, our results remained important for future studies, given the very limited literature on macrobenthos assemblages in this area.

In summary, we have observed some key findings in sediment and macrobenthos assemblages in Cempi Bay during this sampling period. There has been (1) a noticeable sediment gradient: a coarser texture (sand) found in the nearshore areas of the lower and middle reaches of Cempi Bay, a mix of coarse and fine textures (sandy silt) in the middle reach, and finer textures (sandy silt) in the nearshore areas of inner Cempi Bay; (2) a dominant class composition in the Cempi Bay during the dry season comprises Gastropoda, Polychaeta, and Bivalvia; (3) a greater variety of classes and feeding habits in sand and silty sand categories compared to the sandy silt category, and (4) carnivores and deposit feeders were more prevalent in the sand and silty sand categories. In contrast, the sandy silt category showed fewer classes, highlighting the presence of suspended feeders. Since our study was conducted only during the dry season, future research should establish long-term monitoring focused on macrobenthos structures in this area to gain deeper insight into the factors shaping the macrozoobenthos community.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgements

The authors sincerely thank PT Lorax Indonesia for supporting this research under project number P496. This study was conducted to address data gaps in macrobenthos research in the Hu'u District of Sumbawa, where information and literature on water resources are limited.

References

Almaniar, S., Rozirwan, Herpandi, 2021. Abundance and diversity of macrobenthos at Tanjung Api-Api waters, South Sumatera, Indonesia. *AACL Bioflux.* 14, 1486–1497.

Arrighetti, F., Penchaszadeh, P., 2010. Macrobenthos-sediment relationships in a sandy bottom community off Mar del Plata, Argentina. *J. Mar. Biol. Assoc.* 90, 933–939.

APHA, 2017. *Standard Methods for the Examination of Water and Wastewater*, twenty-third ed. American Public Health Association, Washington.

Baker, B.J., Appler, K.E., Gong, X., 2021. New microbial biodiversity in marine sediments. *Annu. Rev. Mar. Sci.* 13, 161–175. https://doi.org/10.1146/annurev-marine-032020-014552

Beesley, P.L., Ross, G.J.B., Glasby, C.J., 2000. *Polychaetes & Allies: The Southern Synthesis.* Environment Australia, Australia.

Blackwell, W., 2013. *Methods for the study of Marine Benthos*, fourth ed. Hellenic Center for Marine Research, Crete, Greece.

Bremner, J., Rogers, S.I., Frid, C.L.J., 2003. Assessing functional diversity in marine benthic systems: a comparison of approaches. *Mar. Ecol. Prog. Ser.* 254, 11–25.

Clarke, K.R., Gorley, R.N., 2015. *PRIMER version 7: User Manual/Tutorial.* PRIMER-E, Plymouth.

Chandramohan, P., Kumar, V.S., Nayak, B.U., 1993. Coastal processes along the shorefront of Chilka Lake. *Indian J. Mar. Sci.* 22, 268–272.

Chen, Q., Jian, S., Chen, P., 2022. Changes in the functional feeding groups of macrobenthos following artificial reef construction in Daya Bay, China. *Glob. Ecol. Conserv.* 33, e01978. https://doi.org/10.1016/j.gecco.2021.e01978.

Commey, N.A., Armah, A.K., Lamptey, E., 2021. Macrobenthic infaunal assemblage structure in nearshore and offshore seabeds of Ghana. *Indo-Pac. J. Ocean Life.* 5, 50–60. https://doi.org/10.13057/oceanlife/o050202

Darr, A., Gogina, M., Zettler, M.L., 2014. Functional changes in benthic communities along a salinity gradient: a western Baltic case study. *J. Sea Res.* 85, 315–324. https://doi.org/10.1016/j.seares.2013.06.003

De Raedemaecker, F., O'Connor, I., Brophy, D., Black, A., 2011. Macrobenthic prey availability and the potential for food competition between 0-year group *Pleuronectes platessa* and *Limanda limanda. J. Fish Biol.* 79, 1918–1939. https://doi.org/10.1111/j.1095-8649.2011.03134.x

Dharma, B., 2005. *Recent & Fossil Indonesia Shells*, first ed. ConchBooks, Jakarta.

Díaz-Castañeda, V., Reish, D.J., 2009. Polychaetes in environmental studies, in: Shain DH (Eds.). *Annelids in Modern Biology.* Hoboken: Wiley-Blackwell. pp. 203–227. https://doi.org/10.1002/9780470455203.ch11

Fahlevy, K., Yudha, F.K., Andika, W., Suprianto, A.E., Irianda, N.J., Irfanto, M., Subhan, B., Madduppa, H., 2018. Assessing fish community structure at two different coral reef depths around Seribu Islands, Jakarta. *J. Ilmu Kelaut. Kepulauan.* 1, 15–29. https://doi.org/10.33387/jikk.v1i1.678

Fahlevy, K., Prabowo, B., Manik, N.W.Q., Carvalho, P.G., Humphries, A.T., Subhan, B., Madduppa, H., 2024. Coral communities distribution in the context of site's reef formation type in Wakatobi National Park, Indonesia. *Ocean Sci. J.* 59, 29. https://doi.org/10.1007/s12601-024-00154-1

Farsi, P., Seyfabadi, J., Owfi, F., Aramli, M.S., 2015. Effect of environmental conditions on spatial distribution of macrobenthic community in the Bushehr coasts of the Persian Gulf. *Turk. J. Fish. Aquat. Sci.* 15, 869–878. https://doi.org/10.4194/1303-2712-v15_4_10

Fauchald, K., 1977. *The polychaete worms: definitions and keys to the orders, families and genera.* Science Series Publications, University of Southern California, California.

Floyd, M., Mizuyama, M., Obuchi, M., Sommer, B., Miller, M.G.R., Kawamura, I., Kise, H., Reimer, J.D., Beger, M., 2020. Functional diversity of reef molluscs along a tropical-to-temperate gradient. *Coral Reefs.* 39, 1361–1376. https://doi.org/10.1007/s00338-020-01970-2

Gagic, V., Bartomeus, I., Jonsson, T., Taylor, A., Winqvist, C., Fischer, C., Slade, E.M., Steffan-Dewenter, I., Emmerson, M., Potts, S.G., Tscharntke, T., Weisser, W., Bommarco, R., 2015. Functional identity and diversity of animals predict ecosystem functioning better than species-based indices. *Proc. R. Soc. B.* 282, 20142620. https://doi.org/10.1098/rspb.2014.2620

Gaudêncio, M.J., Cabral, H.N., 2007. Trophic structure of macrobenthos in the Tagus estuary and adjacent coastal shelf. *Hydrobiologia.* 587, 241–251. https://doi.org/10.1007/s10750-007-0686-6

Gilia, J.M., Arntz, W.E., Palanques, A., Orejas, C., Clarke, A., Dayton, P.K., Isla, E., Teixidó, N., Rossi, S., López-González, P.J., 2006. A unique assemblage of epibenthic sessile suspension feeders with archaic features in the high-Antarctic. *Deep Sea Res. II.* 53, 1029–1052.

Gu, Z., Gu, L., Eils, R., Schlesner, M., Brors, B., 2014. circlize: Implements and enhances circular visualization in R. *Bioinformatics.* 30, 2811–2812. https://doi.org/10.1093/bioinformatics/btu393

Gosner, K.L., 1971. *A Guide to Identification of Marine and Estuarine Invertebrates: Cape Hatteras and the Bay of Fundy*. Wiley-Interscience, John Wiley & Sons, Ltd.

Hale, R., Bigham, K.T., Rowden, A.A., Halliday, J., Nodder, S.D., Orpin, A.R., Frontin-Rollet, G., Maier, K.L., Mountjoy, J.J., Pinkerton, M.H., 2024. Bioturbation and faunal-mediated ecosystem functioning in a deep-sea benthic community recovering from a severe seabed disturbance. *Deep Sea Res. I Oceanogr. Res. Pap.* 204, 104235. https://doi.org/10.1016/j.dsr.2024.104235

Hashim, S.M., Waweru, B.W., Muthumbi, A., 2024. Influence of oxygen minimum zone on macrobenthic community structure in the northern Benguela Upwelling System: A macro-nematode perspective. *Biogeosciences.* 21, 2995–3006. https://doi.org/10.5194/bg-21-2995-2024

Hewitt, J.E., Thrush, S.F., Dayton, P.D., 2008. Habitat variation, species diversity and ecological functioning in a marine system. *J. Exp. Mar. Biol. Ecol.* 366, 116–122.

Hidayat, E.F., Havis, M.I., Sembiring, A., Fahlevy, K., Abdullah, F.A.R., 2025. Ocean wave modelling in Cempi Bay, West Nusa Tenggara during Northwest and Southeast Monsoon. *Indones. J. Oceanogr.* 7, 305–314. https://doi.org/10.14710/ijoce.v7i4.29242

Hurlbert, S.H., 1984. Pseudoreplication and the design of ecological field experiments. *Ecol. Monogr.* 54, 187–211.

Ieno, E.N., Solan, M., Batty, P., Pierce, G.J., 2006. How biodiversity affects ecosystem functioning: roles of infaunal species richness, identity, and density in the marine benthos. *Mar. Ecol. Prog. Ser.* 311, 263–271.

Jayachandran, P.R., Nandan, S.B., Jima, M., Joseph, P., Xavier, N.D.D., Sreedevi, O.K., Prabhakaran, M.P., Joseph, K.J., 2019. Macrobenthic functional feeding groups in a microtidal monsoonal estuary (Kodungallur–Azhikode estuary, India). *Reg. Stud. Mar. Sci.* 25, 100444. https://doi.org/10.1016/j.rsma.2018.100444

Ji, Y., Song, B., Xu, J., Jiang, S., Chen, L., Li, B., 2024. Distribution and influencing factors of macrobenthos on three seagrass beds in the intertidal zone of Shandong province, China. *Front. Mar. Sci.* 11, 1349131. https://doi.org/10.3389/fmars.2024.1349131

Jones, R., Parsons, R., Watkinson, E., Kendell, D., 2011. Sewage contamination of a densely populated coral 'atoll' (Bermuda). *Environ. Monit. Assess.* 179, 309–324. https://doi.org/10.1007/s10661-010-1738-3

Kanaya, G., Nobata, E., Toya, T., Kikuchi, E., 2005. Effects of different feeding habits of three bivalve species on sediment characteristics and benthic diatom abundance. *Mar. Ecol. Prog. Ser.* 299, 67–78. https://doi.org/10.3354/meps299067

Kanhai, A., 2022. Spatial and seasonal variation in polychaete communities according to their trophic categories in Southwest Tobago, West Indies. *Neotrop. Biodivers.* 8, 8–20. https://doi.org/10.1080/23766808.2021.2021051

Klemas, V., 2011. Remote sensing techniques for studying coastal ecosystems: an overview. *J. Coast. Res.* 27, 2–17. https://doi.org/10.2112/jcoastres-d-10-00103.1

Kumar, V.S., Anand, N.M., Gowthaman, R., 2002. Variations in nearshore processes along Nagapattinam coast, India. *Curr. Sci.* 82, 1381–1389.

Lakshmi, A., 2021. Coastal ecosystem services & human well-being. *Indian J. Med. Res.* 153, 382.

Laliberté, E., Legendre, P., Shipley, B., 2014. FD: Measuring functional diversity from multiple traits, and other tools for functional ecology. R Package Version 1.0-12.

Lamptey, E., Armah, A.K., 2008. Factors affecting macrobenthic fauna in a tropical hypersaline coastal lagoon in Ghana, West Africa. *Estuaries Coasts.* 31, 1006–1019. https://doi.org/10.1007/s12237-008-9079-y

Laureto, L.M.O., Cianciaruso, M.V., Samia, D.S.M., 2015. Functional diversity: an overview of its history and applicability. *Nat. Conserv.* 13, 112–116.

Lestariningsih, W.A., Himawan, M.R., Santika, L., 2023. Quantitative study of seagrass density in the waters of Cempi Bay: Implications for conservation and management of marine resources. *J. Sains Teknol. Lingkung.* 9, 739–746. https://doi.org/10.29303/jstl.v9i4.561

Lessin, G., Bruggeman, J., McNeill, C.L., Widdicombe, S., 2019. Time scales of benthic macrofaunal response to pelagic production differ between major feeding groups. *Front. Mar. Sci.* 6, 15. https://doi.org/10.3389/fmars.2019.00015

Lipi, J.A., Noman, M.A., Hossain, M.B., Kamal, A.H.M., Idris, M.H., 2020. Effects of ship-breaking activities on the abundance and diversity of macrobenthos in Sitakundu Coast, Bangladesh. *Biodiversitas.* 21, 5085–5093. https://doi.org/10.13057/biodiv/d211113

Lowe, V., Frid, C.L.J., Venarsky, M., Burford, M.A., 2022. Responses of a macrobenthic community to seasonal freshwater flow in a wet-dry tropical estuary. *Estuar. Coast. Shelf Sci.* 265, 107736. https://doi.org/10.1016/j.ecss.2021.107736

Lovett, D.L., 1981. *A Guide to the Shrimps, Prawns, Lobsters, and Crabs of Malaysia and Singapore.* Universiti Pertanian Malaysia, Serdang.

MarLIN, 2006. *BIOTIC - Biological Traits Information Catalogue. Marine Life Information Network.* Marine Biological Association of the United Kingdom, Plymouth.

Micheli, F., Mumby, P.J., Brumbaugh, D.R., Broad, K., Dahlgren, C.P., Harborne, A.R., Holmes, K.E., Kappel, C.V., Litvin, S.Y., Sanchirico, J.N., 2014. High vulnerability of ecosystem function and services to diversity loss in Caribbean coral reefs. *Biol. Conserv.* 171, 186–194.

Murthy, B.S.R., Reddy, P.R., 2014. An overview of coastal ecosystem structure, dynamics, and management: need for a holistic approach. *J. Indian Geophys. Union* 18, 57–72.

Muskananfola, M.R., Purnomo, P.W., Sulardiono, B., 2020. Impacts of environmental factors on macrobenthos distribution and abundance in mangrove ecosystems on the Northern Coast of Java. *AACL Bioflux.* 13, 2745–2756.

Nakano, D., Suzuki, J., Otsubo, Y., Nagano, M., Honjo, T., 2025. Impact of dam operations on bottom sediment and macrobenthic community in the Kurobe Coast over a quarter century. *J. Environ. Manag.* 391, 126462. https://doi.org/10.1016/j.jenvman.2025.126462

Nasi, F., Auriemma, R., Bonsdorff, E., Cibic, T., Aleffi, I.F., Bettoso, N., Del Negro, P., 2017. Biodiversity, feeding habits, and reproductive strategies of benthic macrofauna in a protected area of the northern Adriatic Sea: a three-year study. *Mediterr. Mar. Sci.* 18, 292–309.

Oksanen, J., Simpson, G., Blanchet, F., Kindt, R., Legendre, P., Minchin, P., O'Hara, R., Solymos, P., Stevens, M., Szoecs, E., Wagner, H., Barbour, M., Bedward, M., Bolker, B., Borcard, D., Carvalho, G., Chirico, M., De Caceres, M., Durand, S., Evangelista, H., FitzJohn, R., Friendly, M., Furneaux, B., Hannigan, G., Hill, M., Lahti, L., McGlinn, D., Ouellette, M., Ribeiro Cunha, E., Smith, T., Stier, A., Ter Braak, C., Weedon, J., 2024. vegan: Community Ecology Package. R package version 2.6-7. Available at: https://github.com/vegandevs/vegan. [Date accessed: 28 June 2024]

Palomares, M.L.D., Pauly, D., 2024. SeaLifeBase. World Wide Web electronic publication. Available at: https://www.sealifebase.org [Date accessed: 28 June 2024]

Pan, J., Pratolongo, D., 2022. *Soft-bottom marine benthos, in: Marine Biology: A Functional Approach to the Oceans and Their Organisms.* CRC Press. https://doi.org/10.1201/9780429399244-10

Pennak, R.W., 1953. *Fresh Water Invertebrates of the United States.* University of Colorado–The Ronald Press Company, New York.

Pejrup, M., 1981. Bottom sediments in Ho Bugt–a Wadden Sea environment. *Geogr. Tidsskr.* 81, 11–16.

Pejrup, M., 1988. The triangular diagram used for classification of estuarine sediments, a new approach, in: de Boer, P.L., Van Gelder, A., Nio, S.D. (Eds.), *Tide-Influenced Sedimentary Environments and Facies.* Sedimentology and Petroleum Geology. D. Reidel, Dordrecht, pp. 289–300.

Pickard, G.L., 1961. Oceanographic features of inlets in the British Columbia mainland coast. *J. Fish. Res. Board Can.* 18, 907–999.

Pratiwi, D., Sumiarsa, D., Oktavia, D., Fatharani, R.H., Sunardi, 2024. Effect of land use type on macrobenthos assemblages, distribution, and functional guild in Upstream Citarum River. *Ecol. Indic.* 160, 111849. https://doi.org/10.1016/j.ecolind.2024.111849

Pridmore, R.D., Thrush, S.F., Hewitt, J.E., Roper, D.S., 1990. Macrobenthic community composition of six intertidal sandflats in Manukau Harbour, New Zealand. *N.Z. J. Mar. Freshw. Res.* 24, 81–96. https://doi.org/10.1080/00288330.1990.9516404

Putri, M.R.A., Nastiti, A.S., 2017. Some biological aspects of Metapenaeus dobsoni and M. affinis in the Cempi Bay waters, West Nusa Tenggara. *Bawal.* 9, 1–10.

Polytraits Team, 2024. Polytraits: a database on biological traits of polychaetes. LifewatchGreece, Hellenic Centre for Marine Research. Available at: http://polytraits.lifewatchgreece.eu. [Date accessed: 28 June 2024]

Pyron, M., Brown, K.M., 2015. Introduction to Mollusca and the Class Gastropoda, in: Thorp, J.H., Rogers, D.C. (Eds.), *Thorp and Covich's Freshwater Invertebrates, fourth edition.* Academic Press, Boston, pp. 383–421. https://doi.org/10.1016/B978-0-12-385026-3.00018-8

Rachman, H., Priyono, A., Wardiatno, Y., 2016. Macrobenthos as bioindicator of river water quality in Ciliwung Hulu sub watershed. *Media Konserv.* 21, 261–269. https://doi.org/10.29243/medkon.21.3.261-269

Rochette, R., Dill, L.M., 2000. Mortality, behavior and the effects of predators on the intertidal distribution of littorinid gastropods. *J. Exp. Mar. Biol. Ecol.* 253, 165–191.

Romano, E., Magno, M.C., Bergamin, L., 2017. Grain size data analysis of marine sediments, from sampling to measuring and classifying: a critical review. Presented at: IMEKO Int. Conf. on Metrology for The Sea, Naples, Italy, 11–13 October 2017.

Sentosa, A.A., Nastiti, A., 2012. Exploration of mangrove vegetation in the outer coastal zone of Cempi Bay, West Nusa Tenggara, in: Sentosa, A.A., Nastiti, A. (Eds.), *Prosiding Seminar Nasional Perikanan Indonesia*. Sekolah Tinggi Perikanan, Jakarta, pp. 13–14.

Sharani, J., Hidayat, J.W., Putro, S.P., 2018. Correlation between macrobenthic structure (biotic) and water-sediment characteristics (abiotic) adjacent aquaculture areas at Tembelas Island, Indonesia. *J. Phys. Conf. Ser.* 1025, 012081. https://doi.org/10.1088/1742-6596/1025/1/012081

Shepard, F.P., 1954. Nomenclature based on sand-silt-clay ratios. *J. Sediment. Petrol.* 24, 151–158.

Sinu, J.V., 2022. Source and composition of organic matter and its role in sediment benthic communities, in: Godson, P.S., Vincent, S.G.T., Krishnakumar, S. (Eds.), *Ecology and Biodiversity of Benthos.* Elsevier, pp. 83–133. https://doi.org/10.1016/B978-0-12-821161-8.00001-5

Sivadas, S.K., Ingole, B., Ganesan, P., Sautya, S., Nanajkar, M., 2012. Role of environmental heterogeneity in structuring the macrobenthic community in a tropical sandy beach, west coast of India. *J. Oceanogr.* 68, 295–305. https://doi.org/10.1007/s10872-011-0099-z

Snelgrove, P.V.R., 1997. The importance of marine sediment biodiversity in ecosystem processes. *Ambio.* 26, 578–583.

Steffani, N., Sedick, S., Rogers, J., Gibbons, M.J., 2015. Infaunal benthic communities from the inner shelf off southwestern Africa are characterised by generalist species. *PLoS ONE.* 10, 1-20. https://doi.org/10.1371/journal.pone.0143637

Sukartaatmadja, S., Sato, Y., Yamaji, E., Ishikawa, M., 2003. The effect of rainfall intensity on soil erosion and runoff for latosol soil in Indonesia. *Bull. Agron.* 31, 71–79.

Sukumaran, S., Vijapure, T., Mulik, J., Ridha, H., 2021. Marine macrobenthos of Northwest India—Reviewing the known and unknown. *Front. Mar. Sci.* 8, 671245. https://doi.org/10.3389/fmars.2021.671245

Sutherland, B.R., Barrett, K.J., Gingras, M.K., 2015. Clay settling in fresh and salt water. *Environ. Fluid Mech.* 15, 147–160. https://doi.org/10.1007/s10652-014-9365-0

Sutherland, T.F., Garcia-Hoyos, L.M., Poon, P., Krassovski, M.V., Foreman, M.G.G., Martin, A.J., Amos, C.L., 2018. Seabed attributes and meiofaunal abundance associated with a hydrodynamic gradient in Baynes Sound, British Columbia, Canada. *J. Coast. Res.* 34, 1021–1034. https://doi.org/10.2112/JCOASTRES-D-17-00213.1

Szczepanek, M., Silberberger, M.J., Koziorowska-Makuch, K., Nobili, E., Kędra, M., 2021. The response of coastal macrobenthic food-web structure to seasonal and regional variability in organic matter properties. *Ecol. Indic.* 132, 108326. https://doi.org/10.1016/j.ecolind.2021.108326

Taufani, W.T., Solichina, A., Saputra, S.W., Ghofar, A., 2019. Aspek reproduksi udang Metapenaeus di perairan Kabupaten Batang dan Kendal. *J. Fish. Mar. Res.* 3, 158–165.

Valentine, J., Roy, K., Jablonski, D., 2002. Carnivore/non-carnivore ratios in northeastern Pacific marine gastropods. *Mar. Ecol. Prog. Ser.* 228, 153–163.

Vanden Eede, S., Van Tomme, J., De Busschere, C., Vandegehuchte, M.L., Sabbe, K., Stienen, E.W.M., Degraer, S., Vincx, M., Bonte, D., 2014. Assessing the impact of beach nourishment on the intertidal food web through the development of a mechanistic-envelope model. *J. Appl. Ecol.* 51, 1304–1313. https://doi.org/10.1111/1365-2664.12314

Wang, X., Li, X., Li, B., Wang, H., 2009. Summertime community structure of intertidal macrobenthos in Changdao Archipelago, Shandong Province, China. *Chin. J. Oceanol. Limnol.* 27, 425. https://doi.org/10.1007/s00343-009-9140-0

Wells, J.T., 1995. Tide-dominated estuaries and tidal rivers. In: Perillo GM. (Eds.). *Dev. Sedimentol., Vol. 53.* Elsevier, pp. 179–205. https://doi.org/10.1016/S0070-4571(05)80026-3

Wickham, H., 2016. *ggplot2: Elegant Graphics for Data Analysis*. Springer-Verlag, New York.

Wilson, D.J., Kritmanson, D.D., 1979. Tidal energy and sublittoral macrobenthic animals in estuaries. *J. Fish. Res. Board Can.* 36, 1197-1206.

WoRMS Editorial Board, 2024. World register of marine species. Available at: https://www.marinespecies.org. [Date accessed: 28 June 2024]

Yu, H.Y., Huang, S.C., Lin, H.J., 2020. Factors structuring the macrobenthos community in tidal algal reefs. *Mar. Environ. Res.* 161, 105119. https://doi.org/10.1016/j.marenvres.2020.105119

Yulianto, I., Kartawijaya, T., Rafandi, M.T., Agustina, S., Pingkan, J., Aminollah, N., Nurjamil, Sabariyono, Widodo, Syahrul Ramadhan, S., Hilyana, S., 2016. *Fishing profile in Saleh Bay and Cempi Bay, West Nusa Tenggara Province.* Dinas Kelautan dan Perikanan Provinsi Nusa Tenggara Barat dan Wildlife Conservation Society Indonesia, Bogor.

Supplementary Materials

Supplementary Table 1. Statistical results of BEST analysis

Variable(s)	Correlation
Silt	0.525
Sand, Silt	0.51
Clay, Sand, Silt	0.469

Supplementary Table 2. The results of DistLM analysis

Variable(s)	Contribution	Pseudo-F	P-value
1. Marginal test			
Clay	0.14963	2.2874	0.013
Sand	0.19251	3.0993	0.002
Silt	0.19569	3.163	0.001
2. Stepwise selection			
Silt	0.19569	3.163	0.001

Supplementary Table 3. Feeding habits of macrobenthos taxa found in Cempi Bay during the dry season

Class	Taxa	Feeding habit
Bivalvia	*Anadara inaequivalvis*	Suspension/Deposit feeder
	Anadara pilula	Suspension/Deposit feeder
	Ciboticola lunata	Suspension feeder
	Donax faba	Suspension feeder
	Mactra violacea	Suspension feeder
	Serratina perplexa	Deposit feeder
	Tellina sp.	Suspension/Deposit feeder
	Vasticardium sp.	Suspension feeder
Echinoidea	*Dendraster* sp.	Suspension feeder
Gastropoda	*Aliculastrum cylindricum*	Suspension feeder
	Cerithium coralium	Detrivore/Herbivore
	Conasprella viminea	Carnivore
	Conus leopardus	Carnivore
	Coralliophila squamosissima	Carnivore
	Lyncina carneola	Herbivore
	Monilea callifera	Carnivore
	Myurellopsis paucistriata	Suspension feeder
	Nassarius glans	Carnivore
	Oliva todosina	Carnivore
	Pirenella cingulata	Deposit feeder
	Polinices flemingianus	Carnivore
	Polinices sp.	Carnivore
	Rhinoclavis kochi	Carnivore
	Strigatella scutulata	Carnivore
	Terebra triseriata	Carnivore
	Trochus maculatus	Herbivore
	Turricula nelliae	Carnivore
	Turricula tornata	Carnivore
	Umbonium vestiarium	Suspension feeder

Supplementary Table 3. Continued

Class	Taxa	Feeding habit
Holothuroidea	*Holothuria* sp.	Suspension/Deposit feeder
Malacostraca	*Callianassa* sp.	Deposit feeder
	Emerita sp.	Deposit feeder
	Gammarus sp.	Omnivore
	Mysis sp.	Omnivore/Suspension feeder
	Penaeus sp.	Carnivore/Suspension feeder
	Solenocera sp.	Carnivore
Ophiuroidea	*Ophiura* sp.	Suspension feeder
Polychaeta	*Eteone* sp.	Carnivore
	Glycera sp.	Carnivore
	Lepidonotus sp.	Carnivore
	Lumbrineris sp.	Carnivore
	Nephtys sp.	Carnivore
	Nereis sp.	Carnivore
	Notomastus sp.	Deposit feeder
	Paraonis sp.	Deposit feeder
Sipunculidea	*Sipunculus* sp.	Deposit feeder