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Variation of Density and Biomass of the Ichthyofauna Associated to Soft Bottoms of a Western Coastal Lagoon of B.C.S., Mexico

Bruma Rachel Castillo Rosas[1], Emelio Barjau González[1*], Juan Manuel López Vivas[1], José Ángel Armenta Quintana[2], Javier Aguilar Parra[3], Rodolfo Daniel Acosta Guerrero[1], Rogelio Esquivel Tiscareño[1]

[1]Departamento Académico de Ciencias Marinas y Costeras, Universidad Autónoma de Baja California Sur, La Paz, B.C.S.
[2]Departamento Académico de Ciencia Animal y Conservación del Hábitat, Universidad Autónoma de Baja California Sur, La Paz, B.C.S.
[3]Departamento Académico de Sistemas Computacionales, Universidad Autónoma de Baja California Sur, La Paz, B.C.S.
Email: rosasr818@gmail.com, *ebarjau@uabcs.mx, jmlopez@uabcs.mx, jarmenta@uabcs.mx, jaguilar@uabcs.mx, roac_19@alu.uabcs.mx, resquivel_20@alu.uabcs.mx

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Abstract

An analysis of the variation of the density and biomass of the fish communities of the lagoon of La Paz, Mexico was carried out from November 2016 to September 2017. A total of 2763 organisms were collected with a total biomass of 211,422.93 g in an area of 5022 m^2, a density and biomass of 0.550 lnd/m^2 and 44.091 g/m^2. The site with the largest biomass was recorded in Zacatecas (11.179 g/m^2) located north of the lagoon, while Grand Plaza recorded the lowest biomass (2.732 g/m^2). Regarding the density, the maximum value was recorded in the site Yate Hundido, located northwest of the lagoon (0.129 lnd/m^2) and the lowest was Las Palmas (0.036 lnd/m^2) located north of the lagoon. The most abundant species was *Diapterus peruvianus* with 683 individuals and a biomass of 37,507.57 g. The physicochemical variables showed two seasons with significant change where we can observe higher temperatures in the summer (average of 27.45˚C) and minimum in winter (average of 22.49˚C). The Shannon-Weaver diversity index showed a difference (p = 0.050) between months, with the highest value recorded in April (H' = 2.133 bits/ind) and the lowest in June (H' = 1.041 bits/ind). The biomass and density values recorded in the lagoon were found to be associated with the spatio-temporal variation of temperature of the lagoon, as well as the resident and transitory species located in the area of study. In addition, the body sizes recorded corresponded to juvenile and young adult individuals.

Keywords

Lagoon of La Paz, Diversity, Abundance, Dominance

1. Introduction

The Mexican coast encompasses a wide variety of estuaries, lagoons, and bays with great diversity of fishes. This highlights the relevance of these areas that provide habitat to numerous communities of fishes with potential for fishing, which use these ecosystems as refuge, feeding ground, and nursery [1] [2].

The lagoon of La Paz is a coastal lagoon with sites recognized for their oceanographic characteristics like shallow bathymetry, dynamic physicochemical factors, as well as predominance of sandy bottom in its northern region, and mud and dirt in the south region [3]. Regarding its climate, it is semi-desert with predominantly high temperatures coupled with low precipitation contribution, as well as tropical cyclones that are capable to change and remove the substrate [4].

Studies about the biomass and density of the ichthyofauna in coastal lagoons provide information about the impact of anthropogenic factors on such ecosystems, besides it allows us to obtain information about the energy input based on the biomass present during the year, as well as the composition and the trophic structure of fish communities [5] [6] [7]. Moreover, similar studies mention that biomass and density are affected by factors like salinity, temperature, dissolved oxygen, and biotic pressures such as increase and decrease of predators and availability of food, which are important characteristics from the economic and ecological point of view, since these provide a wide variety of ecosystem services [8]. In addition, since the construction of marinas and hotels has increased in the lagoon of La Paz, hydraulic dredging is carried out periodically to facilitate port operations and to allow the entry of all kinds of sailboats and yachts to the marina located next to the hotel Grand Plaza that can cause changes in the structure and diversity of the fish communities that inhabit the area, such as those demonstrated in research related to the study area where it is shown that abiotic and anthropogenic factors intervene in affecting the environment, organisms and therefore both their biological processes [9].

2. Methods

2.1. Area of Study

The lagoon of La Paz (**Figure 1**) is located south of the La Paz Bay, in the state of Baja California Sur, between the geographical coordinates 24˚11' and 24˚06' North latitude, and 110˚19' and 110˚25' West longitude. It is separated from the Bay by a sandy barrier denominated "El Mogote" with a length of approximately 11 km from east-west, and 2.7 km in its widest area [10].

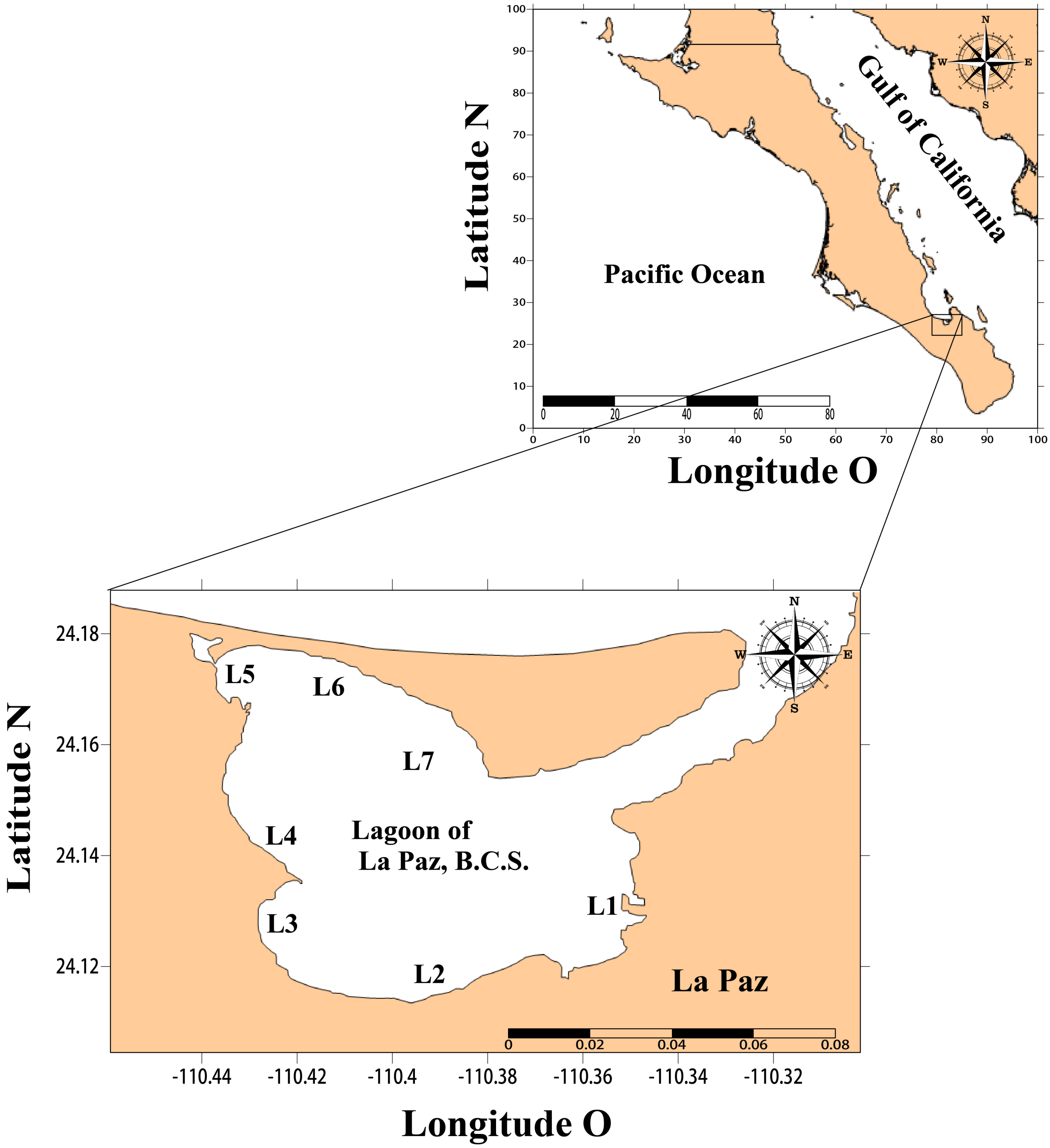


Figure 1. Location of the study area and sampling locations. Grand Plaza (L1), Aeropuerto (L2), Aripez (L3), Cibnor (L4), Zacatecas (L5), Las Palmas (L6), Yate Hundido (L7).

Specimen collection was carried out from November 2016 to September 2017, with a total of 42 replicates from six samplings (one every two months) in seven sites. Collection was carried out using an experimental trawl net with a length of 9.5 m, an opening of 4.5 m, mesh size of 4.44 cm and 95 × 50 cm metal doors. The net is made of polyamide and multifilament and the body of the net is a short tunnel, with a trawling speed of 3.5 km/h, sweep duration of 20 minutes at an average depth of 5 m. A 22-feet-length boat with a 75 HP four-stroke outboard motor, owned by the Autonomous University of Baja California Sur (UABCS). The swept area was set at 5022 m^2 (considering the width and distance traveled, as well as depth). Environmental variables like temperature (T˚), salinity (UPS) and dissolved oxygen were recorded at the beginning of each sweep and were taken at a depth of 5 m with a YSI model 2030 Pro multimeter.

After collection, fish specimens were transferred to the Laboratory of fish ecology at UABCS to be processed. Morphometric measurements of each organism were taken, weight was recorded using a Ohaus Explorer Pro scale, and all specimens were identified to species level using specialized literature. The pre-preservation was carried out by injecting 10% formaldehyde, followed by a rinse with tap water during five days, after which all specimens were preserved in 70% ethanol.

2.2. Data Analysis

Environmental variables were analyzed to test for normal distribution. Kruskal-Wallis test was used to look for significant differences between months and sites.

Biomass was calculated with number of individuals by their average weight [11].

$$B = g/m^2 \quad (1)$$

where B = Biomass, g = grams, m = meters.

Density was calculated by the ratio of individuals per unit of volume [12].

$$D = \text{Ind}/m^2 \quad (2)$$

where D = Density, Ind = Individuals, m = meters.

The following ecological analyses were carried out from biomass:

Shannon & Weaver index (H') is often used when the samples are collected with nets, traps or transects, allowing the comparison of the results with similar studies carried out in other coastal lagoons. This index reflects the heterogeneity of a community based on two metrics: number of species and their relative abundance [13].

$$H' = -\sum (pi)(\ln pi) \quad (3)$$

where: H' = Shannon & Weaver index, lnpi = natural logarithm of the total proportion of the sample.

Pielou's evenness index (J') is calculated from the Shannon & Weaver diversity index (H'). It is a component of diversity and an indirect measure of the relative abundance. It uses values from 0 to 1. Values closer to 1 indicate greater sample evenness, while values closer to 0 indicate unevenness or a greater dominance of some species.

$$J' = H'/\ln(S) \quad (4)$$

where: J' = Evenness index, H' = Shannon & Weaver index, S = Number of species.

Non-metric multidimensional scale (NMDS) is a wide family of multivariate analysis that represent the proximities between a set of elements in a space with a reduced number of dimensions. Thus, it establishes an analogy between proximity (similarity and dissimilarity) and geometric distance, reflecting the differences between both in a function called tension [14].

$$d_{ij} = \left[\sum_{a-1}^{m} \left| x_{ia} - x_{ja} \right| \lambda \right] \frac{1}{\lambda} \tag{5}$$

For the interpretation of this analysis, we used the analysis of similarity (A-NOSIM) to determine the significant groups using PRIMER V7 and Permutational Multivariate Analysis of Variance Analysis (PERMANOVA).

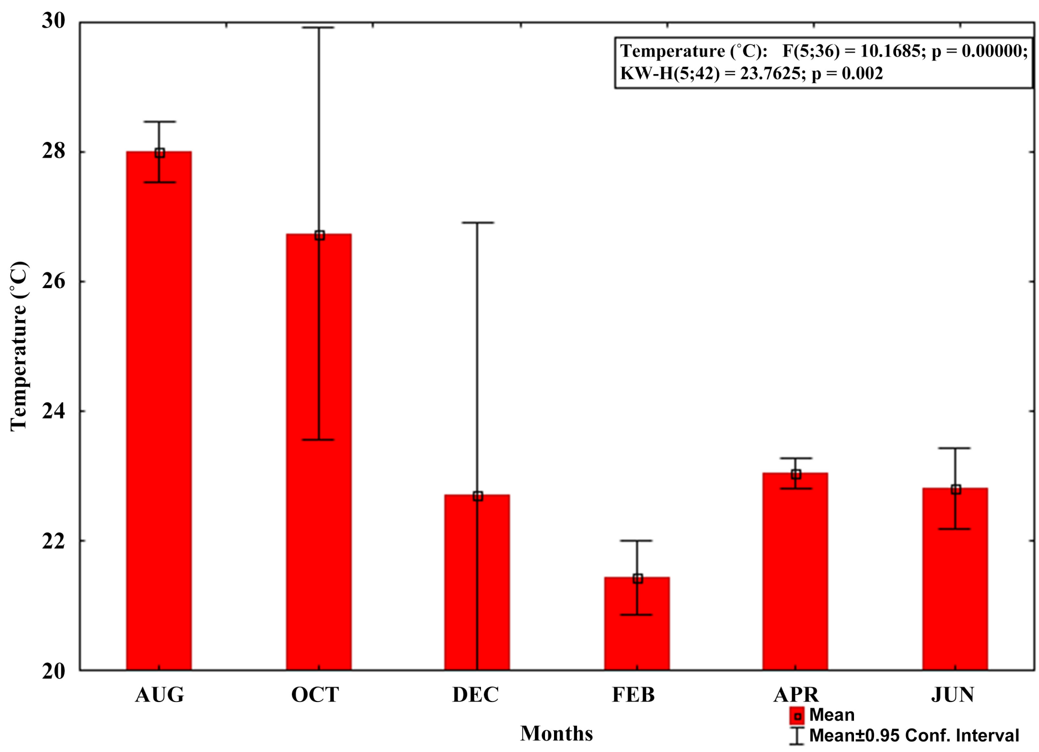
3. Results

3.1. Environmental Variables

The temporal structure of the temperature showed significant differences between months ($p < 0.05$). August recorded the highest temperature (28.17˚C) and the lowest was recorded in February (21.43˚C) (**Figure 2(a)**).

The spatial structure of the temperature did not register significant differences between sites ($p = 0.9675$). The lowest value was recorded in Zacatecas (23.28˚C), while the highest value was recorded in Grand Plaza (25.42˚C) (**Figure 2(b)**).

Salinity did not show significant difference between months ($p = 0.6343$) (**Figure 3(a)**). The highest value was recorded in October (33.97 UPS), and the lowest in April (31.90 UPS). In addition, salinity did not show significant differences



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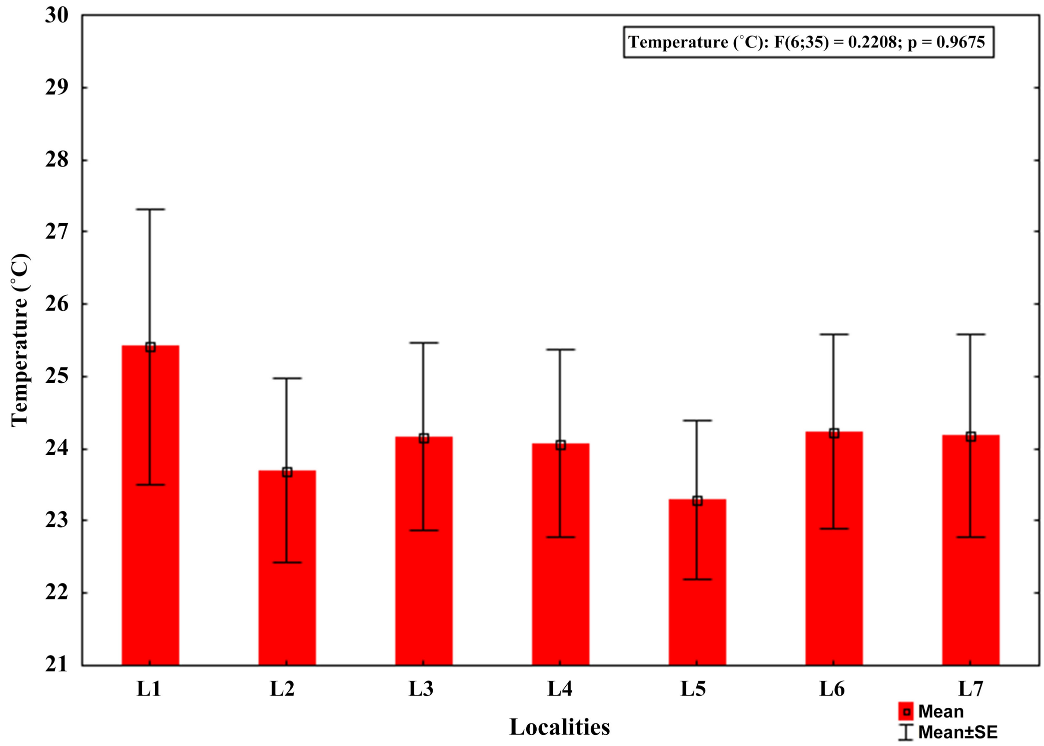
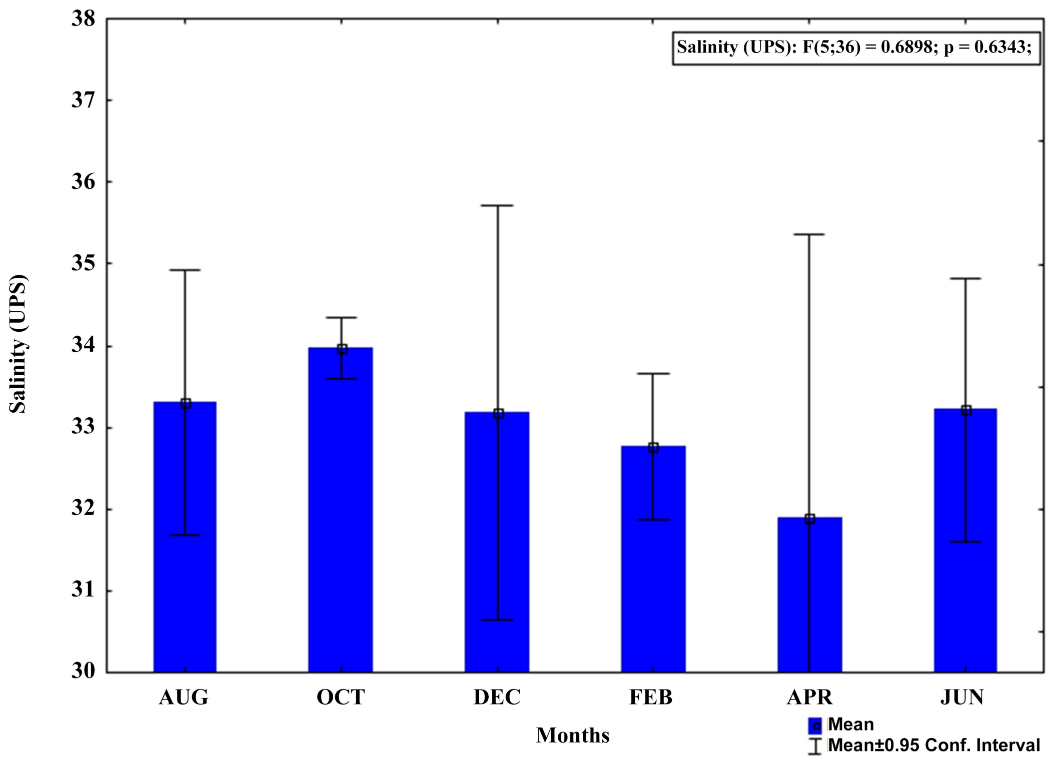


(b)

Figure 2. Temporal and spatial of the temperature of the coastal lagoon of La Paz. Months (a) Aug, Oct, Dec, Feb, Apr, Jun. Localities; (b) Grand Plaza (L1), Aeropuerto (L2), Aripez (L3), Cibnor (L4), Zacatecas (L5), Las Palmas (L6), Yate Hundido (L7).



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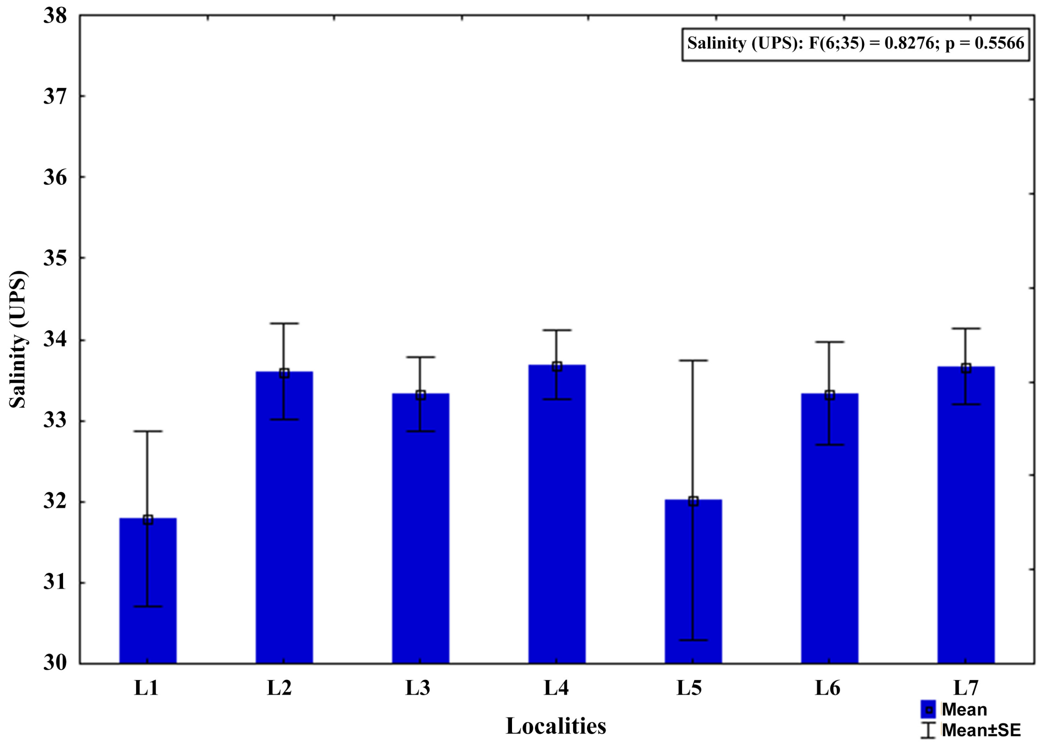


(b)

Figure 3. Temporal and spatial of the salinity of the coastal lagoon of La Paz. Months (a) Aug, Oct, Dec, Feb, Apr, Jun. Localities; (b): Grand Plaza (L1), Aeropuerto (L2), Aripez (L3), Cibnor (L4), Zacatecas (L5), Las Palmas (L6), Yate Hundido (L7).

between sites (p = 0.5756) (Figure 3(b)). The lowest value was recorded in Grand Plaza (31.78 UPS), while the highest was recorded in Cibnor (33.68 UPS).

Dissolved oxygen (DO) did not show significant differences between months ($p < 0.5$). The lowest registry was in August with 12.44 mg/L and the highest in June with 21.92 mg/L (Figure 4(a)). The spatial DO did not show significant differences between sites (p = 0.9095), the highest value was recorded in Yate Hundido with 21.25 mg/L, and the lowest value was recorded in Zacatecas with 18.39 mg/L (Figure 4(b)).

3.2. Biomass

The total weight obtained was 221,422.93 g which was used to calculate the total biomass of 44.091 g/m^2 with *Diapterus peruvianus* (16.937 g/m^2) and Paralabrax *maculatofasciatus* (10.857g/m^2) as the most representative species. The lowest biomass value was recorded in Aeropuerto (2.732 g/m^2) and the highest in Zacatecas (11.179 g/m^2). The highest value of biomass was recorded in April (0.343 g/m^2) and the lowest in August (0.001 g/m^2) (Table 1).

3.3. Density

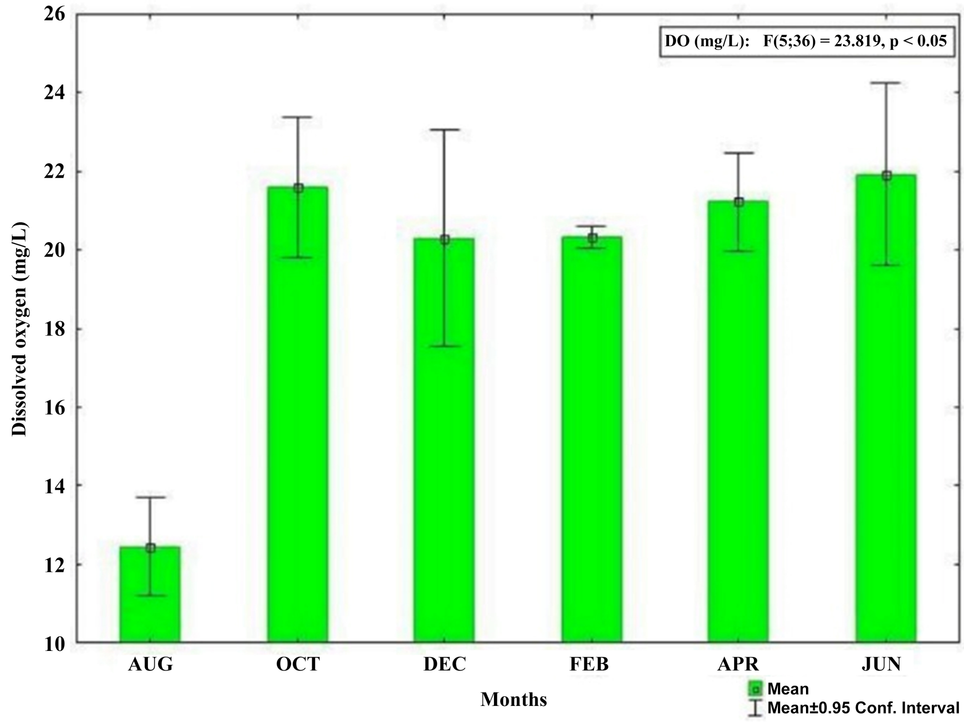
The total area sampled was of 5022 m^2, with a total of 2762 individuals, with a density of 0.550 Ind/m^2 being the most representative: *Diaterus peruvianus* (0.136

Table 1. Species recorded in the lagoon of La Paz: Weight (g), Biomass (kg/m^2) & Density (ind/m^2).

SPECIES	RELATIVE ABUNDANCE	WEIGHT	RELATIVE BIOMASS	DENSITY
Diapterus peruvianus	24.728	37,507.57	16.937	0.136
Paralabrax maculatofasciatus	12.600	24,043.12	10.857	0.0693
Eucinostomus argenteus	8.979	21,377.69	9.654	0.0494
Haemulon sexfasciatum	6.626	16,100	7.270	0.0364
Eucinostomus gracilis	6.553	14,144.53	6.387	0.036
Eucinostomus currani	4.055	10,941.42	4.941	0.0223
Larimus pacificus	3.657	10,652.77	4.811	0.0201
Achirus mazatlanus	3.041	9475.2	4.279	0.0167
Orthopristis chalceus	2.824	8981.13	3.990	0.0155
Diplectrum pacificum	2.715	7549.02	3.409	0.0149
Synodus scituliceps	2.679	5902.96	2.666	0.0147
Urotrygon reticulata	2.209	5133.63	2.318	0.0121
Haemulon scudderi	1.991	5105.38	2.305	0.011
Eugerres axillaris	1.883	3181.44	1.437	0.0104
Anchoa ischana	1.195	3084.9	1.393	0.0066
Stellifer sp.	1.086	2888.56	1.304	0.006
Xenichthys californiensis	1.014	2688.87	1.214	0.0056
Eugerres lineatus	0.941	2622.27	1.184	0.0052
Urobatis maculatus	0.905	2439.21	1.101	0.005
Calamus brachysomus	0.833	1958.1	0.884	0.0046
Eucinosmtomus entomelas	0.797	1922.55	0.868	0.0044
Anisotremus interruptus	0.760	1872.11	0.845	0.0042
Syacion ovale	0.543	1688	0.762	0.003
Orthopristis reddingi	0.507	1558.42	0.677	0.0028
Sphoeroides annulatus	0.507	1500	0.632	0.0028
Diodon holocanthus	0.471	1399.99	0.535	0.0026
Bairdiella icistia	0.471	1185.1	0.531	0.0026
Haemulopsis leuciscus	0.434	1077.22	0.486	0.0024
Gerres cinereus	0.398	1026.82	0.464	0.0022
Serranus psittacinus	0.362	930.8	0.420	0.002
Trachinotus kennedyi	0.326	860.24	0.388	0.0018
Lutjanus argentiventris	0.290	827.73	0.374	0.0016
Microlepidotus brevipinnis	0.290	780.08	0.352	0.0016
Micropogonias altipinnis	0.253	694.7	0.314	0.0014
Bagre panamensis	0.217	681	0.308	0.0012

Continued

Paralichthys woolmani	0.181	632.36	0.286	0.001
Dasyatis brevis	0.181	567.22	0.256	0.001
Pomadasys panamensis	0.181	535.1	0.242	0.001
Hippocampus ingens	0.145	515.67	0.233	0.0008
Cheilotrema saturum	0.145	510.69	0.231	0.0008
Haemulon steindachneri	0.109	498.59	0.225	0.0006
Haemulon maculicauda	0.109	450.05	0.203	0.0006
Umbrina xanti	0.109	422.7	0.191	0.0006
Lutjanus novemfasciatus	0.109	381.34	0.183	0.0006
Occidentaruis platypogon	0.109	283.16	0.172	0.0006
Sphoeroides sechurae	0.072	275.36	0.172	0.0004
Syclopsetta panamensis	0.072	259.4	0.128	0.0004
Paraclinis ditrichus	0.072	233	0.124	0.0004
Pomadasys macracanthus	0.072	215.4	0.105	0.0004
Opistonema libertate	0.072	196.38	0.097	0.0004
Cynoscion reticulatus	0.072	187.25	0.089	0.0004
Urobatis halleri	0.072	187	0.085	0.0004
Diplectrum labarun	0.072	176.6	0.084	0.0004
Rhinobatus productus	0.072	135	0.080	0.0004
Hoplopargus guentheri	0.072	133.7	0.061	0.0004
Etropus crossotrus	0.072	115.63	0.060	0.0004
Cyclopsetta panamensis	0.072	103.7	0.052	0.0004
Paraclinus mexicanus	0.072	75.6	0.047	0.0004
Urotrygon chilensis	0.036	74.4	0.034	0.0002
Diodon hystrix	0.036	61.47	0.034	0.0002
Xenichthys xanti	0.036	60.79	0.028	0.0002
Prionotus birostratus	0.036	55.1	0.027	0.0002
Nematistius pectoralis	0.036	53	0.025	0.0002
Urobatis concentricus	0.036	44	0.024	0.0002
Caranx speciosus	0.036	43.17	0.020	0.0002
Haemulopsis axillaris	0.036	40.6	0.019	0.0002
Cynoscion squamipinnis	0.036	37.7	0.018	0.0002
Symphurus chabanaudi	0.036	33.88	0.017	0.0002
Atractoscion nobilis	0.036	33.7	0.015	0.0002
Prionotus horrens	0.036	24.1	0.015	0.0002
Pseudopenneus grandisquamis	0.036	8.6	0.011	0.0002
Chaetodipterus zonatus	0.036	2.46	0.004	0.0002
Paraclinus sinus	0.036	0.63	0.001	0.0002
TOTAL	**100**	**221,422. 93**	**100**	**0.55**



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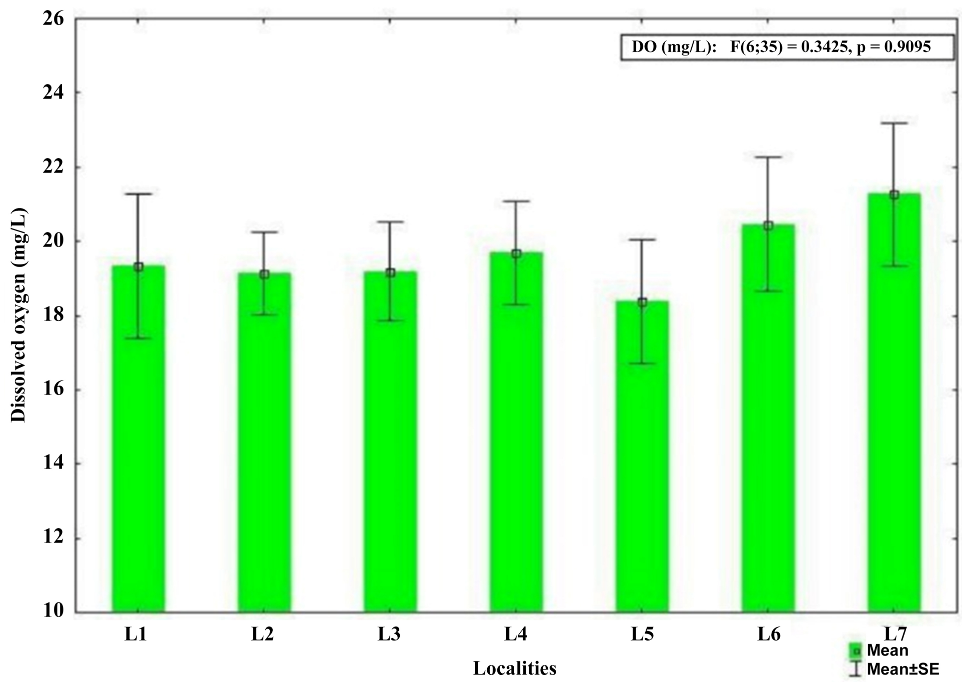


(b)

Figure 4. Dissolved oxygen Months (a) Aug, Oct, Dec, Feb, Apr, Jun. Localities; (b) Grand Plaza (L1), Aeropuerto (L2), Aripez (L3), Cibnor (L4), Zacatecas (L5), Las Palmas (L6), Yate Hundido (L7).

Ind/m^2), *Paralabrax maculatofasciatus* (0.069 Ind/m^2) and *Eucinostomus argenteus* (0.049 Ind/m^2). The spatial structure of density showed the highest value in

Cibnor (0.127 Ind/m^2) and a minimum recorded in Grand Plaza (0.044 Ind/m^2) and Aeropuerto (0.041 Ind/m^2). The temporal structure of density showed the highest value in February (0.193 Ind/m^2), while the lowest was recorded in August (0.034 Ind/m^2) (**Table 1**).

3.4. Shannon-Weaver Index

The temporal analysis based on biomass showed significant differences between months (p = 0.0002). The highest value of diversity was recorded in April (H'= 2.133 bits/ind) and the lowest in June (H'= 1.041 bits/ind) (**Table 1**). However, the spatial analysis did not show significant differences (p = 0.0508). The highest value was recorded in Zacatecas (1.999 bits/ind), while the lowest values were recorded in Grand Plaza (H' = 0.934 bits/ind) and Aeropuerto (H' = 0.934 bit/ind).

3.5. Evenness

The temporal analysis estimated from the biomass, showed significant differences between months (p = 0.008), with the lower values recorded in October (J' = 0.429) and December (J'= 0.630), while the remaining months showed a small variation between 0.875 and 0.939 (**Table 1**). The spatial analysis did not show significant differences (p = 0.411), the highest value was recorded in Cibnor (J'= 0.917) and the lowest was recorded in Yate Hundido (J'= 0.488).

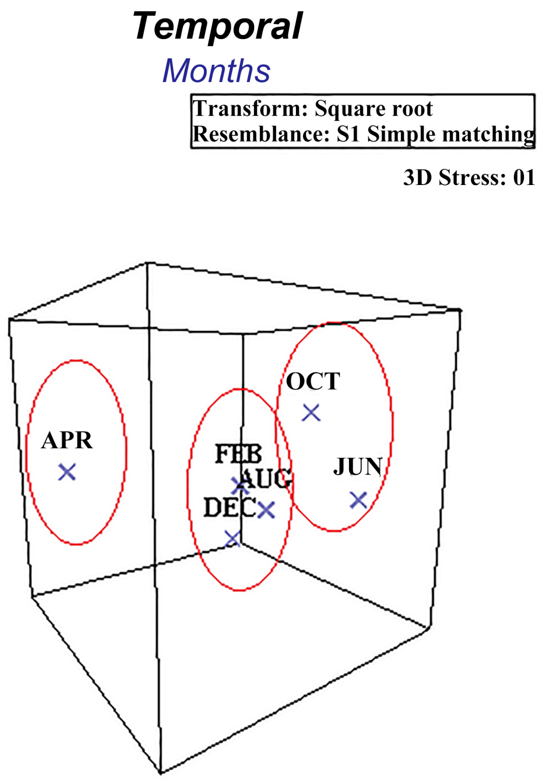
3.6. Non-Metric Multi-Dimensional Scaling Similarity

Based on the analysis of NMDS, biomass showed three groups with tension of 0.01, in which April represented a single group, the second group consisted of February, August and December and the third group by June and October. The results of the temporal analysis of similarity (**Figure 5(a)**) showed August and December with the highest similarities (ANOSIM = 74.324), followed by February (ANOSIM = 72.973) while April showed the lowest similarity compared to other months, which maintained a range from 48% to 55% of similarity. The spatial analysis (**Figure 5(b)**) based on biomass showed five groups with tension of 0.01, in which Aripez represented the first group, the second group consisted of Cibnor and Yate Hundido, the third group was represented by Grand Plaza, the fourth group consisted of Aeropuerto and Las Palmas, and the fifth was re-presented by Zacatecas. The spatial similarity showed Las Palmas with the highest similarity (ANOSIM = 79.452%) compared to Aeropuerto, while the lowest value was recorded in Zacatecas (ANOSIM = 46.575%) compared to Aripez.

4. Discussion

4.1. Environmental Variables

The temporal relation abundance-temperature was defined by temperature. The temporal analysis showed an increase from August to October, with an average



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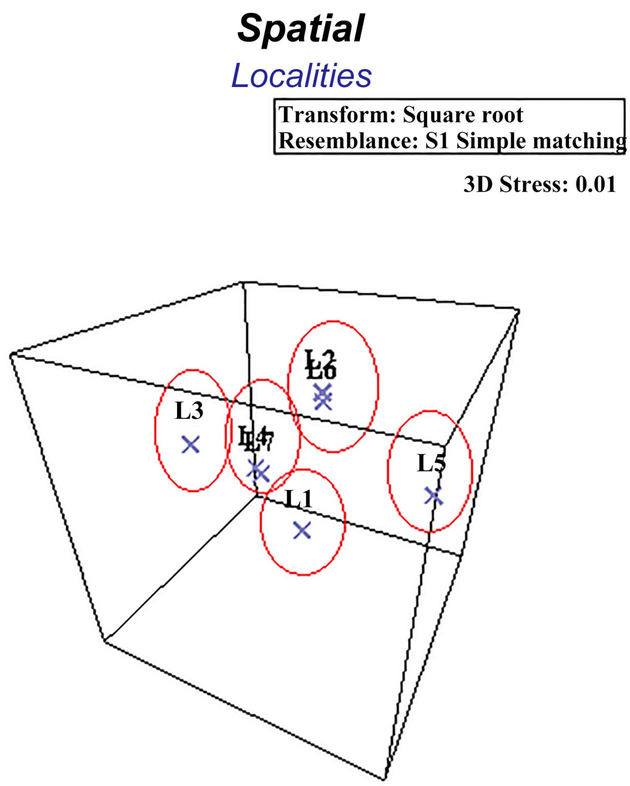

(b)

Figure 5. Temporal and spatial of the Non-Metric Multi-Dimensional Scaling (NMDS) of the coastal lagoon of La Paz.

of 27.45˚C, and a decrease from December to June, with an average of 22.49˚C, favoring the entrance of fish species with subtropical affinity during the first period, and the entrance of fish species with temperate affinity during the second period, similar to a previous report by Gomez-Leo [15] who mentioned that the coldest months are January and February with an average temperature of 20˚C. Moreover, a study by Barjau-González [16] in the bay adjacent to the lagoon of La Paz, showed that the warmest months allow ideal conditions to increase the coverage, biomass and associated fauna. In another study of a coastal lagoon in the gulf of California, showed that there is a seasonal pattern similar to the one found in the present study, finding that the warmest month is in September with an average of 33.5˚C and a minimum in February with an average of 17.5˚C [17]. The spatial analysis of temperature did not show significant differences between sites, but a slight increase was observed between sites. On the other hand, Gomez-Leon [15] mentioned that the temperature has a variation of approximately 4˚C inside the lagoon, in which the northwest part tends to have a temperature of 30˚C and the southwest a record of 26˚C. These variations are caused by the water masses that enter and exit the lagoon throughout the day, which influence the arrival and departure of fish fauna [18].

The temporal analysis of salinity did not show differences between months, however, a study by Gonzalez-Acosta [19] in the lagoon of La Paz, mentioned that there is an evaporation of 33% that increases to 55% during spring. On the other hand, the spatial analysis of salinity showed differences between sites. Barjau-González [16] mentioned that in the Bay of La Paz the salinity increases in shallow areas and decreases in deeper areas. Since the lagoon of La Paz is considered a shallow area, this suggests is a hypersaline lagoon, with low contributions of freshwater and a high degree of evaporation, therefore, high values of salinity are common.

The temporal pattern of DO was considered stable during the year, while the spatial DO showed differences, which can be explained by the differences of depth between the sampled sites, showing a higher saturation in shallow areas and lower in deeper areas. Gutiérrez-Sánchez [20] reports a difference between physicochemical factors in the lagoon complex Bahia Magdalena, due to oceanic influence, bathymetry, and differential evaporation, which he describes as the most important factors that influence the lagoon complex.

4.2. Biomass

This study shows a higher biomass compared to similar studies. Macias [8] who estimated a maximum biomass of 2.99 kg/m^2 in Laguna Madre. Romero-González [21] in a study of biomass in adjacent beaches to the Bay of La Paz, showed that those beaches with smaller size have greater biomass, while beaches with greater extension are influenced by the currents of the San Lorenzo Canal, therefore, showing a higher primary productivity and a greater biomass during the warmer months. This variation may be due to the environmental conditions of the lagoon of La Paz, the movement of organisms determined by the heterogeneity of the habitat and their zoogeographic affinity that allows the arrival and departure of the same organisms. In addition, since it is a lagoon that presents fish species of small sizes, it can be inferred that the lagoon is used as an area for growth, reproduction and feeding, which according to González-Acosta [19], this is because of the predominantly shallow areas in the lagoon. Barjau-González [16] mentioned that biotic and abiotic factors are related to the physical, chemical, and biological conditions of the lagoon, that influence the variation of biomass. Melendez and Alejandra [22] explain that variations of biomass and density depend on the architecture of the habitat and the ability of organisms to adapt, which is reflected in the spatial distribution of biomass according to temperature. In addition, these variations of biomass suggest seasonality of the resident and transient species of the lagoon, because of the seasonal environmental changes.

4.3. Density

The density recorded in the present study was similar to the one obtained by Macias [8], who determined density of the ichthyofauna in the Laguna Madre. This can be explained by the composition of the species found within this lagoon, alongside its hypersalinity and shallow areas, mainly composed of silt-clayey substrates. Barjau-González [16] mentioned that the complexity of the communities in terms of abundance depends on the complexity of the habitat, the food, mobility of the fish, reproduction, and environmental conditions, which is reflected in the results, having seasons of both, high and low density [23]. This is also observed in the values of density obtained, since they show a seasonal pattern consistent with the temporal distribution of temperature [24].

4.4. Shannon-Weaver Index

The diversity index showed significant differences. April recorded the lowest value, while the highest was recorded in October. Based on our results, diversity of the seven sites sampled in the lagoon of La Paz is considered low, which is consistent with reports by Spellerberg and Fedor [25], who mentioned that any values of diversity less than three are considered low. Furthermore, Romero-González [21] mentions that diversity increases during winter on beaches in the bay adjacent to the lagoon of La Paz, which is consistent with our results since the higher values of diversity were recorded in the colder months. This can be explained by the temporality and thermal affinity of the ichthyofauna. Gómez León [15] analyzed the diversity in the Gulf of California, finding dominance of fewer species during the winter and summer periods, which is explained by the influence of environmental factors, such as the weather and the availability of food.

Malpica-Maury [26] found higher diversity during winter, while Barjau-González [16] carried out a similar study finding a seasonal relationship with species recorded during summer. In addition, Rodríguez-Romero *et al.* [27] found a high diversity during April and a low diversity during October in a study made in the Rancho Bueno lagoon, near Magdalena Bay, directly related to the temperature factor which directly influences the diversity. Acevedo-Cervantes [28] made a study in Ojo de Liebre lagoon in the north of B.C.S. Using a hook line fishing technique, registering a higher diversity during March and the lowest during September. However, using a trawl net, the highest values were recorded in September while the lowest were recorded in July. This suggests temporal preferences, which are consistent with times of high and low productivity, where the number of species tend to increase, as food availability also increases, as well as the start of the breeding season.

Regarding the spatial-analysis, diversity did not show significant differences, however, the site with the highest value was Zacatecas, which is located north of the lagoon, while the location of Aeropuerto recorded the minimum and is located to the south of the lagoon. Based on these patterns of variation, diversity of the area is influenced by resident and transient species found in the area, depending on the substrate and the site of the lagoon. In comparison, Romero-González [21] mentioned that sites with the greatest diversity are those protected compared to extensive sites without protection. This is consistent with the sites sampled in this study, especially those with maximums and minimums values.

4.5. Evenness

According to the temporal-analysis of evenness, lowest values were recorded in June and December, opposite results to what was found by Malpica-Maury [26] with higher values during winter and low during summer. This is caused by the dominance of the different species of fish in the area. In addition, Barjau-González [16] also found significant differences, finding higher evenness values during June and lower during August. This may be due to different species moving in and out of the lagoon, causing variation in their abundance due to environmental changes.

According to the spatial analysis, no significant differences were found between sites, lower values were recorded in Aeropuerto and Yate Hundido. Opposite results to a study carried out in the Bay of La Paz by Barjau-González [16], who found differences between sites, which is due to the distribution and preferences of the species, since some shallow areas are used as feeding grounds depending on the time of day and others as shelter and rest. A similar study by Barjau-González [29] and Muñoz-Félix [24], was done in the San Ignacio lagoon, finding low evenness values.

4.6. Non-Metric Multi-Dimensional Scaling

The NMDS analysis in its temporal structure, formed two groups, with April standing out as a single group. Minimum variations of temperature were recorded during this month, while the sites with higher temperatures were included in the second group. Contrary to what was found by Padilla-Serrato [17], with four groups in the Las Guásimas lagoon in Sonora that correspond to the weather seasons. On the other hand, Quiroz-Vázquez *et al.* [30] in the same San Quintín Bay recorded higher temperatures from April to October and the second one to February-November with the lowest temperatures, therefore, temperature fluctuations can explain the diversity and density of organisms, however, it can also be explained by the cyclical and seasonal species typically present in the lagoon, which use it as feeding ground and protection from predators during the first stages of life.

5. Conclusion

The spatiality and temporality pattern of the physicochemical variables of the La Paz lagoon influenced the variation of biomass, density, diversity, richness and similarity of the fish communities associated with soft bottoms. Therefore, we can infer that biomass has a cyclical behavior, influenced on the one hand by environmental variables and on the other, the presence of seasonal and resident species that make up the lagoon, which is defined by their own biological processes (feeding, reproduction, safeguard, etc.). And consequently, they maintain the ecosystem balance, since it has been considered that fish are used as indicators of ecological health in aquatic ecosystems, maintaining their interspecific and intraspecific relationships through the transfer of energy with the addition of other members of the fauna present in the zone.

Authors Contribution

BRC co-wrote the manuscript with EBG, RET, RDAG, JAP. EGB and BRCR carried out fish collection, identification, and data analysis. EBG contributed to the project and the revisions. All authors read and approved the final manuscript. Also, they all declare that they have not conflict of interest.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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