THE BIVALVES (MOLLUSCA) FROM PRIORITY MARINE REGIONS IN THE CENTRE-SOUTH OF THE MEXICAN TRANSITIONAL PACIFIC, ASSOCIATED WITH THE ROCKY INTERTIDAL ZONE

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In Mexico, due to its high biological diversity, use of its resources, and a lack of knowledge about its biodiversity, Priority Marine Regions have been designated. The classification of these regions has served as an instrument for the large-scale conservation because the species composition is relatively homogeneous in these regions. This study reports some ecological attributes of bivalves from the Priority Marine Regions located in the Mexican Transitional Pacific ecoregion. Three samplings have been carried out in 2016–2018 in the rocky intertidal zone. In each sample per site, an area of 10 m^2 was covered, and the sampling unit was 1 m^2. A total of 4119 specimens were recorded, by identifying 53 species (35 genera, 18 families, and two specimens identified to genus). The richness of the species expected was calculated using non-parametric estimators, by showing acceptable completeness of the inventory. The highest species richness and diversity were recorded in the Copala-Punta Maldonado region (33 species), whereas the highest abundance and density were found in the Colola-Maruata region (30.9 individuals/m^2). The best-represented species in abundance and distribution were *Chama coralloides*, *Brachidontes adamsianus*, *Isognomon janus*, and *Choromytilus palliopunctatus*. By considering their life form and degree of occurrence, studied bivalves attached to a hard substrate (epifaunal species) and restricted to habitats with particular characteristics (occasional species) were the most commonly found. The information provided here is directed to eight Marine Regions designated as a priority for conservation in Mexico, which is important for planning, decision-making, and formulating initiatives aimed at helping to co-ordinate management practice through outreach efforts to the conservation and sustainable use of bivalves as marine resources.

Key words: biodiversity, Bivalvia, conservation, ecological attributes, Mexican Pacific, molluscs

Introduction

Of the molluscs, marine bivalves are the group with the most information available (Ríos-Jara, 2015; Vahidi et al., 2021; Albert et al., 2022). Species of this group are important due to their ecological relevance as indicators of environmental deterioration and bioaccumulation of pollutants. In addition, they are fished and cultivated for human consumption and have ornamental, artisanal, and industrial use (Baqueiro-Cárdenas et al., 2007; Barrientos-Luján et al., 2022).

In Mexico, the information on bivalves deals with ecological issues where species inventory is also known. These studies have been carried out in the northern Pacific and Gulf of California (e.g. Hendrickx et al., 2007; Zamorano & Hendrickx, 2011; Esqueda-González et al., 2014, 2022; Pérez-Estrada et al., 2023), and other ones in the central Pacific. On the coasts of the states of Jalisco, Colima, and Michoacán, the studies of Holguín-Quiñones & González-Pedraza (1994), Landa-Jaime & Arciniega-Flores (1998), Villarroel et al. (2000), Ríos-Jara et al. (2020), have been reported.

In the South Pacific, the studies of Holguín-Quiñones & González-Pedraza (1989), Zamorano et al. (2008), Flores-Garza et al. (2011, 2014), and López-Rojas et al. (2017) presented species lists. Overall, Castillo-Rodríguez (2014) reported 2576 species for the Mexican Pacific, 66.45% gastropods and 26% bivalves, while Barrientos-Luján et al. (2022) reported 265 species for the coasts of Oaxaca, Guerrero, and Michoacán.

Furthermore, considering their high diversity, bivalves have been used to understand the origin and dynamics of the latitudinal diversity gradient in the oceans (Roy et al., 2000; Krug et al., 2007). However, they have also been used to demonstrate that large-scale diversity patterns are set by the spatial and temporal dynamics of changes in origin, extinction, and geographic range (Jablonski et al., 2017; Chattopadhyay et al., 2021).

Marine ecoregions are areas where species composition is relatively homogeneous, which may be determined by the predominance of a small number of ecosystems or a distinct set of oceanographic or topographic features (Spalding et al., 2007). Likewise, ecoregions support global and regional conservation planning efforts. These designations are a logical framework for large-scale conservation strategies (Abell et al., 2008).

In the Mexican Pacific, five marine ecoregions were described, for which the priority need for a strategic plan for long-term biodiversity conservation is recognised. One of them is the Mexican Transitional Pacific ecoregion. It presents a great variety of coastal ecosystems with a high diversity of fish, crustacean and mollusc species (Wilkinson et al., 2009). In the Mexican Transitional Pacific ecoregion, there are some Priority Marine Regions, which have served as a logical framework for large-scale conservation as they are intended to ensure biological connectivity and protection of ecosystem integrity in areas, where the species composition is relatively homogeneous (Arriaga-Cabrera et al., 2009).

Interaction processes, spatial and temporal dynamics, species inventories, and community sizes are fundamental for an integral knowledge of marine biodiversity as well as for proposing conservation strategies and adequate management of natural resources (Carrascal & Palomino, 2006; Ríos-Jara et al., 2020). Research tasks were to present the species richness, abundance and density, life forms, hierarchical location, diversity, and similarity of bivalve communities, which inhabit the rocky intertidal of the Priority Marine Regions of the central-southern zone of the Mexican Transitional Pacific ecoregion. This information will allow the development of better strategies for conserving and preserving marine resources.

Material and Methods

Study area

The study has been carried out in eight Priority Marine Regions located in the south-central zone of the Mexican Transitional Pacific ecoregion, which covers the coast of the states of Oaxaca, Guerrero, and Michoacán (Fig. 1). The selection of the sampling sites was made considering the spatial heterogeneity as well as the accessibility to the sites. Each site was georeferenced and classified according to its exposure to waves, type, and substrate stability, using the criteria of Flores-Garza et al. (2012). Finally, the rock type was determined according to the descriptions found in the geological charts of the Instituto Nacional de Estadística, Geográfica e Informática (INEGI, 2021), and by our own field observations (Table 1).

Table 1. Geographical location of the Priority Marine Regions, state, polygon, geographical extension and the sampling sites with their most relevant habitat characteristics

Priority Marine Regions	State	Polygon		Geographical extension (km^2)	Sampling sites	Habitat characteristics (Stability and type of substrate; type of rock; wave exposure)
		Latitude (N)	Longitude (W)			
36. Huatulco	Oaxaca	15.90° to 15.70°	96.18° to 95.75°	166	San Agustín	Middle stability with rock masses, large boulders, and coral fragments; acid intrusive igneous rock type; middle wave exposure
35. Puerto Ángel-Mazunte	Oaxaca	15.73° to 15.64°	96.30° to 96.35°	73	Puerto Ángel	Middle stability with rock masses, large boulders, and some rolled boulders; gneiss type metamorphic rock type; middle wave exposure
34. Chacahua-Escobilla	Oaxaca	16.04° to 15.79°	97.79° to 97.03°	615	Roca Blanca	High stability with rock masses; acid intrusive igneous rock type; high wave exposure
33. Copala-Punta Maldonado	Guerrero	16.54° to 15.60°	99.41° to 98.20°	6 352	Punta Maldonado	Middle stability with large boulders and rolled boulders; acid intrusive sedimentary sandstone rock type; middle wave exposure
32. Coyuca-Tres Palos	Guerrero	16.59° to 17.47°	99.42° to 100.55°	829	Acapulco	Low stability with Rolled boulders and gravel; acid intrusive igneous and artificial substrate rock type; middle wave exposure
31. Piedra Tlacoyunque	Guerrero	17.63° to 17.23°	101.72° to 101.03°	1 230	Ojo de Agua	Low stability with large boulders and rolled boulders; basic intrusive igneous rock type; middle wave exposure
30.Mexiquillo-Delta del Balsas	Michoacán	18.04° to 16.84°	102.81° to 101.94°	8 641	Caleta de Campos	Middle stability with rock masses, large boulders, and some rolled boulders; intermediate extrusive igneous (volcanic) rock type; middle wave exposure
29. Colola-Maruata	Michoacán	18.31° to 18.18°	103.42° to 103.2	112	Colola	High stability with rock masses; acid intrusive igneous rock type; high wave exposure

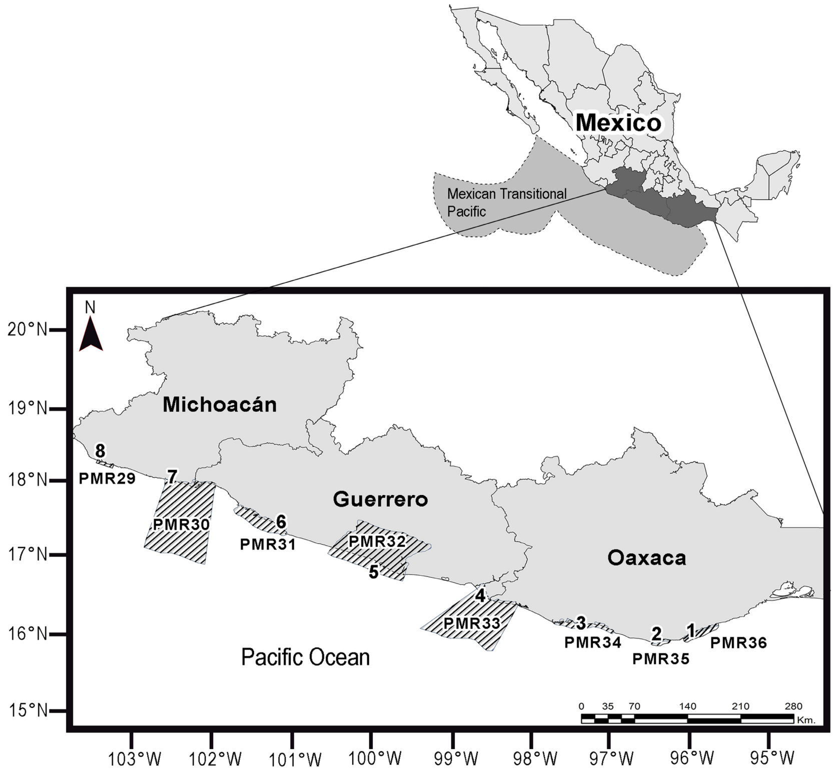

Fig. 1. Geographical location of the Priority Marine Regions (PMR) and sampling sites (numbers) in the Mexican Transitional Pacific ecoregion. Designations of Priority Marine Regions: PMR36 – Huatulco, PMR35 – Puerto Ángel-Mazunte, PMR34 – Chacahua-Escobilla, PMR33 – Copala-Punta Maldonado, PMR32 – Coyuca-Tres Palos, PMR31 – Piedra Tlacoyunque, PMR30 – Mexiquillo-Delta del Balsas, PMR29 – Colola-Maruata. Sampling sites: 1 – San Agustín, 2 – Puerto Ángel, 3 – Roca Blanca, 4 – Punta Maldonado, 5 – Acapulco, 6 – Ojo de Agua, 7 – Caleta de Campos, 8 – Colola.

San Agustín (15.68° N, 96.23° W) was the sampling site in the Priority Marine Region Huatulco. It is considered a priority site for the conservation of corals (López-Pérez & López-García, 2008). It is located within the extensions of the Huatulco National Park (CONANP, 2023), also designated as a RAMSAR-1321 site (RAMSAR, 2023) and Huatulco Biosphere Reserve, Mexico (UNESCO, 2023). In the Priority Marine Region Puerto Ángel-Mazunte, Puerto Ángel (15.65° N, 96.48° W) was the sampling site considered a priority site for the coral conservation (López-Pérez & López-García, 2008). Roca Blanca (15.93° N, 97.35° W) was the sampling site in the Chacahua-Escobilla Priority Marine Region. It is located within the geographic extensions of the Lagunas de Chacahua National Park (CONANP, 2023), also designated as a RAMSAR-1819 site (RAMSAR, 2023).

In the Priority Marine Region Copala-Punta Maldonado, Punta Maldonado was the sampling site, considered a priority site for the conservation of Mexico's coastal and oceanic environments (CONABIO, 2023). Acapulco (16.83° N, 99.9° W) was the sampled site in the Priority Marine Region Coyuca-Tres Palos and Ojo de Agua (17.30° N, 101.05° W) in the Priority Marine Region Piedra Tlacoyunque. Ojo de Agua belongs to the Petacalco-Piedra Tlacoyunque beaches and is considered a priority site for the conservation of the coastal and oceanic environments of Mexico (CONABIO, 2023).

Caleta de Campos (18.06° N, 102.75° W) was the sampling site in the Priority Marine Region Mexiquillo-Delta del Balsas, located between the Mexiquillo-Caleta de Campos beaches. It is considered a priority site for the conservation of coastal environments and oceanic of Mexico (CONABIO, 2023). Finally, Colola (18.28° N, 103.4° W) was the Priority Marine Region Colola-Maruata sampling site. Colola is an important nesting beach site for three sea turtles. It was designated a protected natural area (CONANP, 2023) and site RAMSAR-1788 (RAMSAR, 2023).

Collection of samples

Three field trips were conducted: the first in November 2016, the second in March 2017, and the third in February 2018. The systematic sampling has been carried out in the rocky intertidal zone during low tide hours, covering an area of 10 m^2 parallel to the coast; the sampling unit was 1 m^2. All individuals within the sampling unit (1 m^2) were collected. An exhaustive search for bivalves was carried out in soft sediments, among algae, under rocks, inside crevices and porous rocks, in coral remains, and inside other organisms. After the first 1 m^2 collection was completed, the frame that delimited the sampling unit was moved perpendicular to the coastline and placed again on the rocks. The distance between the sampling units was 2 m^2. This procedure was repeated until ten sampling units were completed. The collected specimens were preserved in 96% alcohol, then identified and quantified.

Laboratory work

Species identification was carried out using the references in Coan & Valentich-Scott (2012). The update of the nomenclature was consulted in the database of the MolluscaBase website (MolluscaBase, 2023). The species have been classified into functional groups according to their life forms and were catalogued with the criteria of Esqueda-González et al. (2014), namely endolithic bivalves (found inhabiting stones or other hard substrates), epifaunal bivalves (found attached to a hard substrate), and semi-infaunal bivalves (found partially buried in the sediment but protruding above the sediment).

Data analysis

Species richness (S) was measured based on the number of bivalve species found in the samples, and expected richness was calculated through sample-based rarefactions using the non-parametric estimators Chao1, Chao2, Jacknife1, Jacknife2, and bootstrap (Moreno, 2001). Observed and expected species accumulation curves were constructed with 10 000 randomisations without replacement based on the number of samples taken during the entire study, using the software PRIMER 6 (Clarke & Gorley, 2006).

The structure of the bivalve community was analysed by ecoregion (central-south zone of the Mexican Transitional Pacific ecoregion) and sites (Priority Marine Regions). Abundance (N) was estimated by the number of individuals found for each species. Singleton species were those represented by one individual, and doubletons were those represented by two individuals (Magurran, 2005). Density (De) was calculated as the mean of the number of individuals divided by the total sample units. The percentage of species was evaluated according to their life forms at each sampled site.

The Olmstead-Tukey correlation method determined the degree of occurrence of the species (hierarchical location) within the community (Sokal & Rohlf, 1969). This method is based on the calculation of two estimators, the relative abundance and the frequency of occurrence (average in percentage of the number of samples, in which all species are present) of the species. The dominant species (D) were those, which relative abundance and frequency of occurrence values exceeded the arithmetic mean of both estimates. The constant species (C) were those, which abundance value did not exceed the average value of the total abundance but exceeded the average estimate for the frequency of occurrence. The species' numerous little frequent (NLF) were those, which abundance value was higher than the estimated average value for abundance, and the value of frequency of occurrence did not exceed the estimated average value for this variable. Finally, the occasional species (O) were those, which abundance value and frequency of appearance did not exceed the estimated arithmetic mean for the frequency of appearance and abundance (Flores-Garza et al., 2012; Galeana-Rebolledo et al., 2012).

Diversity was generally measured for the south-central zone of the Mexican Transitional Pacific ecoregion and each of the Priority Marine Regions. The Shannon-Wiener index (H') with base 2 logarithm was applied, and equity was evaluated using Pielou's evenness or equity index (J'). Similarity analysis of bivalve communities was carried out with non-parametric multivariate techniques using PRIMER 6 (Clarke & Warwick, 1999). Similarity matrices were constructed using the Bray-Curtis index after transformation of the data by Log(x + 1) of the species abundance to homogenise the order of magnitude between values. The SIMPROF test was used as a criterion to identify statistically different groupings in the dendrogram (Clarke et al., 2008). Subsequently, the SIMPER test was performed to characterise the composition of each group to identify the species with the highest contribution to the formation of each biological association (Clarke & Gorley, 2006).

Results

A total of 4119 bivalve specimens were analysed for the south-central zone of the Mexican

Transitional Pacific ecoregion, distributed in 18 families, 33 genera, 53 species, and two specimens that were only identified to genus (Electronic Supplement). The species richness calculated, using non-parametric estimators, had a minimum of 63 species and a maximum of 77 species. These values had a representation of 72% and 87%, respectively, and the species accumulation curves showed an asymptotic trend (Fig. 2). The Copala-Punta Maldonado region had the highest richness with 33 species, followed by the Piedra de Tlalcoyunque region with 26 species, both located areas in the state of Guerrero. The lowest richness, with 13 species, was found in the Colola-Maruata region in Michoacán (Electronic Supplement).

It was estimated that 13 species exceeded 1% of the relative abundance and together contributed 91.11% of the total abundance found. The species with the highest abundance were *Chama coralloides* (Olsson, 1971), *Brachidontes adamsianus* (Dunker, 1857), *Choromytilus palliopunctatus* (Carpenter, 1857), *Isognomon janus* (Carpenter, 1857), and *Leiosolenus aristatus* (Dillwyn, 1817). In ten species, including the two specimens identified to genus, a minimum abundance (singletons) was found. In four species, the presence of two individuals (doubletons) in the totality of samples was determined. The estimated density of bivalves for the south-central of the Mexican Transitional Pacific ecoregion was 17.2 individuals/m^2. The Colola-Maruata region recorded the highest density with 30.9 individuals/m^2, followed by the Copala-Punta Maldonado region with 26.1 individuals/m^2. Finally, the Mexiquillo-Delta del Balsas region recorded the lowest density with 9.4 individuals/m^2 (Table 2).

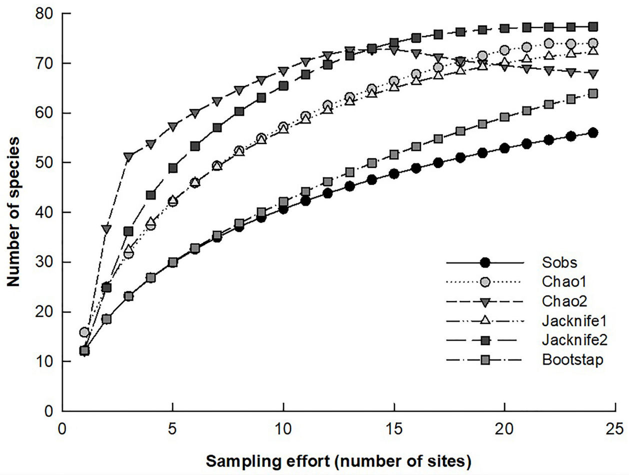

Fig. 2. Observed bivalve species richness (S_{obs}) and expected species richness (rarefaction curves of Chao1, Chao2, Jacknife1, Jacknife2, and Bootstap) from the south-central zone of the Mexican Transitional Pacific ecoregion.

Regarding bivalve life forms, 18 species were endolithic. Of them, *Acar gradata* (Broderip & Sowerby, 1829), *A. pusilla* (Sowerby I, 1833), *A. rostae* (Berry 1954), and *Isognomon janus*, which are normally reported as epifaunal, were found as endolithic in the Copala-Punta Maldonado, and Huatulco regions. In the Punta Maldonado-Copala region, the sampling site is composed of sedimentary sandstone-type rocks, while in the Huatulco region, these species were found in coral remains. Twenty-nine species of epifaunal bivalves and 12 semi-infaunal species were recorded (Electronic Supplement). The highest richness of epifaunal species was found in the Coyuca-Tres Palos region. The highest richness of endolithic species was recorded in the Copala-Punta Maldonado region, and the highest richness of semi-infaunal species was observed in the Piedra de Tlacoyunque region (Table 2).

Table 2. Ecological attributes of bivalves from the Priority Marine Regions and the centre-south zone of the Mexican Transitional Pacific ecoregion

Priority Marine Regions	S	N	De	H'	J'	Life forms (%)			Degree of occurrence (%)			
						En	Ep	Se	D	C	NLF	O
36. Huatulco	19	457	15.23	2.73	0.64	31.58	57.95	10.57	68.53	10.49	10.49	10.49
35. Puerto Ángel-Mazunte	18	561	18.72	2.56	0.61	5.56	77.74	16.67	83.32	5.58	0.00	11.13
34. Chacahua-Escobilla	13	400	13.33	2.36	0.62	7.69	92.8	0.00	85.71	7.10	7.10	0.00
33. Copala-Punta Maldonado	33	783	26.14	3.75	0.74	51.52	39.34	9.16	45.45	6.06	9.09	39.40
32. Coyuca-Tres Palos	25	370	12.33	2.94	0.63	4.00	16.00	80.00	68.00	0.00	0.00	32.00
31. Piedra Tlacoyunque	26	339	11.32	3.14	0.67	3.86	69.00	26.95	61.54	7.69	3.85	26.90
30. Mexiquillo-Delta del Balsas	16	282	9.43	2.71	0.68	6.25	87.50	6.25	81.25	6.25	0.00	12.50
29. Colola-Maruata	13	927	30.91	2.06	0.56	7.70	84.60	7.70	100.00	0.00	0.00	0.00
Mexican Transitional Pacific ecoregion	55	4119	17.22	3.63	0.64	25.00	53.60	21.41	35.71	5.35	8.92	50.00

Note: S – species richness, N – abundance, De – density, H' – diversity, J' – equity, E – epifaunal, En – endolithic, S – semi-infaunal, D – dominant, C – constant, NLF – numerous little frequent, O – occasional.

It was estimated that, in the south-central zone of the Mexican Transitional Pacific ecoregion, occasional species obtained the highest percentage (50%), followed by dominant (35.71%), NLF (8.92%), and constant species (5.35%) (Table 2). The Colola-Maruata and Chacahua-Escobilla regions registered the highest (100.00%, and 85.71%, respectively) percentage of dominant species. Species classified as constant and NLF were most present in the Huatulco region, with 10.50%. The highest percentage of occasional species was found in the Copala-Punta Maldonado and Coyuca-Tres Palos regions, with 39.4% and 32.0%, respectively (Table 2).

The values of the diversity and equity indices, estimated for the bivalves in the central-southern zone of the Mexican Transitional Pacific ecoregion, were H' = 3.63 bits/individual and J' = 0.64. In the Copala-Punta Maldonado region, the highest value of diversity and equity indices (H' = 3.75 bits/individual, and J' = 0.74) was registered, followed by the Piedra de Tlacoyunque region (H' = 3.14 bits/individual, and J' = 0.67). The lowest values of the diversity and equity index were recorded in the Colola-Maruata region (H' = 2.05 bits/individual, and J' = 0.55) (Table 2).

The SIMPROF analysis identified bivalve communities in two statistically distinct groupings. Group B was made up only of the community of the Copala-Punta Maldonado region (Fig. 3). Group A was made up of the rest of the communities; within this group the species *Chama coralloides*, *C. echinata* (Broderip, 1835), *Isognomon janus*, *Plicatula penicillata* (Carpenter, 1857), *Brachidontes adamsianus*, *Plicatulostrea anomioides* (Keen, 1958), *Acar gradata*, *Lamarcka mutabilis* (Sowerby I, 1833), *Saccostrea palmula* (Carpenter, 1857), *Choromytilus palliopunctatus*, *Limaria pacifica* (de' Orbigny, 1846), and *Striostrea prismatica* (Gray, 1824), classified as dominants, contributed 92.9%.

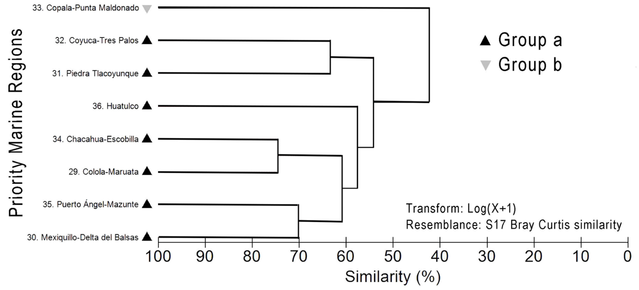

Fig. 3. Grouping dendrogramme, based on the Bray Curtis index, for the Priority Marine Regions in the central-south zone of the Mexican Transitional Pacific ecoregion.

In group A, the communities from the Colola-Maruata and Chacahua-Escobilla regions presented the highest percentage of similarity. Both sites showed affinity in the physical characteristics of the habitat, such as an increased exposure to waves and intrusive igneous rock massif substrates, which provide high stability. Among the ecological aspects of these sites, the following stand out: similarity in the values of species richness and diversity index (the lowest estimated in the analysed sites), clear dominance of epifaunal species, the highest number of species ranked as dominants, and the absence of occasional species (Table 2).

Subsequently, the bivalve communities of the Mexiquillo-Delta del Balsas and Puerto Angel-Mazunte regions had 70% similarity (Fig. 3). These sites are similar in terms of wave exposure (middle), substrate heterogeneity (middle), and rocky substrate that can be found as massifs, slabs, and some boulders, which provide mean stability. In the ecological characteristics of both communities, low species richness and diversity index (not as low as in the previously described sites) were registered. On both sites, epifaunal species had a clear dominance, with a high number of semi-infaunal species. In the hierarchy of species, the dominant ones are in the majority, but occasional species are also present (Table 2).

In the Piedra de Tlacoyunque and Coyuca-Tres Palos regions, the communities showed a 63.40% similarity (Fig. 3). In both sites, similarities were observed in the physical characteristics of the habitat, such as mean exposure to waves, high heterogeneity of the substrate, and the type of rocky substrate between slabs, some boulders, and gravel. In the ecological characteristics, the two communities presented high species richness and diversity values, an increased number of semi-infaunal and endolithic species, and a higher percentage of occasional species than on the sites with 70% similarity (Table 2).

Discussion

The number of bivalve species found in this study represents 8% of the total species reported by Castillo-Rodríguez (2014) for the Mexican Pacific, as well as 15% of the 265 species reported by Barrientos-Luján et al. (2022) in the Mexican Tropical Pacific. In this study, fewer bivalve species are reported compared to those published in the states of Jalisco, Colima, and Michoacán (Holguín-Quiñones & González-Pedraza, 1994;

Ríos-Jara et al., 2008). The difference in the species number represented from those published in Jalisco, Colima and Michoacán is attributed to the extension of the study areas that leads to the spatial variability of the different habitats, since it has been reported in studies conducted vertically to the coast, that the distribution of bivalves is wide, and the turnover of species is remarkable (Esqueda-González et al., 2018). However, our species list is similar to that published in the states of Guerrero and Oaxaca by Holguín-Quiñones & González-Pedraza (1989), Flores-Garza et al. (2014), and Flores-Rodríguez et al. (2014).

Non-parametric estimators of species richness have been used in several studies. The importance of considering them to obtain more complete inventories and their quality has been pointed out (Bouchet et al., 2002). It has also been observed that their bias and precision vary depending on the taxon examined. However, they are still a good indicator to evaluate the sampling effort and completeness of the inventory (Escalante, 2003; López-Gómez & Williams-Linera, 2006; González-Oreja et al., 2010; Bautista-Hernández et al., 2013). In this study, we used five non-parametric estimators to evaluate the inventory and the sampling effort, and according to the results, 70% of the estimated species for the community were exceeded.

The highest number of species was recorded in the Copala-Punta Maldonado and Piedra de Tlalcoyunque regions, both located in the state of Guerrero, which present medium wave stability with substrate variability (slabs and boulders), and medium to low stability. These characteristics of the area are conducive to the high bivalve species diversity (Galeana-Rebolledo et al., 2012; Flores-Garza et al., 2014; López-Rojas et al., 2017, 2020). The singleton and doubleton species had a percentage of 28% of the total species recorded for the south-central region of the Mexican Transitional Pacific. This percentage is high considering that many bivalve species tend to live in agglomerated form forming dense assemblages or populations, which are often referred to as beds or, in more extreme cases, reefs (Dame & Kenneth, 2011).

The species *Chama coralloides*, *Brachidontes adamsianus*, *Isognomon janus*, *Choromytilus palliopunctatus*, and *Leiosolenus aristatus* were dominant according to the degree of occurrence, as well as the most abundant and best distributed in the rocky intertidal of the south-central region of the Mexican Transitional Pacific. Other studies have already reported this behaviour carried out in the ecoregion (Villarroel et al., 2000; Flores-Garza et al., 2014; Flores-Rodríguez et al., 2014) and can be attributed to the fact that species of the families Chamidae and Mytilidae, in addition to being eurytopic, retain abilities to withstand extreme physical factors (i.e. temperature, salinity, desiccation, and oxygen tension), allowing them to exploit hard substrates and dominate rocky habitats (Suchanek, 1986; Dame, 1996; Cardoso et al., 2016). Even species of Isognomonidae are numerous and common bivalves, found in intertidal communities worldwide (Morton & Morton, 1983).

The bivalve community, reported here, was represented mostly by epifaunal species, followed by endolithic and, to a lesser extent, semi-epifaunal species in accordance with Esqueda-González et al. (2014) in the report of the three categories in Mazatlán Bay. The highest percentage of endolithic species was recorded in the Copala-Punta Maldonado region. López-Rojas et al. (2023) mentioned that the substrate type in Punta Maldonado is conducive to the optimal development of these species. Concerning hierarchical location, the highest percentage of bivalve species was restricted to habitats with particular characteristics (occasional species). The most abundant and widely distributed species (dominant species) also represented a high percentage, and well-distributed species with low abundance (numerous infrequent species), and abundant species with low distribution (constant species), represented a lower percentage.

Due to low local abundance and restricted distribution, 27 bivalve species were considered occasional or rare. In Acapulco, Galeana-Rebolledo et al. (2012) reported a high number of rare species, including *Septifer zeteki* (Hertlein & Strong, 1946), *Barbatia lurida* (Sowerby, 1833) and *Pododesmus foliatus* (Broderip, 1834), which are also reported in our study. With this comparison, we cannot confirm that there is a loss of rare species in the area. However, we consider that the behaviour of species with restricted distribution is related to the characteristics of the habitat, since in marine ecosystems, the increase in rare species is associated with the heterogeneity of the substrate (Ellingsen et al., 2007). It has also been mentioned that many area-specific species may be rare (Thrush et al., 2006). In this study, the highest number of rare species were endolithic, specific to habitats, where the species can drill through rocks.

The diversity of bivalves from the rocky intertidal zone of the south-central region of the Mexican Transitional Pacific is high. Previous study conducted at sites in this ecoregion agrees with data reported in our research regarding the high diversity (Zamorano et al., 2008; Flores-Garza et al., 2014; Flores-Rodríguez et al., 2014). The diversity values correspond to what is expected in this ecoregion, since it is located in tropical zone, where the waters are influenced by the California and Humboldt currents, which favour the increase of diversity indices due to the convergence of oceanic currents or upwelling systems (Cruz-Motta et al., 2020). In addition, we can assume that habitat heterogeneity in the sampled sites contributed to the high diversity since bivalves are distinguished by their dominance of rocky intertidal zones, characterised by vertical gradients of dominant factors such as exposure to air, light, temperature, and wave action (Dame, 1996).

In the rocky intertidal habitats, it is expected that the similarity between bivalve communities may be influenced by the physical characteristics of the habitat, such as wave exposure, stability, and substrate type, since the interaction between them may infer their existence (Dame, 1996). It has even been reported that wave exposure can determine the distribution of bivalves inhabiting the intertidal zone (Esqueda-González et al., 2022). In this study, it was observed that the percentage of similarity decreased as the wave intensity decreased and the heterogeneity of the substrate type increased. Thus, the communities with the highest similarity percentage were those found in sites exposed to waves. In contrast, the communities with the lowest percentage were found in sites with high substrate heterogeneity.

The bivalve community of the Copala-Punta Maldonado region was statistically different from the others. We attribute this difference to the high number of endolithic species and the type of rock at the sampling site. This has already been reported in other bivalve studies, that the type of rock (sedimentary sandstone type) generates a habitat conducive to the development of endolithic bivalves (Owada, 2006).

Our results provide evidence that the increase in diversity is related to the complexity of the substrate and the variety of microhabitats, in which the availability of habitats with appropriate conditions for bivalves increases. This observation agrees with Cruz-Motta et al. (2020), who reported that small-scale, site-specific ecological processes on rocky shores determine locally the diversity of rocky shore assemblages. Some other reports also state that the high species richness is related to the coastal geomorphology and heterogeneity of the sites sampled (Flores-Garza et al., 2011; Ríos-Jara et al., 2020).

Conservation planners are currently seeking effective strategies to protect species, dynamic ecosystem hotspots, and loss of diversity at the gene, species, and ecosystem scales (Harvey et al., 2021). These conservation strategies should consider community-level assessments, including species richness, habitat specificity, reproductive strategy, and endemism (Ríos-Jara et al., 2020). This study directly addresses the provision of information for ecosystem management and protection, as it is expected that marine communities with higher species richness may have greater resilience to the environmental stress (Selig et al., 2014).

In addition, this study was carried out on rocky intertidal coasts, for which it is known that, due to their ecological characteristics and accessibility, conjoint studies of these as a whole are appropriate to understand the changes caused by anthropogenic impacts and the effects of climate change (Cruz-Motta et al., 2010). The information provided here is important for future research planning, management decisions, and initiatives intended to help co-ordinating management practices through outreach efforts for the conservation and sustainable use of marine resources.

Conclusions

The richness of species and diversity of bivalves, reported by this study for the central-southern region of the Mexican Transitional Pacific, corresponds to data expected in a tropical zone. Furthermore, compared to the total number of species reported in the Mexican Pacific, it is high, considering that only specimens associated with the rocky intertidal zone of the Priority Marine Regions of Oaxaca, Guerrero, and Michoacán were included. Finally, the species richness estimators used to assess the inventory quality indicated that the sampling effort were appropriate to achieve a sufficient list of species.

The species *Chama coralloides*, *Brachidontes adamsianus*, *Isognomon janus*, *Choromytilus palliopunctatus*, and *Leiosolenus aristatus*, due to their dominance and distribution, are considered representative bivalve species associated with the rocky intertidal zone, of the priority marine regions, from the central-southern region in the Mexican Transitional Pacific.

The most diverse priority marine regions were those with high substrate heterogeneity and mean wave intensity. Epifaunal bivalves were the most frequently found in the rocky intertidal zone, and the best represented according to their hierarchical location were the occasional and dominant bivalves. The bivalve communities with the highest similarity percentage were found in habitats with little substrate heterogeneity and high waves. The species, mostly contributed to the differences between the bivalve communities, were those which way of life was classified as endolithic.

This research reports on the bivalve community associated with the rocky intertidal zone in eight Priority Marine Regions for conserving biodiversity in Mexico. This information on species richness, diversity, and habitat specificity is important for planning further research, management decision-making, and insights helping to co-ordinate conservation practices and sustainable resource use.

Supporting Information

The data on the species list of bivalves and their characteristics (Electronic Supplement. Family/species, abundance, life forms, and frequency of the occurrence of bivalves (Mollusca) from the central-south zone of the Mexican Transitional Pacific ecoregion and Priority Marine Regions) may be found in the **Supporting Information**.

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ДВУСТВОРЧАТЫЕ МОЛЛЮСКИ (MOLLUSCA) КАМЕНИСТОЙ ПРИЛИВНОЙ ЗОНЫ В ПРИОРИТЕТНЫХ МОРСКИХ РЕГИОНАХ ЦЕНТРАЛЬНОЙ ЧАСТИ ЮГА МЕКСИКАНСКОГО ПЕРЕХОДНОГО ТИХООКЕАНСКОГО РЕГИОНА

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В Мексике из-за ее высокого биоразнообразия, использования ее ресурсов и отсутствия знаний о биоразнообразии были определены приоритетные морские регионы. Классификация этих регионов послужила инструментом крупномасштабной охраны, поскольку видовой состав в этих регионах относительно однороден. В этом исследовании сообщается о некоторых экологических характеристиках двустворчатых моллюсков из приоритетных морских регионов, расположенных в мексиканском переходном тихоокеанском экорегионе. В 2016–2018 гг. на каменистой литорали было проведено три отбора проб. В каждой пробе с участка была охвачена площадь 10 м^2, а единица выборки составляла 1 м^2. Всего было зарегистрировано 4119 экземпляров, выявлено 53 вида (35 родов, 18 семейств и 2 экземпляра, идентифицированных до рода). Ожидаемое видовое богатство было рассчитано с использованием непараметрических оценок, демонстрирующих приемлемую полноту инвентаризации. Наибольшее видовое богатство и разнообразие отмечены в регионе Копала-Пунта Мальдонадо (33 вида), тогда как наибольшая численность и плотность отмечены в регионе Колола-Маруата (30.9 особей/м^2). Наибольшие показателями численности и распространения характеризовались *Chama coralloides*, *Brachidontes adamsianus*, *Isognomon janus* и *Choromytilus palliopunctatus*. Относительно жизненной формы и степени распространенности наиболее представленными двустворчатыми моллюсками были группы видов, прикрепленных к твердому субстрату (эпифаунальные виды) и приуроченных к местообитаниям с определенными характеристиками (случайные виды). Представленная здесь информация представляет данные для восьми морских регионов, признанных приоритетными для охраны природы в Мексике. Это важно для планирования, принятия решений и формулирования инициатив, направленных на помощь в координации методов управления посредством информационно-просветительской деятельности по сохранению и устойчивому использованию двустворчатых моллюсков как морских ресурсов.

Ключевые слова: Bivalvia, биоразнообразие, Мексиканский Тихоокеанский регион, моллюски, охрана, экологические характеристики