Acta oceanográfica del Pacífico
ISSN 1390-129X
eISSN 2806-5522

Macroinvertebrados de la zona intermareal rocosa de Capaes y Punta Blanca, provincia de Santa Elena

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ACTA OCEANOGRAFICA DEL PACÍFICO
Instituto Oceanográfico y Antártico de la Armada, Ecuador
ISSN: 1390-129X
ISSN-e: 2806-5522
Periodicity: Semestral
vol. 5, no. 2, 2023
acta.oceanografica@inocar.mil

Received: 09 March 2023
Accepted: 11 May 2023

URL: http://portal.amelica.org/ameli/journal/648/6484428005/

Abstract: The rocky intertidal zones of Capaes and Punta Blanca in the province of Santa Elena (Ecuador) present several communities of macroinvertebrates, therefore the objective of the research was to analyze and compare the distribution and abundance of nine stations established in the two study areas. Seventeen samples were collected in quadrats of 1 m each in an area of 160 m2 in the two study areas. Five classes of macroinvertebrates were identified, Gasteropoda with 4 orders and 12 species, Crustacea with 1 order and 3 species, Bivalvia with 1 order and 1 species, Malascostraca with 1 order and 1 species, Polyplacophora with 1 order and 1 species. It was observed in both zones that the substrate is made up of interstratified sandstones. In the rocky intertidal zone of Capaes, 2234 ind/m2 were recorded, with the Gasteropoda class being the most abundant with 1403 ind/m2 , showing Thais brevidentata as dominant, while the Malacostraca class had a relative abundance of 4.38%, evidenced by Pachygrapsus marmoratus and an index of 2.52 bits. In the Punta Blanca area, 2224 ind/m2 , the most abundant Gasteropoda class with 1153 ind/m2 , evidenced by Thais brevidentata as the dominant species, the Bivalve class with 15 ind/m2 , with 0.67% of relative abundance, the only species being Brachidontes adamsianus and an index of 2.53 bit. The homogeneity in Capaes was maintained with a value of 0.966 and in Punta Blanca with a value of 0.920. The observations made at the Capaes and Punta Blanca stations made it possible to determine the distribution and abundance of the benthic macrofauna present, most of which were of the Gasteropoda class with 62.8% relative abundance and Malacostraca, with 4.39% abundance, thus achieving the objectives set in little-known areas for the development of research work.

Keywords: Macroinvertebrates, distribution, abundance, diversity indices, Capaes, Punta Blanca.

Resumen: Las zonas intermareales rocosas de Capaes y Punta Blanca en la provincia de Santa Elena (Ecuador) presentan varias comunidades de macroinvertebrados, por tal razón el objetivo de la investigación fue analizar y comparar la distribución y abundancia de nueve estaciones establecidas en las dos zonas de estudio. Se obtuvieron 17 muestras colectadas mediante cuadrantes de 1 m cada uno en una superficie de 160 m^2 en las dos áreas de estudio. Se identificaron 5 clases de macroinvertebrados, Gasterópoda con 4 órdenes y 12 especies, Crustácea con 1 orden

y 3 especies, Bivalvia con 1 orden y 1 especie, Malascostraca con 1 orden y 1 especie, Polyplacophora con 1 orden y 1 especie. Se observó en las dos zonas que el sustrato está constituido por areniscas interestratificada. En la zona intermareal rocosa de Capaes se registró 2234 ind/m^2, siendo la clase Gasterópoda la más abundante con 1403 ind/m^2, evidenciando a Thais brevidentata como dominante, contrariamente la clase Malacostráca con 4.38% de abundancia relativa evidenciado en Pachygrapsus marmoratus y un índice de 2.52 bits. En la zona de Punta blanca se registró 2224 ind/m^2, la clase Gasterópoda de mayor abundancia con 1153 ind/m^2, evidenciando a Thais brevidentata como especie dominante, la clase Bivalva contrariamente con 15 ind/m^2 existiendo 0.67% de abundancia relativa siendo la única especie Brachidontes adamsianus y un índice de 2.53 bit. La homogenidad, en Capaes se mantuvo con un valor de 0.966 y en Punta Blanca con un valor de 0.920. Las observaciones realizadas en las estaciones de Capaes y Punta Blanca permitieron determinar la distribución y abundancia de la macrofauna bentónica presente siendo en su mayoría la clase Gasterópoda con un 62.8% de abundancia relativa y Malacostraca, con un 4.39% de abundancia, de esta manera se logró los objetivos planteados en áreas poco conocidas para el desarrollo de trabajos de investigación.

Palabras clave: Macroinvertebrados, distribución, abundancia, índices de diversidad, Capaes, Punta Blanca.

Introduction

The term aquatic macroinvertebrates includes invertebrate organisms larger than 1 mm. These species have a high ecological importance as predators and prey of other organisms, they are part of the food web serving as food for fish, reptiles, birds and mammals. (Rosenberg & Resh, 1993)Cabrera (2008) demonstrates the importance of these ecosystems in terms of richness and diversity of macroinvertebrates, dominant groups in coastal and sublittoral marine sediments, being of vital importance in the structure and dynamics of the benthos and its interaction with the coastal marine environment, for example for environmental quality studies.

Among invertebrates, mollusks and crustaceans are the most abundant and form an important part of fishing activity worldwide. In the first group, most of the living species of mollusks belong to the classes Gasteropoda, Pelecypoda and Cephalopoda (Russell-Hunter, 1968). (Russell-Hunter, 1968) and whose basic structural and physiological organization is maintained, but with a diversity of forms. Nielsen & Beaumont (2009) mention that there are diagnostic characters that can be recognized in almost all mollusks: the mantle, the foot, the radula, the central nervous system. Since the shell shows a great diversity of forms, the internal anatomy is another fundamental element to be used for identification. The second group includes all those organisms with rigid, external skeletons and articulated limbs, inhabitants of rocky intertidal and deep zones, among which are the Cirripedia and Malacostraca classes, these organisms are distributed in all

oceans, seas and bays especially in the equatorial tropical belt, being the Pacific Ocean where the greatest diversity of species is recorded (Cabrera, 2008)..

The Ecuadorian coast has an extension of 1100 km, made up of a great variety of habitats such as estuaries, beaches (rocky and sandy), cliffs (high and low) and coral reefs, where there is a great diversity of organisms, including benthic macroinvertebrates. In the Capaes and Punta Blanca sectors (Entrance 4), both plants and animals from the coastal areas have been used as a source of food resources through fishing and extraction. This area constitutes a semi-enclosed bay beach with a medium slope and an urbanized beach front except for a ridge bluff considered a rocky coastal strip, at shallow depths with a macroalgae community on its surface. In addition, marine macroinvertebrates such as mollusks and crustaceans are an important part of the artisanal fishing activity in this sector.

It is important to mention that marine ecosystems have fed humans for many millennia, until recently it was considered as an inexhaustible source of resources, but in just a matter of decades the picture has changed dramatically with the accelerated destruction, loss of habitats and lack of information of existing marine resources such as marine macroinvertebrates. There is little protection in beach areas, the presence of colonization is observed that varies the geography and nature of the substrate, in addition to the direction, the angles of these rocky strata are in relation to the local tidal range and the direction of currents, waves and other water movements, (Bayard & M., 1974) it is of utmost importance to investigate the type of soil in which these organisms develop.

The importance of marine macroinvertebrates in these ecosystems should also be highlighted, especially in these poorly studied areas (Cruz 1983, 2009; Villamar, 1983, Mite & Gonzabay, 2009). For this reason, the present investigation had the purpose of revealing the distribution and abundance of macroinvertebrate mollusks and crustaceans in the rocky intertidal zone in the Capaes and Punta Blanca sectors (Entry 4), the records obtained are a contribution to the basic information of the area and the coastal strip of the province of Santa Elena, the same that can be used in the best way for further studies.

Materials and methods

The study was conducted on the beaches of Capaes and Punta Blanca during 2015 and then compared with the months of June and July 2018 to see the population variations in the selected months, the study area presented an average temperature of 26ºC. The sampling areas located in the province of Santa Elena, the same that present intertidal rocky areas with abundant population of marine macroinvertebrates, represented by species of mollusks and crustaceans.

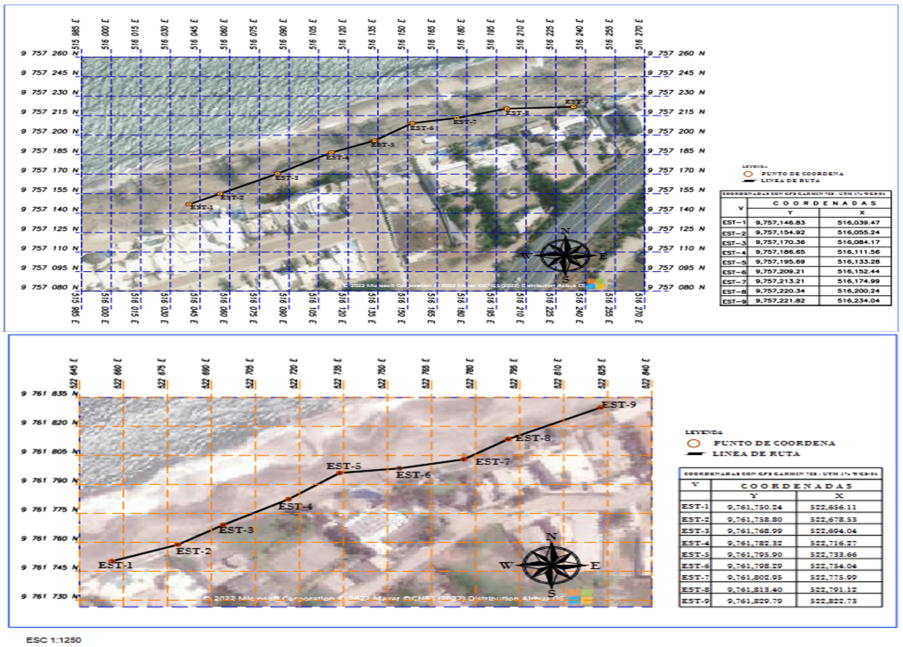

Figure 1. Location of sampling stations in the study areas at Capaes and Punta Blanca beaches.

Figure 1

Location of sampling stations in the study areas at Capaes and Punta Blanca beaches.

For the geographic positioning of the study areas, the Universal Transverse Mercator (UTM) projection system was used for Capaes beach, located at kilometer 2, via Ballenita - Spondylus route, located between 9'757,146.83 longitude and 516,234.04 latitude. While Punta Blanca beach, located at kilometer 12, is located between 9'761.750.74 Longitude and 522.822.73 Latitude (Fig. 1 a and b).

Sample collection and processing

Nine stations were selected for this research, using the quadrat method for the study (Millavich & Carbonini, 2010). (Miloslavich & Carbonini, 2010)Each station had an area of 80 x 20 m and a total surface area of 160 m. . Each sampling station was separated by a 35.38 m space. Three quadrants were taken at each station, located in the high, mid and low tide zones.

Due to the morphology of the sampling area, sampling was carried out two hours before the low tide limit, starting from the lowest tide level to the limit of the highest tide of the rocky part. At each station, three quadrants were used, located from the high, middle and low part of the rocky beach, where the organisms found were observed. The temperature was taken once a week with a bucket thermometer ranging from 0 to 40. C and the location of the study areas were georeferenced with a GPS Map GARMIN 78s.

For the soil analysis, the geographic characterization database of the Ecuadorian Space Institute (http://181.211.99.244:8080/visorIEE/composer/) was used, with the following procedure: Coordinates were taken by GPS at the location of the two sampling areas, data that were recorded on the IEC page (Ecuadorian, 2016).

Subsequently, the location map of the area was downloaded from the web page, which determines the sampling area together with the descriptive characteristics of the soil recovered from the maps in which they are listed according to surface texture and depth, drainage, effective depth, stoniness, toxicity, pH, salinity, general fertility, temperature and humidity regimes, organic matter, cation exchange capacity and base saturation that correspond to the sampling areas.

For the individual population analysis, the number of animals was counted by calculating the percentage of species diversity by class and phyllum, with the following formula:

$$\% = \frac{\text{\# especies por clases o phyllum de la población}}{\text{Total población}} * 100$$

For the taxonomic identification of the invertebrates, we used the manual of marine benthic invertebrates: mollusks, crustaceans and echinoderms of the Ecuadorian littoral zone (Mair J., Mora E., Cruz M., 2002). (Mair J., Mora E., Cruz M., 2002)Guide for the identification of aquatic invertebrates (Palma, 2013), Catalog of marine bivalves of Ecuador, Scientific and technical bulletin of the INP (Mora, 1990). (Mora, 1990)FAO Guide for the Identification of Species for Fisheries Purposes of the Eastern Pacific, Plants and Invertebrates Volume I (Fischer W., Hendrickx M., 1995) and Most common genera of Molluscs, Gasteropoda and Pelecypoda in Mexico (Pagaza, B. S., 1995). (Pagaza, B. S., & Perez, 2003)The species diversity indices that have been used to analyze the structure of the macroinvertebrate community (Moreno, 2001) were applied.

Data analysis

To verify that the assumptions of normal distribution were met with a $p = 0.05$, the Shapiro-Wilk normality test was applied and applying the homoscedasticity, it was obtained by the Bonferroni confidence interval method, observing an overlap between the two confidence intervals, so the null hypothesis that they are statistically equal is not rejected, the Levene test was applied and a $p = 0.24$ was obtained, which is greater than the $p = 0.05$, so the variance of both zones will not be rejected.

To better demonstrate the two zones, the data were averaged and represented by a box-and-whisker plot, observing significant differences. For the statistical analysis, the Statgraphic 18 Centurion program was used to determine the variation in the macroinvertebrate community structure, a non-parametric Multidimensional Analysis (MDS-Anosim) was applied using square root transformations to create the Bray-Curtis similarity matrix (Clarke & Warwick, 2001).

Subsequently, a graphic representation was made using MDS diagrams of the species in which the similarity of averages between them can be observed, using variables for each subject in the two areas (Clarke & Warwick, 2001).

Results

At the coastal level between the Capaes and Punta Blanca zones, there were no significant differences in the distribution of species (Fig. 2). In the rocky

intertidal zone of Capaes, 5 classes of marine macroinvertebrates were identified, being the group of mollusks the most abundant represented by the class Gasteropoda with 62.8% of relative abundance, followed by Crustacea with 17.41%, Poliplacophora with 10.43% while in lower population density was observed the class Bivalva with 4.97%, followed by the group Malacostraca with 4.39% of abundance (Fig. 3).

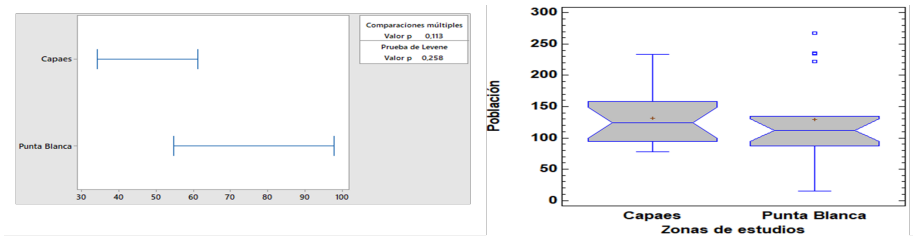

Figure 2 Population distribution of macroinvertebrates between Capaes and Punta Blanca.

Figure 2

Population distribution of macroinvertebrates between Capaes and Punta Blanca.

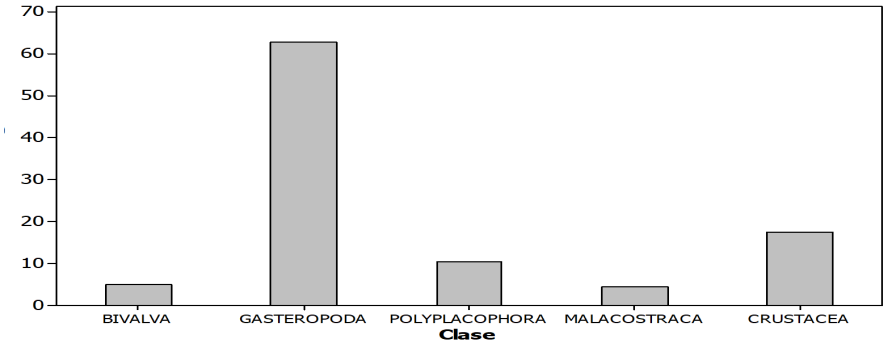

Figure 3. Mollusks and Crustacean Classes found in Capaes.

Figure 3

Mollusks and Crustacean Classes found in Capaes.

As for the temporal variation of abundance values by species, they fluctuated between 6 and 56 ind/m. . The maximum relative abundance was reported in May with the species *Chiton stokessi* with 56 ind/m. , followed by *Tegula picta* with 44 ind/m. , *Tetraclita* with 38 ind/m. and *Cantarus ringens* with 35 ind/m. , decreasing its population in October with 27, 26, 19, and 14 ind/m. , due to environmental conditions that in that month were not suitable for the development of these organisms. (Fig. 4).

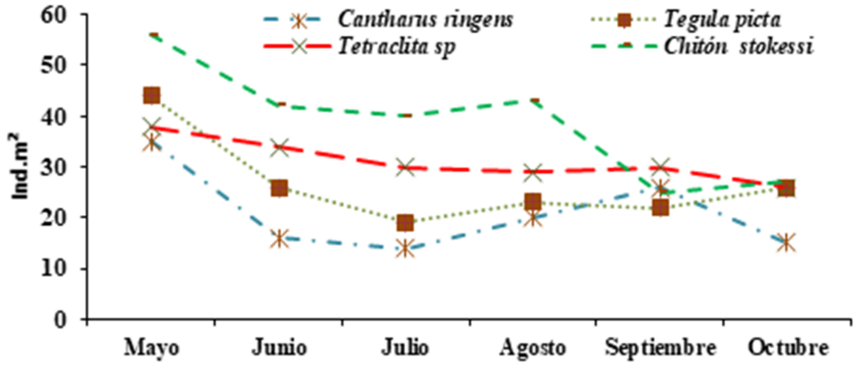

Figure 4. Temporal variation of the most abundant species on Capaes beach.

Figure 4

Temporal variation of the most species on capaes beach

The species *Planaxis planicostatus, Olivela sp, Mitra tristis, Pachygrapsus marrmoratus* and *Thais melones, are* found in medium density in the months of May, July and September with an abundance of 32, 26, 22, 18 and 15 ind/ m^2 respectively, decreasing sharply in October because it is a month where temperatures range between 25 and 26 °C, temperatures not favorable for the development of these species (Fig.5).

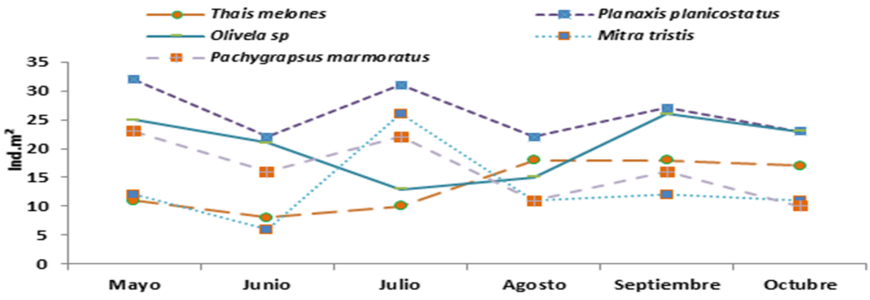

Figure 5. Temporal variation of species with medium population density in Capaes beach.

Figure 5

Temporal variation of species with medium population density in Capaes beach

The distribution of *Thais brevidentata* was irregular, with the highest population density observed in May with 39 ind/m^2, decreasing notably in June with 13 ind/m^2, it is worth mentioning that from July there were slight increases until October, while *Columbela labiosa* registered decreasing behavior from May, which was its maximum density with 32 ind/m^2, *Columbela major had a population of* 15 ind/m^2 in May, decreasing slightly to 13 ind/m^2 in June and reaching its minimum population density in September with a value of 9 ind/m^2, increasing to a population of 21 ind/m^2 in October (Fig. 6).

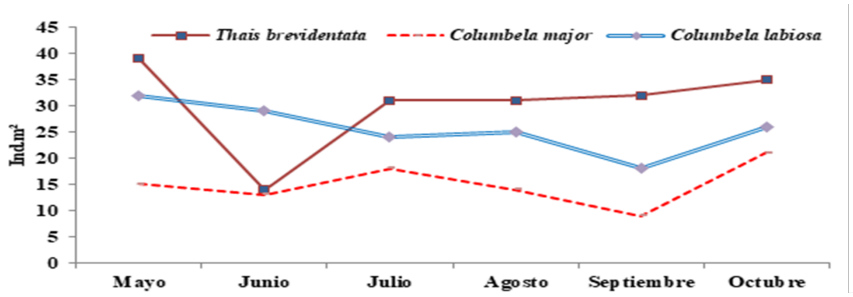

Figure 6. Temporal variation of the most abundant species on Capaes beach.

Figure 6

Temporal variation of the most abundant species on Capaes beach.

Among the species that were constantly and irregularly distributed in the study area were *Brachidontes adamsianus, Cantharus gematus, Thais biserialis, Balanus trigonus and Balanus sp*, which were favored by the environmental conditions during all monitoring months. It is worth mentioning that the species *Balanus trigonus* increases its abundance in June and decreases its population in September, increasing in October (Fig. 7).

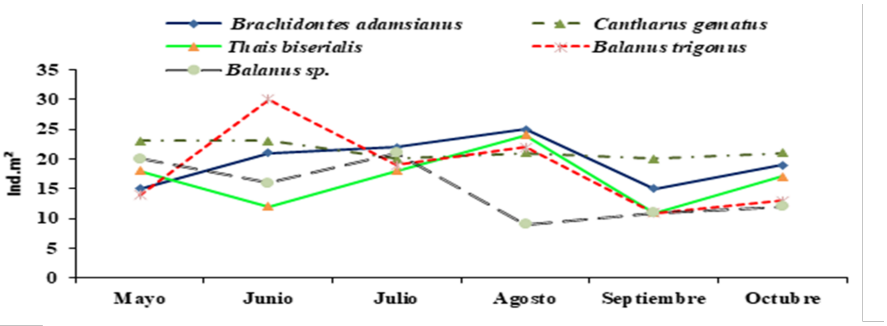

Figure 7. Temporal variation of the constant species in Capaes beach.

Figure 7

Temporal variation of the constant species in Capaes beach.

Diversity

In the Capaes area, in the rocky intertidal zone, the maximum diversity values were recorded at stations E1, E4, E7 and E9 with an average of 2.60 bits, while the minimum diversity values were observed at stations E2, E3, E6 and E8 with a value of 2.44 bits.

The Pielou's evenness index registered homogeneity in the distribution of species in the study area with an average value of 0.96 bits, registering its highest values in stations E4, E5 and E6 with an average of 0.98 bits, showing that, within the distribution of species, none of them is dominant. It is worth mentioning that Simpson's dominance index presented very low values, indicating that there was no dominance in the distribution of species due to the diversity of organisms in the study area. There is a seasonal variation due to the amplitude in distance from the beach (Fig. 8).

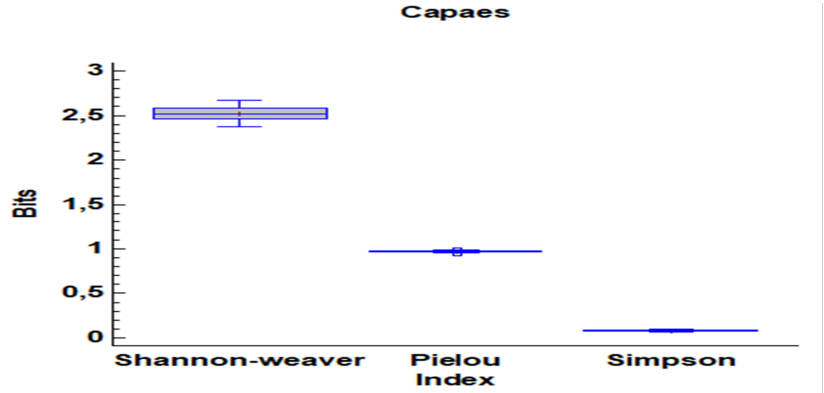

Figure 8. Distribution of Shannon Weaver, Pielou and Simpson ecological indices in the Capaes stations.

Figure 8

Distribution of Shannon Weaver, Pielou and Simpson ecological indices in the Capaes stations.

In Punta Blanca 5 classes of marine macroinvertebrates were identified, being the group of mollusks the most abundant and the Bivalve Class absent in the sector. In the Arthropod group, the Crustacea class represents a considerable percentage, dominated by the Gastropod class, which showed a high percentage (Fig. 9).

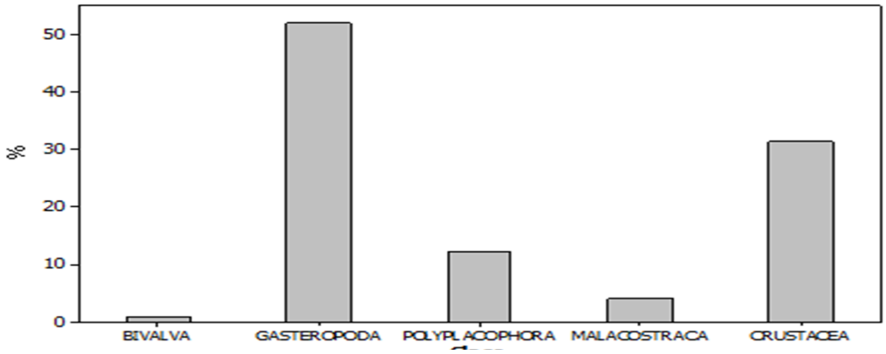

Figure 9. Mollusk and crustacean classes found in Punta Blanca.

Figure 9

Mollusk and crustacean classes found in Punta Blanca.

The highest population diversity occurred in May for the species *Chiton stokessi* with 61 ind/m. , *Tetraclita* with 63 ind/m. and *Balanus trigonus*with 55 ind/m. , which decreased sharply in October with 36 ind/m. and 26 ind/m. . The species *Thais biseriales* and *Olivela, are* part of the second group of species with the highest diversity in April with 31 and 30 ind/m. . The species *Brachidontes adamsianus* presents a minimum diversity of 3 ind/m. in April, which does not vary with the diversity of 6 ind/m. in September, due to the fact that the elements (rocky substrate) for the development of this species are affected by natural phenomena such as high tides and waves (Fig. 10).

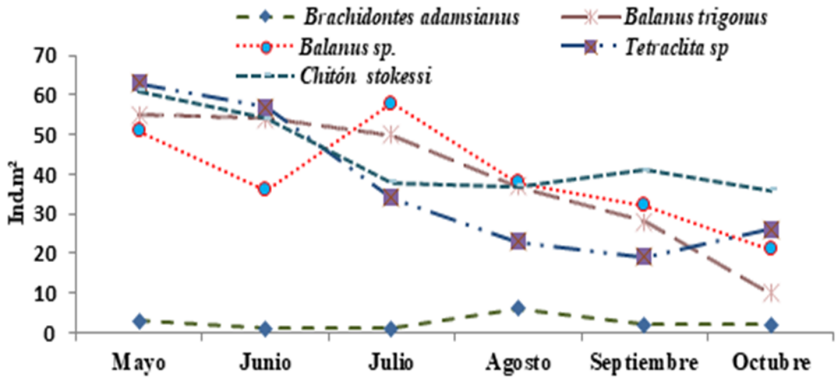

Figure 10. Temporal variation of the most abundant species on Punta Blanca beach.

Figure 10

Temporal variation of the most abundant species on Punta Blanca beach.

The species *Thais biserialis* with 31 ind/m. , *Mitra tristis with 23 ind/m.* , *Catharus gematus with* 21 ind/m. , *Tegua picta with 18 ind/m.* , are found in medium density in the months of May, July and September with an abundance of 31, 23, 21 and 18 ind/m favored by the environmental conditions of the period, but whose diversity is affected and decreases in the month of October (Fig. 11).

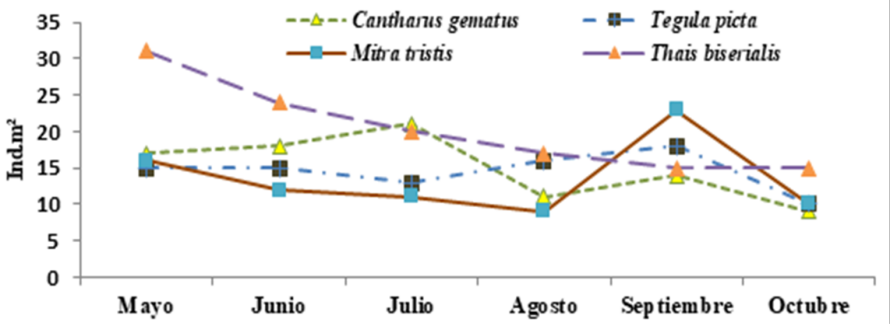

Figure 11. Temporal variation of species with medium population density at Punta Blanca beach.

Figure 11

Temporal variation of species with medium population density at Punta Blanca beach.

The distribution of *the species Planaxis planicostatus and Cantharus ringens* was irregular, with the highest population density in July and August with 30 ind/m^2, decreasing notably in June and September with 12 ind/m^2 and for *Cantharus ringens* with 9 ind/m^2. , while *Thais brevidentata* registered a decreasing behavior since May and its maximum density with 26 ind/m^2, reaching its minimum population density for the month of June with a value of 15 ind/m^2, increasing for October to a population of 26 ind/m^2, while *Thais melones* and *Pachygrapsus marmoratus* presented a population of 16 and 21 ind/m^2 for the month of May, decreasing slightly for June to 4 and 20 ind/m^2 and observing its minimum population for September with a value of 8 ind/m^2 and increasing for October to a population of 10 ind/m^2 (Fig. 12).

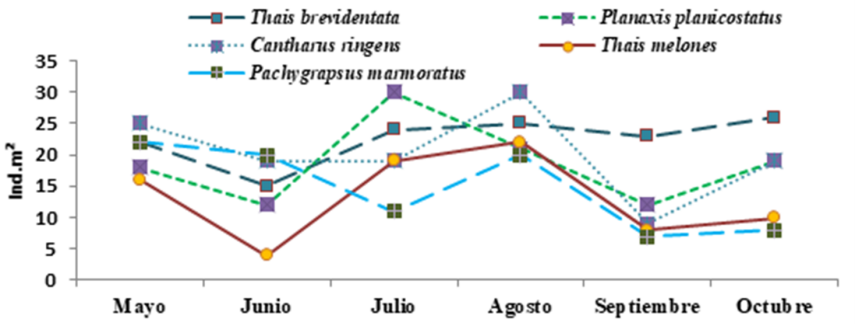

Figure 12. Temporal variation of the most abundant species at

Figure 12

Temporal variation of the most abundant species at Punta Blanca beach.

Among the species that are constantly and irregularly distributed in the study area are *Columbela major and Columbela labiosa,* which were favored by the environmental conditions during all monitoring months. It is worth mentioning that the species *Columbela labiosa* increases its abundance in September and drops sharply in October (Fig. 13).

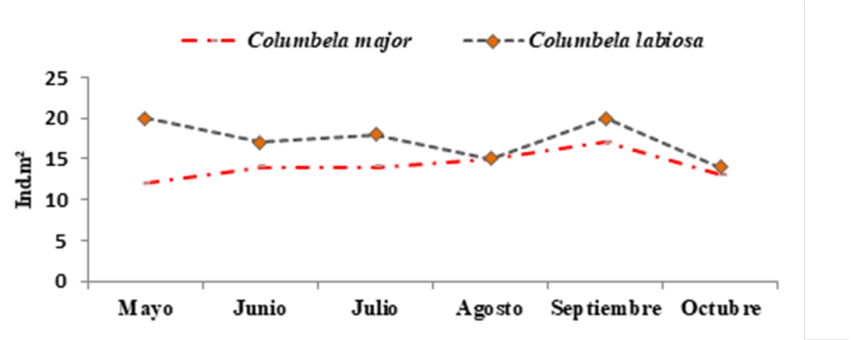

Figure 13. Temporal variation of species that remain constant at Punta Blanca beach.

Figure 13

Temporal variation of species that remain constant at Punta Blanca beach.

In the rocky intertidal zone of Punta Blanca, maximum diversity values were recorded at stations E8 and E9 due to the width and spacing of the rocky beach zone with an average of 2.64 bits, while minimum diversity values were observed at stations E1, E2, E4, E5, E6, E7 with a value of 2.43 bits (Fig. 14a).

The Pielou's evenness index recorded homogeneity in the distribution of species in the study area with a value of 0.96 bits. It is worth mentioning that Simpson's dominance index showed very low values indicating that there was no dominance in the distribution due to the number of organisms in the sector (Fig. 14b).

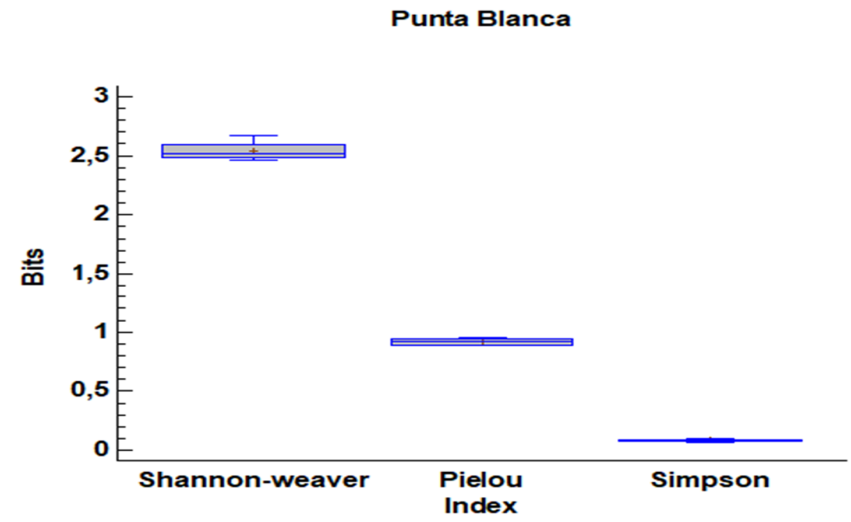

Figure 14. Distribution of Shannon Weaver (a), Pielou and Simpson (**b**) ecological indices at Punta Blanca stations.

Figure 14

Distribution of Shannon Weaver (a), Pielou and Simpson (b) ecological indices at Punta Blanca stations.

The MDS-Anosim showed statistically significant differences in 2015 (R: 0.188; $p<0.01$). SIMPER showed similarity in the two study zones. In zone 1, whose representative species were in a first group to *Mitra tristis* presents an abundance of 4.7%. The second group, *Columbella labiosa, Pachygrapsus marmoratus* and *Brachidontes adamsianus* with 6.8 % of similarity in abundance, these are related to a third group formed by *Thais brevidentata, Tetraclita, Chiton Stokessi, Planaxi planicostatus, Olivela,* and *Cantharus* gematus with 6.7 %.

In zone 2 there is a similarity with the fourth group formed by *Columbella major and Thais melones with a* maximum affinity of 8.2 % and its relationship with *Cantharus ringens* and *Thais biserialis*. While the group formed by *Tegula picta, Balanus trigonus and Balanus* sp. are related in abundance with 6.7% and similarity marked by their low density of 5.5% in relation to the other groups (Fig. 15).

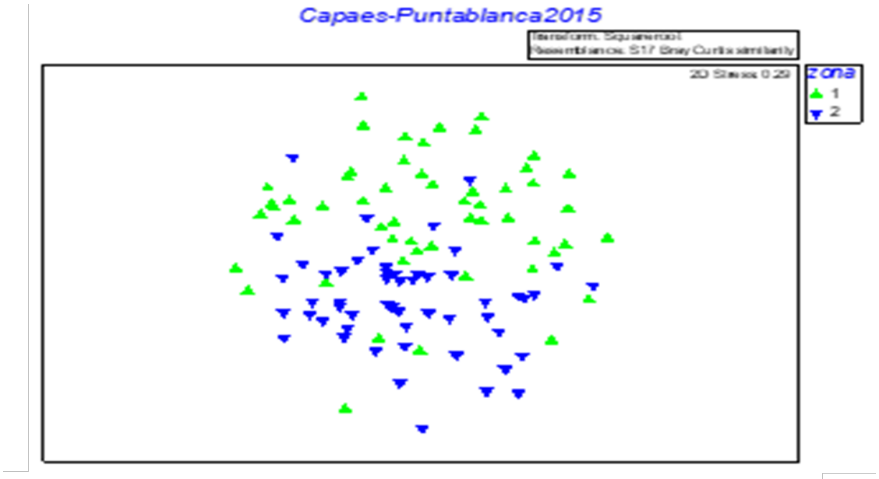

Figure 15. MDS diagram of the community structure in Capaes and Punta Blanca.

Figure 15

MDS diagram of the community structure in Capaes and Punta Blanca.

CAPAES

Within the distribution of macroinvertebrate species, it was observed that both populations did not report differences in population distribution (Fig. 16), while at the Class level, the abundance of Mollusks and Crustaceans found in the Capaes area showed a slight difference, which is statistically interpreted as a similar distribution of organisms in the Class Gasteropoda. (Fig. 17).

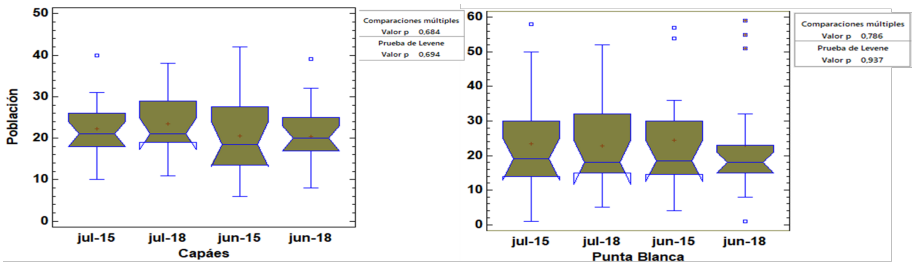

Figure 16. Population distribution of macroinvertebrate populations between Capaes

Figure 16

Population distribution of macroinvertebrate populations between Capaes and Punta Blanca.

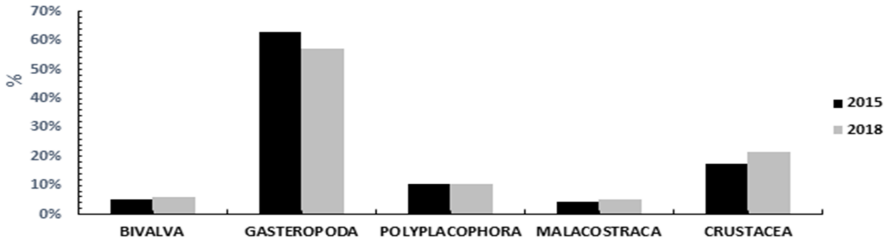

Figure 17. Classes of mollusks and crustaceans found in Capaes.

Figgure 17

Classes of mollusks and crustaceans found in Capaes

As part of the comparison made between the months of June and July of the years 2015 and 2018, it was found that the species *Chiton stokessi* remained the most abundant. No significant differences in its abundance were observed between the years studied. In June 2015, an average of 39 ind/m. was recorded, while in June 2018, the figure was 38 ind/m. . Similarly, in July 2015 and 2018, where 42 ind/m. were identified in both periods.

These results indicate a stability in the presence of *Chiton stokessi* during the months of June and July of the years analyzed. The species maintained a similar population abundance, suggesting a consistency in its distribution and density in the study area during those specific months. These findings contribute to a better understanding of the temporal pattern of this species in the Punta Blanca ecosystem (Fig. 18)

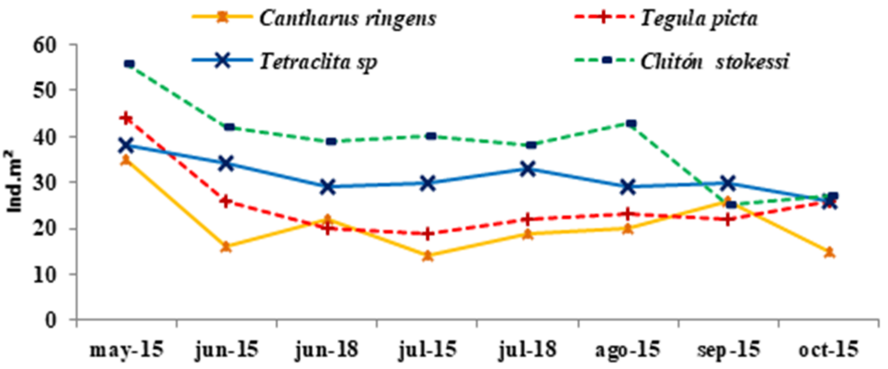

Figure 18. Temporal variation of the most abundant species on Capaes beach.

Figure 18

Temporal variation of the most abundant species on Capaes beach.

In June 2015, the species *Planaxis planicostatus* presented an abundance of 22 ind/m. , while in 2018 this number increased slightly to 25 ind/m. . In July 2015, the abundance of *Planaxis planicostatus* was 31 ind/m. , and in 2018 it increased to 33 ind/m. , consolidating it as the most abundant species in both years and months.

On the other hand, *Thais melone* showed lower abundance in June 2015, with 8 ind/m2, while in 2018, for the same month, 10 ind/m2. In July 2015, the

abundance of *Thais melone* was 10 ind/m2, and in 2018 it increased to 15 ind/m2 .

Regarding *Olivela sp*, it was observed in both June 2015 and 2018, an average of 20 ind/m2. In July 2015 and 2018, the average abundance of *Olivela sp was* 12 ind/m2.

Mitra tristis showed low abundance values in the months of June 2015 and 2018, with 6 and 8 ind/m2, respectively. However, in July 2015 and 2018, higher populations were observed, with 26 and 29 ind/m2, respectively.

The species *Pachyprapus marmoratus* presented an average value of 17 ind/m. in the months of June 2015 and 2018. In July 2015 and 2018, the average abundance was 21 ind/m2.

These results provide detailed information on the variations in abundance of different species during the months of June and July in the years 2015 and 2018 in the study area (Fig. 19).

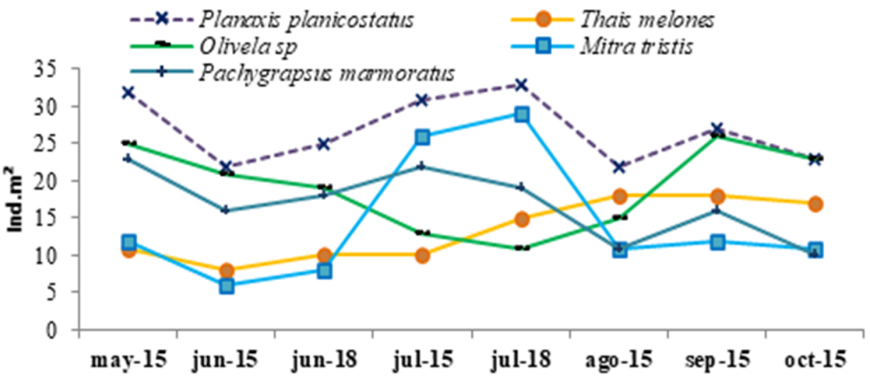

Figure 19. Temporal variation of the most abundant species at

Figure 19

Temporal variation of the most abundant species at Capaes beach.

Among the species considered, *Thais brevidentata* was the most abundant in several months. In June 2015, its abundance was 14 ind/m2, while in June 2018, 17 ind/m2. In July 2015, 31 ind/m2 of *Thais brevidentata* were observed, and in July 2018, the number decreased slightly to 29 ind/m.

As for *Columbela major*, its abundance was found to vary over the months and years analyzed. In June 2015, 13 ind/m2, and in June 2018, the figure decreased to 11 ind/m2. In July 2015, 18 ind/m2 were observed, and in July 2018, abundance increased slightly to 20 ind/m2.

On the other hand, *Columbela labiosa* showed outstanding abundance in June 2015, with 29 ind/m2, and in June 2018, with 22 ind/m2. In July 2015, the species recorded 24 ind/m2, and in July 2018, the amount increased to 26 ind/m2.

These results highlight the fluctuations in abundance of the species considered over different months and years. *Thais brevidentata*was the most abundant species in several months, while *Columbela major* and *Columbela labiosa* also showed significant levels of abundance at certain timesBeginning of the formEnd of the form (Fig. 20).

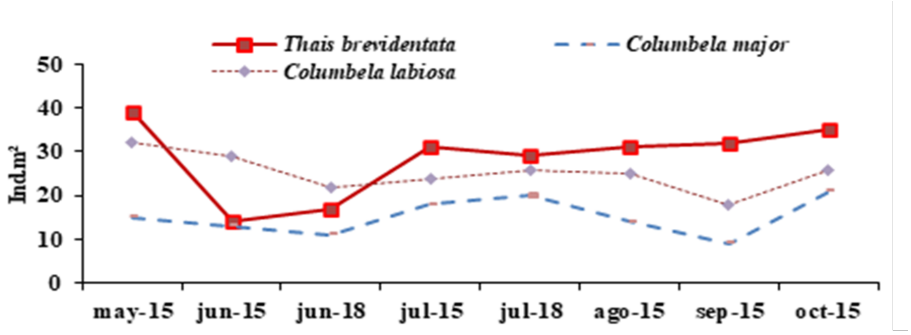

Figure 20. Temporal variation of the most abundant species at Capaes beach.

Figure 20

Temporal variation of the most abundant species at Capaes beach.

During June and July 2015 and 2018, different values of abundance per square meter were recorded for several species.

In June 2015, the species *Brachidontes adamsianus* presented an abundance of 21 ind/m², while in June 2018, this figure increased to 25 ind/m². For its part, *Cantharus gematus* maintained a constant abundance with 23 ind/m² in both years.

Thais biserialis showed a decrease in abundance in June 2015, with 12 ind/m², and in June 2018, with 10 ind/m². As for *Balanus trigonus*, a higher abundance was recorded in June 2018, with 32 ind/m², compared to June 2015, where 30 ind/m² were observed. Finally, *Balanus sp*. presented a decrease in abundance in June 2018, with 19 ind/m², compared to June 2015, where 20 ind/m² were recorded.

In July 2015, *Brachidontes adamsianus* showed an abundance of 22 ind/m², while in July 2018, this figure decreased slightly to 20 ind/m². *Cantharus gematus* also maintained similar abundance in both years, with 20 ind/m² in July 2015 and 18 ind/m² in July 2018.

Thais biserialis and *Balanus trigonus* recorded a constant abundance in July of both years, with values of 18 ind/m² and 20 ind/m², respectively. On the other hand, *Balanus sp*. showed an increase in abundance in July 2018, with 25 ind/m², compared to July 2015, where 21 ind/m² were recorded.

These results reflect the variations in the abundance of the species considered during the months of June and July in the years 2015 and 2018(Fig. 21).

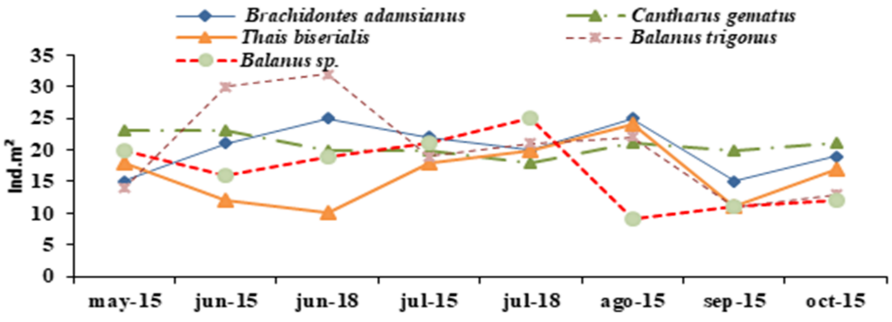

Figure 21. Temporal variation of the most abundant species at Capaes

Figure 21
Temporal variation of the most abundant species at Capaes beach.

PUNTA BLANCA

In a comparative study conducted in the Punta Blanca area in 2015 and 2018, the percentage of organisms found by class was analyzed. The results revealed that the gastropod class showed the highest percentage of abundance of organisms, representing 52% and 48% in the two study years, respectively. No significant difference was observed between the two periods analyzed.

On the other hand, the crustacean class occupied second place in terms of abundance, with a percentage of 31% and 36% in the corresponding years. It is important to note that the bivalve class presented the lowest abundance of organisms, representing only 1% in both years.

These results highlight the predominance of the gastropod class in the Punta Blanca area, followed closely by the crustacean class. The scarce presence of organisms of the bivalve class suggests a possible decrease in their population in recent years. These findings provide valuable information for understanding the distribution and abundance of the different groups of organisms in the study area (Fig. 22).

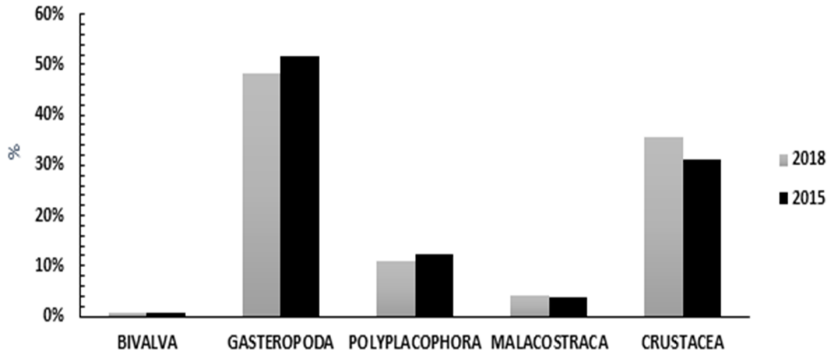

Figure 22. Classes of mollusks and crustaceans found

Figure 22
Classes of mollusks and crustaceans found at Punta Blanca.

A comparison was carried out between two months of monitoring, in the years 2015 and 2018, specifically during the months of June and July. During this period, *Tetraclita sp* was identified as the most abundant species in the studied area.

The results showed that there were no significant differences in the abundance of *Tetraclita sp* between the two years analyzed. In 2015, 57 ind/m. were recorded on average, while in 2018 the figure was slightly lower, with an average of 55 ind/m. . As for the month of July, 34 ind/m. were observed in 2015 and 37 ind/m. in 2018.

These findings indicate that the presence of *Tetraclita sp* remained relatively stable during these two years, with no significant differences in abundance. This provides relevant information on the dynamics of this species in the study area during the months of June and July, allowing a better understanding of its behavior and distribution over time (Fig. 23).

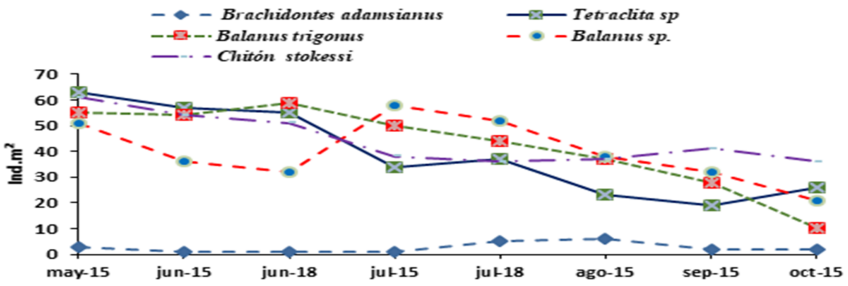

Figure 23. Temporal variation of the most abundant species at Punta Blanca beach.

Figure 23

Temporal variation of the most abundant species at Punta Blanca beach.

Within this group, the species *Thais biserialis* stands out as the most abundant only in the month of May 2015. However, a significant decrease in its abundance was observed during the months of June 2015 and 2018, with values of 24 and 20 ind/m. , respectively. Furthermore, in the month of July 2015 and 2018, the species recorded figures of 20 and 18 ind/m. , respectively. These results indicated a significant decrease in the presence of *Thais biserialis* in the months after May, June and July, providing relevant information about its temporal distribution pattern in the study area. (Fig. 24).

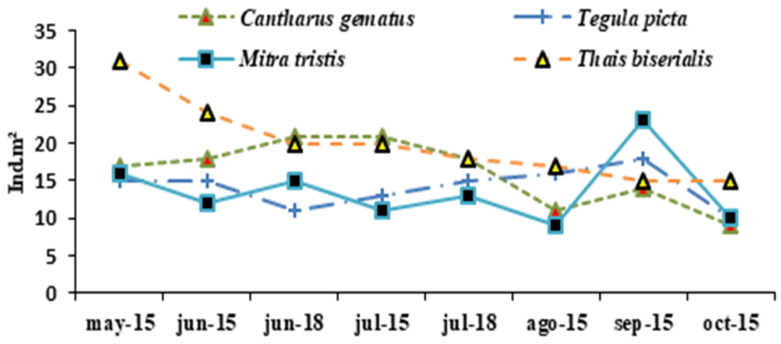

Figure 24. Temporal variation of the most abundant

Figure 24

Temporal variation of the most abundant species at Punta Blanca beach.

In the comparison of the months of June and July between 2015 and 2018, a decrease in the population of *Planaxis planicostatus* was observed in the month of June. In 2015, a population of 12 ind/m. was recorded, while in 2018, it was 16 ind/m. .

On the other hand, it was found that the species *Planaxis planicostatus* reached its highest abundance in the month of July in both 2015 and 2018. In these years, population values of 30 ind/m. were recorded in both periods.

These results indicate variability in the population of *Planaxis planicostatus* among the different months and years studied, with a lower presence in June and a significant increase in July (Fig. 25).

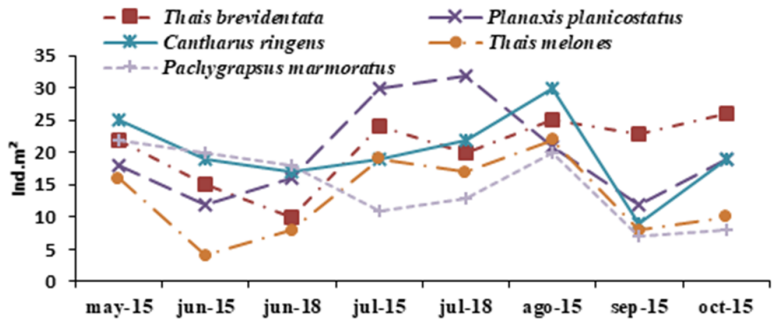

Figure 25. Temporal variation of the most abundant species at Punta Blanca beach.

Figure 25

Temporal variation of the most abundant species at Punta Blanca beach.

Columbela labiosa was identified as the most abundant species in terms of population, with an average of 19 ind/m. in the month of June in both 2015 and 2018. Likewise, for the month of July in both years, an average of 18 ind/m. was observed.

These results indicated that *Columbela labiosa* showed a constant and relatively stable presence in the months of June and July during the years studied. The species maintained a similar population abundance in both periods,

suggesting a certain consistency in its distribution and density in the study area during those specific months in the Punta Blanca ecosystem (Fig. 26).

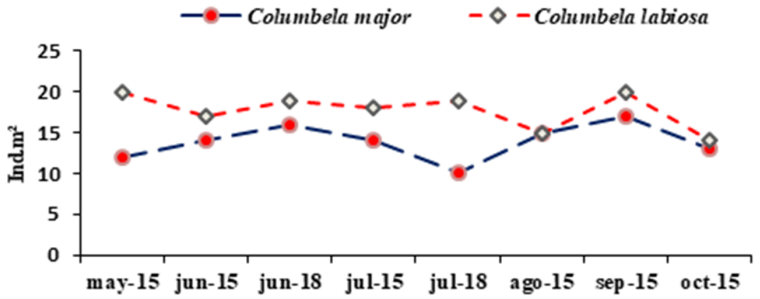

Figure 26. Temporal variation of the most abundant species at Punta Blanca beach.

Figure 26

Temporal variation of the most abundant species at Punta Blanca beach.

The MDS-Anosim showed statistically significant differences (R: 0.371; $p<0.01$) (Fig.27).

SIMPER revealed that the two study areas have a similarity of 48.24%. The most representative species in both sites are *Chiton stokessi, Tetraclita sp*. and *Balanus trigonus*. In addition, the species *Thais biseriales* and *Olivela sp*. belong to the second most diverse group.

In zone 2 (Punta Blanca), the presence of *Brachidontes adamsianus, a* species that shows a clear preference for rocky substrates in the intertidal zone, has been identified. In addition, a second group of species, composed of *Tegula picta, Columbella major, Mitra stistis and Thais melones,* has been found to be closely related in terms of abundance, representing approximately 5% of the population together with *Pachygrapsus marmoratus* (Fig. 27).

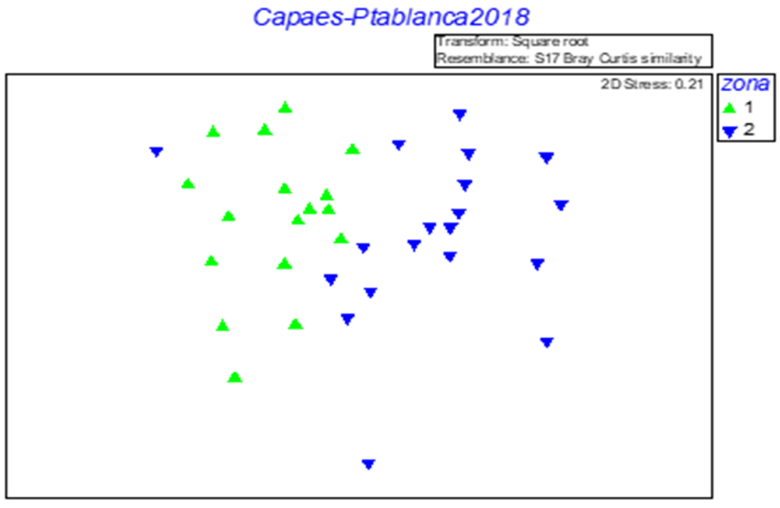

Figure 27. MDS diagram of the community structure in Capaes and Punta Blanca 2018.

Figure 27

MDS diagram of the community structure in Capaes and Punta Blanca 2018.

The present investigation in the areas of Capaes and Punta Blanca, allowed us to obtain records of distribution and abundance of species, very scarce data in these areas, recording *Branchidontes adamsianus* as the only species of bivalves present in the study area, followed by 11 species of Gastropods such as *Thais brevidentata, Tegula picta, Planaxis planicostatus, Columbela labiosa, Cantharus gematus, Thais melones, Mitra tristis, Thais biserialis, Cantharus ringers Olivela sp, Columbella major, Chiton* stokessi and crustaceans represented by *Tetraclita sp, Balanus Trigonus, Balanus sp*. and *Pachygrapsus marmoratus*, in comparison with that reported by (Cruz, 2009. in the intertidal zone of Santa Elena Bay, where he mentions that the dominant species was *Branchidotes puntarenensis* with 64.2%, and in 2007 it continued to predominate with 86%.

According to Villamar & Port, (2009) mentioned that in the Salinas area, crustaceans *Balanus sp*. and crabs *Grapsus grapsus were* recorded with 23%. In the Aeolian cove of Baltra Island in Galapagos, 12 species of mollusks were recorded, including *Acanthochitona hirudiniformes* and *Onchidella steindacheri, Chiton stokessi, Ostrea palmula* and frequent crustaceans among the rocks represented by the infrequent *Grapsus grapsus Oxius verreauxii, Porcellana sp, Calcino sp* (hermit).

While (Cruz, 2013) mentions that in Manta Bay in Punta Mal Paso a total of 19 mollusks were recorded, 10 are bivalves, being the species *Branchidotes adamsianus* with 11.5% abundance, representing 120 ind/m. and 9 gastropods with the species *Littorina paytensis* with 53.4%, representing 100 ind/m. .

An average Shannon Weaver Diversity index of 2.52 bits was recorded in the Capaes sector, Pielou's equitability index recorded homogeneity in the distribution of species in the study area with a 0.966 and Simpson's index 0.08 bits. In the rocky intertidal zone of Punta Blanca an average Shannon Weaver Diversity index of 2.53 bits was recorded, the Pielou's evenness index recorded homogeneity in the distribution of species in the study area with a value of 0.92 bits and Simpson's index 0.09 bits.

In relation to what is stated by Villamar & Port, (2009)(2009), Salinas has the highest richness of organisms with 7 species, representing 34% of the total number of individuals, the highest diversity index for the area was located at the Salinas del Yacht Club station (1.8 bits), likewise, the highest uniformity index (0.97 bit) and Simpson's dominance was observed at the Ballenita station.

The MDS-Anosim diagram showed (R: 0.188; $p<0.01$), confirming the initial trend in 2018 (R: 0.371; $p<0.01$). Thus determining a difference in terms of diversity, since a similarity in terms of abundance was observed, that is to say that over the years there was no alteration or environmental phenomenon that harmed the organisms. The study was carried out specifically in a rocky intertidal zone, which is why there are greater quantities of organisms, especially the gastropod class, in the two areas and years of research, which are of great importance for the ecology of the species.

Conclusions

The 13 species of mollusks and 4 species of crustaceans identified in this research are part of the first records in the Punta Blanca study area.

The group of macroinvertebrates in the rocky intertidal zone of Capaes and Punta Blanca was represented mostly by mollusks and crustaceans, also recording species of echinoderms, but in minimal quantities not considered in the study. The most abundant mollusk species in the Capaes and Punta Blanca area were *Chiton stokessi and Thais brevidentata*, while the most abundant crustacean species were *Tetraclita sp* and *Balanus trigonus*.

The Capaes and Punta Blanca sectors have similar species diversity and abundance records since they have the same soil type and are located in the same coastal strip.

It is recommended to continue with studies of marine macroinvertebrates, conducting continuous monitoring using the appropriate methodology at both times of the year in order to obtain continuous records of the diversity and distribution of species of mollusks and crustaceans, if they change or are similar with the presence of natural phenomena, environmental parameters and anthropogenic incidence.

In addition, this area should be recognized for its biological diversity and not only for its attractive beaches. It is worth mentioning that the present study is the first to be carried out in these areas on the distribution and abundance of macroinvertebrates.

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