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Habitat Preference and Community Assemblage of Bivalves in the Intertidal Zone

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Abstract

This study investigates the ecological dynamics of mollusk communities across four intertidal zones in Capiz. A total of 7,869 individual mollusks representing 11 families were collected from September 2024 to December 2024. Results showed that Veneridae was the most abundant and diverse family across all sites. Marked spatial variation was observed, with Guise recording the highest abundance (≈4,727–4,872 individuals), dominated by *Meretrix lyrata*, while Lonoy and Culasi exhibited significantly lower abundances due to anthropogenic disturbance and unfavorable environmental conditions. Bungkayaw showed moderate abundance but was constrained by very low dissolved oxygen levels, while Culasi experienced high temperature stress. Diversity indices revealed that Culasi had the highest Shannon diversity (H' = 1.38), whereas Guise had low diversity despite high abundance, indicating species dominance. Sediment analysis indicated that nutrient-rich substrates with higher organic matter supported greater productivity, while calcium-rich sediments favored shell formation. However, extreme physicochemical conditions such as low dissolved oxygen, high temperature, and low pH negatively affected species distribution and survival. Overall, results demonstrate that mollusk community structure is strongly shaped by the interaction of water quality, sediment characteristics, and human disturbance. The study highlights the sensitivity of intertidal mollusks to environmental changes and emphasizes the need for coastal habitat conservation to maintain biodiversity and ecosystem stability in intertidal zones, especially under increasing anthropogenic pressures.

Keywords: assemblage, species composition, bivalves, intertidal

1. Introduction

The Philippines is an archipelagic nation with abundant marine resources. It is home to roughly 10% (22,000) of the world's conservative mollusk species (Rosenberg 2014). Mollusks comprised 28% of inland fisheries production (PSA, 2016). As daily use of aquatic products rises, their expansion continues on a global scale. The increasing variety of aquatic species and products on the market goes hand in hand with this. (Shen et al 2016).

Within the phylum Mollusca, bivalves are the second biggest class. Over 9,200 bivalve species have been documented across freshwater, brackish, and marine ecosystems (Huber, 2010). As one of the most economically important fisheries resources, bivalves provide essential nutrients, supporting both human nutrition and global food security (Biandolino et al., 2019). For thousands of years, it has been a part of human culture and society. Their use in the wide range of human activities and customs, including agriculture, food, trade, and tourism, demonstrates this. (Prado-Carpio et al., 2018).

Mollusks constitute approximately 15–25% of macro benthic communities, underscoring their ecological significance in soft-bottom ecosystems (Appeltans et al., 2012). Through feeding behaviors like filtration and deposit feeding, they modify habitats, support higher trophic levels, and improve sediment and water quality (Lourido et al., 2006). Their diversity spans numerous species with varied ecological functions, though key traits—such as sedentarism, abundance, longevity, and close sediment association—determine their suitability as bioindicators (Baderan et al., 2019). Critical habitat parameters, including organic matter, pH, and nutrient levels, directly regulate shellfish growth (Dumbauld et al., 2009; Smaal et al., 2019), emphasizing the need to maintain optimal conditions for population sustainability (Newell, 2004).

Furthermore, because marine water has a variety of substrates, the majority of bivalve species inhabit therein. (Roshitafandi et al. 2018; Sharma et al. 2023). Marine bivalves inhabit a variety of environments, including deep sea water, tidal zones, and shallow water (Kon et al, .2020). In surface water bodies, aquatic mollusks can be used as a biological indicator of environmental quality (Lopes et al., 2022) and as a reliable way of assessing environmental changes including physico-chemical characteristic of water, additional chemicals, and pollution parameters. (Alhejoj 2017). Given their significance to human consumption and the health of the environment, mollusk population loss in the upcoming years would undoubtedly be a major concern. (Bangao et al., 2024).

Both biotic and abiotic factors affect mollusk diversity and abundance. Mollusks serve as highly sensitive bioindicators in estuarine and marine ecosystems, with their population dynamics directly reflecting changes in key physicochemical parameters including temperature, salinity, pH, and dissolved oxygen. Their responsiveness to these environmental variables makes them particularly valuable for assessing ecological health and monitoring water quality. (Garg et al., 2009). Mollusks of particular regions and habitat types have been particularly noted, as they contribute to the diverse array of species in local biodiversity (Gofas et al., 2011). Despite their significant economic and societal value, mollusk populations in Capiz, Philippines remain poorly characterized, with limited comprehensive data available on local species diversity and distribution. As a result, research on mollusk assemblage is deemed necessary for comprehending the ecological condition and communal dynamics of mollusks.

Currently, extensive intertidal zones have been lost to urban reclamation projects, while proposed marine ecosystem rehabilitation initiatives have been incorporated into forthcoming development frameworks. This trend underscores the urgent need to address the degradation of intertidal ecosystems while promoting the sustainable management and restoration of these crucial marine habitats. Through the assessment of mollusk populations in both the intertidal zone and shellfish farming areas, the study seeks to underscore the ecological significance. Stressing the importance of implementing robust conservation measures. The results are expected to guide the creation of management strategies that harmonize urban development with environmental preservation, ensuring biodiversity and resilience of Capiz's marine ecosystems. Ultimately, this study aims to generate critical baseline data to inform sustainable development strategies and guide ecosystem restoration efforts in the province.

2. Materials and Methods

2.1 Study area

The study was conducted in five (4) intertidal zone of Capiz composed of Brgy. Lonoy Sapian, Brgy. Culasi Roxas City, farming sites in Brgy. Butacal sitio Bungkayaw, Panay Capiz, and Brgy. Dulangan, Sitio Guise, Pilar Capiz where different ecosystem are present (Figure 1). The locations of each sampling were determined through Global Positioning System (GPS) with their corresponding coordinates in each sites. The location is near the residential area, adjacent to mangrove and marine ecosystem that are composed of sandy to muddy substrates to have diverse marine ecosystem.

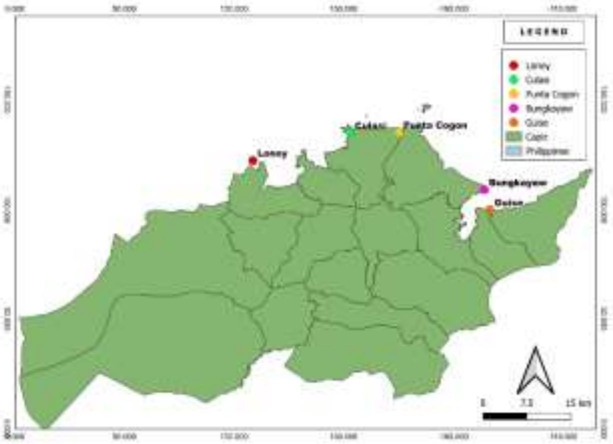

Figure 1. Map showing the four (4) sampling site in Capiz, Philippines.

2.2. Data Gathering

Sampling occurred from September 2024 through December 2024, during low tide to ensure visibility and manageable sampling procedures. Two (2) transects of 100 meters in length were established in the intertidal zone. Each sample was taken within a quadrant of 50 cm x 50 cm in each transect, 5 m apart, and positioned parallel to the shoreline. A. Gleaning for shellfish was done using a shovel, and different tools for digging and hand picking in every quadrant. Collected samples were placed in zip-lock bags, labeled with their local names and the collection date, and kept for identification and further analysis. Prior to species enumeration, key physicochemical parameters, including temperature (°C), pH, conductivity (µS/cm), salinity (ppt), and dissolved oxygen (mg/L), were measured using a multi-parameter water quality meter (AZ 86031). All mollusks that were found by the researcher were counted and tallied. A species specimen was taken by the researchers to determine their taxonomic classification from January to March 2025.

2.3. Soil analysis

Sediment samples were collected using a customized polyvinyl chloride (PVC) corer, adapted from the design by Uba et al. (2020). Samples were taken from the topmost 3-inch and 6-inch depths, placed in labeled plastic bags, and stored in a secure dry location. Soil samples were analyzed at the CAPSU Pontevedra Soil Laboratory for essential chemical properties, including: organic matter content (%), available phosphorus (P), exchangeable potassium (K), magnesium (Mg), calcium (Ca), and soil pH. For cation extraction, 10 grams of soil were mixed with 3 spoons of charcoal and 50 mL of Pechmann and English solution in a reagent bottle, shaken for 30 minutes, and filtered through a funnel lined with filter paper. Potassium was determined via the Cobalt Nitrite Method: 2 mL of extract was treated with formaldehyde, sodium cobalt nitrite, and isopropyl alcohol, shaken, refrigerated, and measured at 650 nm. Calcium analysis followed the Turbidimetric Method, in which 0.5 mL of extract was combined ammoniacal citrate and soap solution, chilled, and read at 400 nm (Grigorakis et al, 2020). For magnesium, a starch solution was prepared, and 3 mL of extract was mixed with hydroxylamine hydrochloride, Titan yellow, and NaOH before measurement at 510 nm. Phosphorus was quantified by mixing 5 mL of extract with Troug solution, sulfonol, and $SbCl_2$, shaking vigorously, and reading absorbance at 660 nm.

Physical properties were assessed using the Hydrometer Method: 40 g of soil was soaked in NaOH, mixed, diluted to 1L, and measured at 30 seconds and 2 hours to determine texture. Soil pH was measured by mixing 20 g of soil with 20 mL of water, soaking for 30 minutes, and recording the value. Organic matter content was determined using the involving potassium dichromate and sulfuric acid oxidation, followed by titration with $FeSO_4$ (Walkley-Black et al. 2023). Lime requirement was evaluated by mixing soil with $CaCl_2$, soaking overnight, and adjusting pH. Spectrophotometric readings were recorded and computed for final results.

2.4 Data analysis

Identification of the shellfish was based on international taxonomic databases including the World Register of Marine Species (WoRMS) and Molluscabase). The study focused on the population density, species density, evenness, species richness, and overall species diversity of the intertidal mollusks, and on their correlations with physico-chemical parameters. Community diversity was quantified using the Shannon-Wiener index ($H' = -\Sigma p_i \ln p_i$), where p_i represents the proportional abundance of species i ($p_i = n_i/N$, with n_i being the number of individuals of species i and N the total community abundance) (Shannon & Weaver, 1949). Species evenness was calculated following Pielou (1977) as $J' = H'/\ln S$, where S denotes total species richness.

Table 1. Sampling site and its corresponding central coordinates.

Sampling Site	**Coordinates**	**Habitat**
Brgy.Butacal, Sitio Bungkayaw.	11°6006, 122°7953	Coastal/Brackish water/Sandy-muddy
Brgy. Culasi Roxas City	11°6001, 122°7193	Coastal water/Sandy-muddy
Brgy. Dulangan Sitio Guise	11°510802, 122°929307	Coastal/Brackish water/Sandy-muddy
Brgy. Lonoy Sapian	11°5567, 122°5665	Coastal/Brackish water/Sandy-muddy

3. Results

`A total of 7,869 individual mollusks were collected across all sampling sites between September 2024 and December 2024. Specimens represented 11 families: Arcidae (2 species), Cardidae (1), Donacidae (1), Mytilidae (1), Lucinidae (1), Ostreidae (1), Psammobiidae (1), Pteriidae (1), Solecurtidae (1), Tellinidae (1), and Veneridae (5 species) (Figure 2). The family Veneridae exhibited both the highest abundance and greatest species diversity among all collected taxa. The species composition and spatial distribution of intertidal mollusks across study sites, showing significant site-specific variations. Guise (Figure 2A), representing the most pristine site with minimal anthropogenic disturbance, maintained the highest mollusk abundance (n = 4,727 individuals) consistently throughout sampling periods. Compose of *Meretrix lyrata* dominated the community, representing 81% of the total species, followed by *Gari togata* (14%), *Tellina serrata* (3%), *Coquina donax* (1%), and *Katelysia hiantuna* (1%). Bungkayaw (Figure 2B) characterized by extensive muddy-sandy substrates, exhibited the second-highest abundance (2,049 individuals). Similar to Guise, *Meretrix lyrata* was the most prevalent species (88%), accompanied by *Tegillarca granosa* (2%) *Tellina serrata* (5%), *Coquina donax* (3%) and, *Katelysia hiantuna* (2%).

The highly disturbed site of Lonoy (Figure 2C) impacted by gleaning and overharvesting, had only 255 individuals across five species. *cc* was the dominant species (45%), with *Tegillarca granosa* (24%), *Vasticardium pectiniforme* (15%), *Modiolus philippinarum* (14%), and *Isognomon isognomon* (2%) making up the remaining population. Similarly, Culasi (Figure 2D) another highly disturbed area near residential zones was affected by plastic pollution and human activities, resulting in only five mollusk species: *Tellina serrata* (22%), *Katelysia hiantuna* (11%), *Andontia bullula* (28%), *Anomalocardia squamosa* (33%), and *Pharella acutidens* (6%).

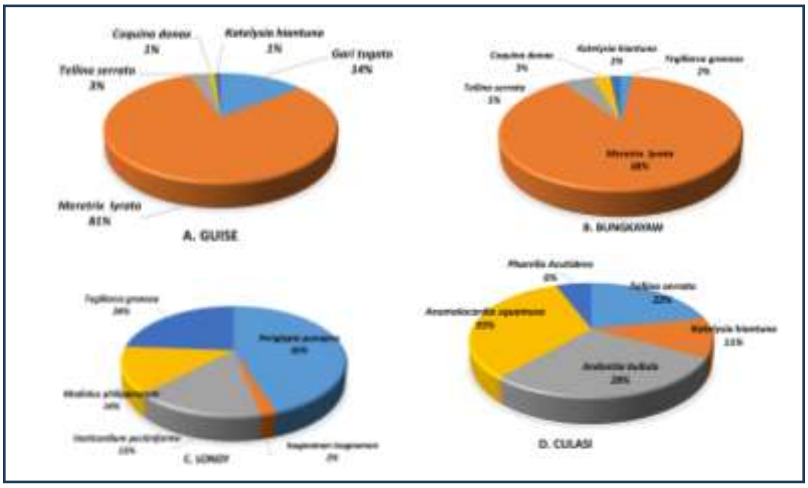

Figure 2. Relative abundance of the most frequent mollusk per area

Table 2. Biodiversity metrics including species richness (S), total abundance (N), Shannon-Wiener diversity index (H'), and Pielou's evenness index (J') were calculated for shellfish communities across the four study sites: Bungkayaw, Culasi, Guise, and Lonoy

Site	S	N	H’	J’
Bungkayaw	5	2049	0.50	4.87
Culasi	4	967	0.91	3.37
Guise	5	4597	0.89	4.88
Lonoy	5	256	0.65	4.81

Table 2 presents biodiversity data from four sites Lonoy, Culasi, Bungkayaw, and Guise including species richness (S), total abundance (N), Shannon diversity index (H’), Margalef’s richness index (d’), and Pielou’s evenness index (J’). Culasi exhibited the highest Shannon diversity with a total of (H’ = 1.38), indicating the greatest species diversity among the sites. In contrast, Guise had the highest abundance N = 4,872 but the lowest diversity H’ = 0.89 and evenness J’ = 0.45.

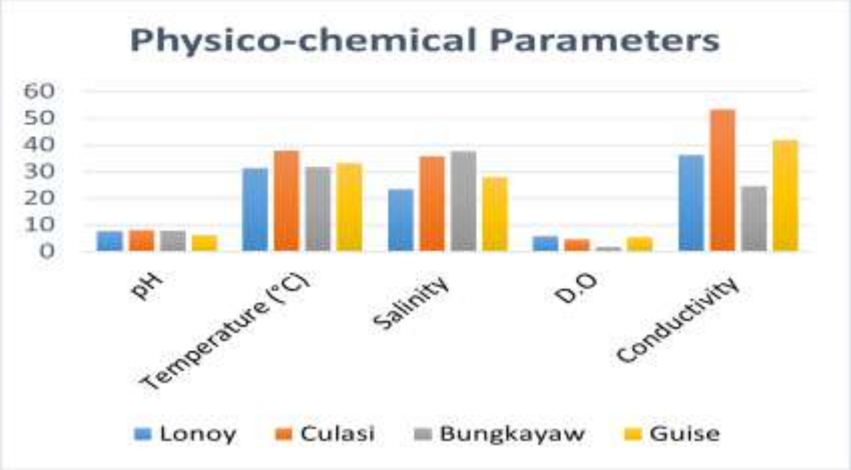

Figure 3. Physicochemical parameters in all sampling site: pH, temperature (°C), salinity (ppt), dissolved oxygen (mg/L), and conductivity (µS/cm)

The water quality parameters shown in the figure can have a significant influence on the growth, survival, reproduction, and overall health of shellfish such as oysters, mussels, clams, and scallops. The pH values in Lonoy (7.7), Culasi (7.96), and Bungkayaw (7.81) are within the favorable range for most shellfish, allowing them to efficiently form and maintain their calcium carbonate shells. However, the lower pH in Guise (6.11) may negatively affect shell formation, growth rates, and larval development because acidic conditions can reduce the availability of carbonate ions needed for shell production.

Temperature directly affects metabolism, feeding activity, and growth. The temperatures recorded in Lonoy (31.2°C), Bungkayaw (31.6°C), and Guise (33.1°C) are relatively high but may still be tolerated by tropical shellfish species. However, the very high temperature in Culasi (37.8°C) could cause thermal stress, increasing metabolic demands and potentially reducing growth and survival if exposure is prolonged. Salinity is another critical factor. Bungkayaw (37.5) and Culasi (35.7) have salinity levels close to normal seawater, which are generally suitable for marine shellfish. Lonoy's lower salinity (23.3) may favor species adapted to brackish environments but could stress strictly marine species. Sudden changes in salinity can reduce feeding efficiency and slow growth.

Dissolved oxygen (DO) is essential for respiration. Lonoy (5.7 mg/L) and Guise (5.4 mg/L) have oxygen levels that can adequately support shellfish growth. Culasi (4.6 mg/L) is somewhat lower but may still be acceptable. In contrast, Bungkayaw's very low DO level (1.7 mg/L) is likely stressful and may severely limit growth, reduce feeding activity, and increase mortality, especially among juvenile shellfish.

Conductivity reflects the concentration of dissolved ions in the water and is often associated with salinity. Higher conductivity values in Culasi (53.2) and Guise (41.9) indicate greater mineral availability, while the lower conductivity in Bungkayaw (24.5) may reflect different water chemistry. Although conductivity itself does not directly determine shellfish growth, it can influence physiological processes through its relationship with salinity and water quality. Overall, Lonoy appears to provide the most favorable conditions for shellfish growth, with suitable pH, moderate temperature, adequate dissolved oxygen, and moderate salinity. Culasi may support growth but could cause heat stress due to its high temperature. Guise has adequate oxygen levels but its acidic pH may hinder shell development. Bungkayaw, despite having favorable salinity, is likely the least suitable site because of its extremely low dissolved oxygen concentration, which can significantly impair shellfish growth and survival.

Table 3. Sediment analysis from sampling siteSoil texture: SM = sandy-muddy

Area	Soil Texture	pH	OM%	P	K	Ca	Mg
Bungkayaw	SM	6.54	4.84	71	1113	1670	421
Culasi	SM	7.49	2.67	73	589	1907	421
Guise	SM	7.97	2.99	51	81	2114	365
Lonoy	SM	7.61	1.17	3	520	2239	482

The differences in substrate characteristics among the four areas strongly influence the growth, survival, and assemblage of shellfish. Shellfish generally thrive in soft-bottom habitats with adequate organic matter and balanced nutrient availability because these conditions support the growth of benthic microorganisms and detritus that serve as food sources. In **Lonoy**, the sandy-muddy substrate and slightly alkaline pH (7.61) provide a stable environment for burrowing shellfish; however, the low organic matter content (1.17%) and very low phosphorus level (3) may limit food availability, resulting in lower productivity and potentially fewer shellfish species. **Culasi** has a muddy sandy substrate with a near-neutral pH (7.49), higher organic matter (2.67%), and high phosphorus (73) and potassium (589) levels. These conditions favor the accumulation of nutrients and organic particles, making the area suitable for a greater abundance and diversity of shellfish. **Bungkayaw** exhibits the highest organic matter content (4.84%) and potassium level (1113), indicating a nutrient-rich environment that can support abundant benthic food resources. Although its slightly acidic pH (6.54) may be less favorable for some calcifying shellfish species, the rich organic substrate may still promote high shellfish density, particularly for species tolerant of lower pH conditions. In **Guise**, the muddy-sandy substrate and alkaline pH (7.97) are favorable for shell formation because calcium carbonate precipitation is enhanced under alkaline conditions. The high calcium content (2114) further supports shell development, although the relatively low potassium level (81) may reduce overall productivity compared to the more nutrient-rich sites. Overall, muddy-sandy substrates with higher organic matter and nutrient concentrations, such as those found in Culasi and Bungkayaw, are likely to support greater shellfish abundance and diversity, while alkaline conditions and high calcium levels, as observed in Guise and Lonoy, contribute to stronger shell formation and growth. These substrate properties collectively shape the composition and distribution of shellfish assemblages across the study areas.

4. Discussion

The results show that a total of 7,869 individual mollusks representing 11 families were collected across all sampling sites, with Veneridae being the most abundant and diverse family. However, the distribution of mollusks varied greatly among sites, indicating strong site-specific environmental influences. Guise recorded the highest overall abundance, largely dominated by *Meretrix lyrata*, but showed low diversity and evenness due to strong species dominance. Across bivalve studies, this pattern usually reflects numerical dominance by one or a few species rather than a species-rich, balanced assemblage (Asadi et al., 2018). Low evenness is repeatedly interpreted as unequal distribution of individuals among species, and values closer to 1 are associated with greater ecological balance or stability (Vito, 2018). In contrast, Bungkayaw had moderate abundance with similar dominance patterns, while Lonoy and Culasi exhibited much lower abundances, reflecting more disturbed conditions. Interestingly, Culasi showed relatively higher Shannon diversity despite low total abundance, suggesting a more balanced distribution of fewer individuals. Several bivalve studies show this exact structure. In Lamongan, *Gafrarium pectinatum* made up 82% of individuals, and the community had very low Shannon diversity and evenness with high dominance (Asadi et al., 2018). In Ngemboh, *G. pectinatum* again dominated 30% of total abundance and strongly shaped the ecological indices (Guntur et al., 2019). These patterns indicate that high abundance does not necessarily correspond to high diversity, and that community structure is strongly shaped by environmental conditions and disturbance levels.

Environmental and habitat characteristics appear to be the main drivers of these differences. Sites with high organic matter and nutrient-rich sediments, such as Bungkayaw, potentially support greater food availability for benthic organisms. The 4.84 percent of organic matter in this site is ideal since sediment organic matter does affect bivalve growth, but not in one direction. It tends to support growth when it increases accessible organic food, and it tends to suppress growth when enrichment drives sulfide, acidity, turbidity dilution, or crowding in fine muddy sediments (Leal et al., 2007; Curtin et al., 2021; Cerdeira-Arias et al., 2024). While Guise benefits from high calcium levels that favor shell formation which is important since when calcium is low, calcification drops sharply. In mussel larvae, shell formation begins to fail below about 3 mM Ca2+, and reduced calcium in brackish systems is identified as a critical limit on biomineralization and distribution (Thomsen et al., 2017).

However, stressors such as very low dissolved oxygen in Bungkayaw and extremely high temperatures in Culasi likely limit species diversity and physiological performance. Low dissolved oxygen and high temperature reduce bivalve survival, growth, feeding, and aerobic performance, while increasing metabolic strain and oxidative or immune stress across multiple species and life stages. Temperature also worsens oxygen stress because warmer water holds less oxygen and raises bivalve oxygen demand (Steeves et al., 2025; Roman et al., 2019). Similarly, lower organic matter in Lonoy may restrict food resources, contributing to its low mollusk abundance. Overall, the interaction between sediment quality, water physicochemical conditions, and anthropogenic disturbance shapes the observed patterns in mollusk abundance, diversity, and distribution across the study sites.

5. Conclusion

In conclusion, the study demonstrates that intertidal mollusk abundance, diversity, and community structure vary significantly across the sampling sites due to differences in environmental conditions and levels of anthropogenic disturbance. Guise supported the highest abundance of mollusks but exhibited low diversity and evenness due to the dominance of *Meretrix lyrata*, suggesting a simplified community structure under relatively stable but species-selective conditions. In contrast, Culasi and Lonoy showed reduced abundance, likely resulting from higher levels of human disturbance, unfavorable physicochemical conditions, and limited habitat quality. Bungkayaw, despite having nutrient-rich sediments, was constrained by very low dissolved oxygen levels, which likely limited species diversity and overall community stability.

Overall, the findings indicate that mollusk communities in the study area are strongly influenced by the interaction of water quality parameters, sediment characteristics, and human activities. Key factors such as dissolved oxygen, temperature, organic matter content, and substrate composition play critical roles in shaping species distribution and survival. These results highlight the sensitivity of intertidal mollusks to environmental changes and emphasize the importance of maintaining good water quality and habitat conditions to support sustainable coastal biodiversity.

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