Lat. Am. J. Aquat. Res., 39(2): 250-260, 2011
DOI: 10.3856/vol39-issue2-fulltext-6

Research Article

Seasonal changes in a fish assemblage associated with mangroves in a coastal lagoon of Baja California Sur, Mexico

Jesús Rodríguez-Romero[1], Laura del Carmen López-González[2], Felipe Galván-Magaña[3] Francisco J. Sánchez-Gutiérrez[3], Roxana B. Inohuye-Rivera[1] & Juan C. Pérez-Urbiola[1]
[1]Centro de Investigaciones Biológicas del Noroeste, P.O. Box 128, La Paz, B.C.S. 23000, México
[2]Instituto Nacional de la Pesca, Pitágoras 1320, Col. Santa Cruz Atoyac, México, D.F. 03310, México
[3]Centro Interdisciplinario de Ciencias Marinas, Av. Instituto Politécnico Nacional s/n
P.O. Box 592, La Paz, B.C.S. 23000, México

ABSTRACT. The fish assemblage in a coastal lagoon with mangroves known as "Rancho Bueno" was determined and associated with environmental parameters. We used an experimental otter trawl net to catch the fish, and 62 fish species were identified from 48 genera and 30 families. The most abundant species were: *Etropus crossotus*, *Eucinostomus gracilis*, *Paralabrax maculatofasciatus*, *Sphoeroides annulatus*, and *Eucinostomus dowii*. The water temperature changed seasonally, being warm from July through December and cold from January through June. We found more fish species during the warm season than during the cold season. The southern area of the coastal lagoon had the highest diversity and species richness. The small size of the fishes registered confirms the ecological role of coastal lagoons as nursery areas that offer protection and feeding to commercially important fish near Bahía Magdalena, Mexico.

Keywords: soft-bottom fish assemblage, environmental parameters, mangrove, Rancho Bueno, Baja California Sur, Mexico.

Cambios estacionales de la comunidad de peces asociada a zonas de manglar en una laguna costera de Baja California Sur, México

RESUMEN. Se determinó la estructura de peces asociada a factores ambientales en una laguna costera con manglar denominada "Rancho Bueno". Se utilizó una red de arrastre experimental para la captura y se identificaron 62 especies de peces de 48 géneros y 30 familias. Las especies más importantes fueron *Etropus crossotus*, *Eucinostomus gracilis*, *Paralabrax maculatofasciatus*, *Sphoeroides annulatus* y *Eucinostomus dowii*. La temperatura del agua varió estacionalmente, siendo cálida de julio a diciembre y fría de enero a junio. Se registró un mayor número de especies de peces durante la época cálida comparada con la época fría. La zona sur de la laguna costera presentó una mayor diversidad y riqueza específica. El menor tamaño de los peces registrados, confirma el papel ecológico de las lagunas costeras, consideradas como áreas de crianza las cuales proporcionan protección y alimentación a los peces de importancia comercial cerca de Bahía Magdalena, México.

Palabras clave: comunidad de peces de fondos suaves, parámetros ambientales, manglar, Rancho Bueno, Baja California Sur, México.

Corresponding author: Jesús Rodríguez-Romero (jrodri04@cibnor.mx)

INTRODUCTION

The western coast of the Baja California Peninsula is influenced by the temperate California Current and by the tropical North Equatorial Current (Galván-Magaña *et al.*, 2000; Bizzarro, 2008); this is a zone with transitional marine conditions influenced by upwellings, which contribute to high primary

productivity almost year round. It is a biologically active center (BAC), where many marine fish from different trophic levels are found (Lluch-Belda, 2000).

The study area named Rancho Bueno is a coastal lagoon located at the southern area of the Bahía Magdalena-Almejas lagoon complex, which is an important fishing area, mainly for artisanal fisheries (Ramírez & Gutiérrez, 1987; Bizzarro *et al*., 2007; Bizzarro, 2008) and sardine (Robinson, 2000).

In spite of this high natural productivity, there are few published data on fish species taxonomy, abundance and diversity from this important fishing area (Galván-Magaña *et al.*, 2000; Rodríguez-Romero *et al*., 2008, 2009). Also is poor known the relation between the fish assemblages and environmental parameters in this area, or how these parameters determine the seasonal or spatial changes in the fish structure. The objective of our study is to know the influence of environmental parameters in the seasonal and spatial changes of the fish assemblages in a shallow coastal lagoon in the western coast of Baja California peninsula.

MATERIALS AND METHODS

Study area

The coastal lagoon of Rancho Bueno is located between 24°17′30″-24°20′45″N, and 111°20′30″-111°27′40″W. It is 10.9 km long and 1.2 km wide. The depth is shallow, from 1 to 6 m, with ~95% of its perimeter bordered by mangrove (*Rhyzophora mangle*, *Laguncularia racemosa* and *Avicennia germinans*). The bottom includes sand, silt and clay, and some stony areas (Mendoza & Lechuga, 1995).

From October 1993 through September 1994, we did twelve surveys at ten locations. One tow was carried out at each location using an experimental otter trawl net of 6.0 m length and 4.0 m wide with doors of 0.60 x 0.40 m and 3.15 cm mesh size. The bottom temperature, salinity, water depth, and bottom type were recorded. Specimens were fixed in 10% formaldehyde solution for later identification using specific keys for each fish species.

Using the weight data of each species, ecological indexes were calculated. The relative abundance (*RA*) and relative weight (*RW*) were calculated as follows: $RA(\%) = (n / N) * (100)$ and $RW(\%) = (w / W) * (100)$, where n is the number of species captured, N is the total number of specimens, w is the weight of each species, and W is the weight of all specimens.

The species richness index (D) proposed by Margalef (1969) was calculated as follows: $D = (S - 1) / \ln N$, where S is the number of species and N is the total number of individuals. The Shannon-Wiener diversity index (H') was calculated as follows: $H' = -\sum (n_i / N) \log (n_i / N)$, where: n_i is the number of individuals of species i and N is the total individuals of all species in the sample. The evenness index (Pielou, 1966) was calculated as follows: $E = H' / \ln (S)$, where H' is the Shannon index and S is the number of species. The dominance or Biological Value Index (BVI) (Sanders, 1960) was calculated as follows: $BVI = \sum_j Pu_{ij}$, where i is the species, j is the sample locality, and Pu_{ij} is the point level of species i at locality j.

A Principal Components Analysis (PCA) by season and locations were used, including environmental and ecological data.

RESULTS

The Rancho Bueno coastal lagoon was divided into three zones: North (locations 1, 2, 3, 4), Central (5, 6, 7), and South (8, 9, 10) (Fig. 1). The warm season went from July to December 1993, with average water temperatures ranging from 22.6 to 27.9°C; whereas the cold season went from January through June 1994, with average temperatures ranging from 18.8 to 22.0°C. The temperature increased from north to south in the coastal lagoon, averaging 21.0°C at location 1 (North) and 25.1°C at location 10 (South). Salinity changed little during the year, ranging from 34.6 to 35.5 psu. Spatial variations in salinity were small, ranging from 34.3 psu at location 1 to 36.6 psu at location 10 (Tables 1 and 2).

The depths and substrate types are shown in Table 2. The Northern Zone (locations 1 to 4), had sandy bottoms and greater depths than the Southern Zone (locations 8 to 10), which had higher salinity and shallow depths.

We captured 3,082 fish, all juveniles, with a total weight of 102.04 kg, belonging to 62 species in 48 genera and 30 families. The most important families were: Haemulidae (ten species); Lutjanidae, Gerreidae and Paralichthyidae (five species each), Serranidae (four species), and Sciaenidae and Urolophidae (three species each). The most common species were: *Etropus crossotus* (688 specimens), *Eucinostomus gracilis* (544), *Paralabrax maculatofasciatus* (253), *Sphoeroides annulatus* (242), *Eucinostomus dowii* (229), *Orthopristis reddingi* (133) and *Diapterus peruvianus* (108).

Locations 9, 10 and 5 had the highest numbers of fish. The months with highest organism numbers were: September 1994 (937 fish from 32 species)

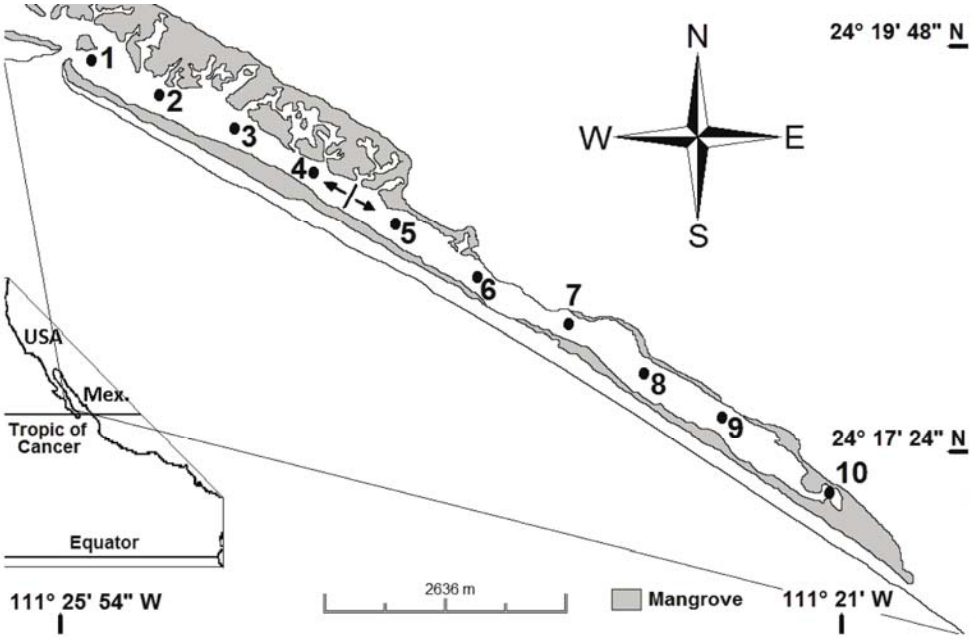

Figure 1. Study area and sampling locations Rancho Bueno coastal lagoon in southern Bahía Magdalena, Baja California Sur, Mexico.

Figura 1. Área de estudio y localidades de muestreo en la laguna costera de Rancho Bueno ubicada al sur de Bahía Magdalena, Baja California Sur, México.

Table 1. Average water temperature and salinity during 1993-1994 in Rancho Bueno, Mexico.

Tabla 1. Temperatura y salinidad promedio durante 1993-1994 en Rancho Bueno, México.

Month	Average Temperature (°C)	Average Salinity (psu)
Oct.	27.6	34.8
Nov.	25.2	35.0
Dec.	22.6	34.7
Jan.	22.0	35.0
Feb.	19.9	35.5
Mar.	20.5	34.9
Apr.	18.8	35.0
May	18.9	35.2
Jun.	21.0	35.5
Jul.	22.7	35.0
Aug.	25.7	35.1
Sep.	27.9	35.0

and October 1993 (469 fish from 36 species). Six of the 62 species were found at all locations: *E. crossotus*, *P. maculatofasciatus*, *Paralichthys californicus*, *S. annulatus*, *Symphurus atramentatus* and *Synodus lucioceps.*

The fish species better represented by relative abundance, in order of importance, were: *E. crossotus, E. gracilis, P. maculatofasciatus, S. annulatus, E. dowii, O. reddingi* and *D. peruvianus*, composing 71.3% of the specimens and over 35% of the total relative weight (Fig. 2). On each sampling, *E. crossotus* and *E. gracilis* had the highest relative abundance (22.3 and 17.6%); while *P. maculatofasciatus* had the highest relative weight (11.2%). It is important to mention that of 62 fish species, 38 (61.29%) are of commercial importance (species marked with an asterisk in Table 4).

The highest seasonal and spatial species richness according to species abundance occurred in October (3.9); whereas the lowest richness occurred in April (0.4). The lowest value was from the northern zone during the cold months; whereas the highest value was from the southern zone during the period September through January.

The diversity index ranged from 0.4 to 3.6 (bits ind^{-1}), with the minimum value at location 7 in April; whereas the maximum diversity was found at location 10 in October (both in the southern zone). Locations 1 to 4 in the northern zone had lower diversity than locations 7 to 10 in the southern zone, which also had the highest diversity.

The lowest evenness occurred in the cold season (values below 0.6.); the minimum value (0.25) was at

Table 2. Characteristics of Rancho Bueno coastal lagoon, Mexico sampling sites.
Tabla 2. Descripción de las localidades de muestreo en la laguna costera Rancho Bueno, México.

Zone	Site	Substrate type	Tow depth (m)	Temperature (°C)	Salinity (psu)
North	1	Sand	2.9	21.04	34.36
	2	Sand	2.5	21.17	34.10
	3	Sand	3.6	21.26	34.13
	4	Sand	3.5	21.34	34.44
Central	5	Sand-silt	2.1	21.59	34.61
	6	Sand-silt	2.0	22.73	34.96
	7	Sand-silt	2.2	24.17	35.40
South	8	Silt	1.4	24.24	35.87
	9	Silt	1.8	24.63	36.12
	10	Silt	1.6	25.07	36.58

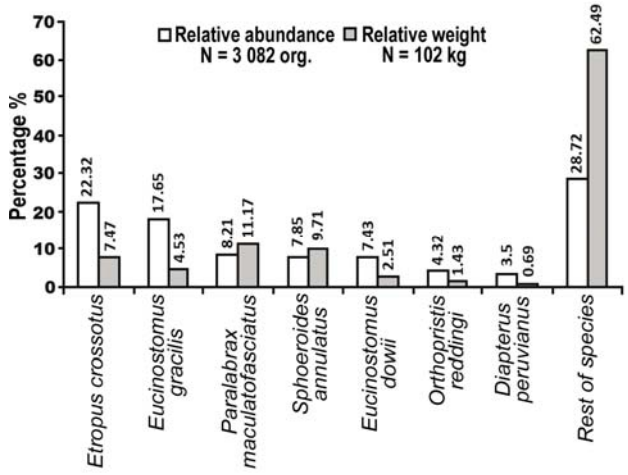

Figure 2. Relative abundance and weight of dominant fish species at Rancho Bueno coastal lagoon.

Figura 2. Abundancia relativa y biomasa de las especies dominantes de peces en la laguna costera de Rancho Bueno.

location 4 in May, followed by location 7 in April (0.39). The highest evenness (1.0) in some locations was recorded in November, December, February, and August. In general, the cold season had lower evenness than the warm season (0.72 to 0.77). In table 3 are shown the monthly values of ecological indexes.

The fish species of highest importance according to the Biological Value Index were: *E. crossotus*, *E. gracilis, S. annulatus*, *P. maculatofasciatus* and *E. dowii*, with index values of 94, 64, 62, 60 and 48, respectively (Fig. 3).The monthly analyses of this index are shown in Table 4.

Using PCA, we detected two main groups of fish (Fig. 4). In the first group were six species: *P. californica, O. cantharinus, U. halleri, S. ovale, E. crossotus* and *P. maculatofasciatus*, which were associated to northern locations (1, 2, 3 and 4) in the coastal lagoon, with higher biomass in deep locations and close to the entrance to the open ocean.

The other group included 11 fish species at locations 5 to 10, which are in the center and south area, with lower biomass but higher organism numbers and evenness, associated to shallow waters with higher water temperature and salinity.

The seasonal PCA (Fig. 5) recorded two periods, associated to cold waters during January-June (winter-spring), and a warm period from July to December (summer-fall). In this last period the diversity, species number, and organism abundance showed the highest affinity with 12 dominant fish species, including *P. maculatofaciatus, Sphoeiroides annulatus, Lutjanus argentiventris, Hoplopagrus guntheri, Calamus brachysomus, Balistes polylepis* and others. During the cold period, with highest biomass and salinity, the most common species were: *P. californicus*, *U. halleri*, *E. crossotus*, A. *mazatlanus*, O. *cantharinus* and *S. lucioceps.*

DISCUSSION

The topographic and hydrographic characteristics of the coastal lagoon of Rancho Bueno, provide optimal conditions as a nursery, feeding, and reproduction area for many fish species that are important as commercial species. This ecosystem has high primary productivity that promotes species richness. Mendoza & Lechuga (1995), found higher accumulated organic matter in

Table 3. Monthly values of ecological indices by zone and sampling site. D: Species richness (Margalef, 1969), H′: Diversity (Shannon-Wiener), E: Evenness (Pielou, 1966).

Tabla 3. Valores mensuales de los índices ecológicos por zona y localidades de muestreo. D: Riqueza de especies (Margalef, 1969), H′: Diversidad (Shannon- Wiener), E: Uniformidad (Pielou, 1966).

	Location	October			November			December			January			February			March		
		D.	H'	E	D	H'	E	D	H'	E	D	H'	E	D	H'	E	D	H'	E
North	1	2.06	1.97	0.62				1.86	1.92	0.96	1.52	2.07	0.89				1.23	1.29	0.55
	2	2.64	2.03	0.59	1.86	1.92	0.96	2.4	2.5	0.97	0.91	0.92	0.92				1.37	1.66	0.83
	3	2	2.22	0.79	0.91	0.92	0.92	1.82	1.58	1							1.21	1.73	0.86
	4	2.32	2.38	0.72	1.82	1.58	1	2.41	2.63	0.94	1.94	2.24	0.8	0.72	1	1	1.37	1.45	0.72
Central	5	2.72	2.8	0.88	0.72	0.81	0.81	2.59	2.82	0.89	1.64	2.01	0.78	0.56	0.92	0.92			
	6	2.34	2.62	0.93	0.62	0.97	0.97	1.12	1.46	0.92	1.21	1.42	0.71	1.24	1.52	0.96	1.2	1.77	0.76
	7	0.87	0.86	0.43	1.44	1	1	1.5	1.72	0.66	1.44	1.55	0.77	2.12	2.13	0.71	0.72	0.67	0.42
South	8	2	1.78	0.59	2.16	2	1	2.73	2.41	0.73	2.16	2.53	0.9				1.82	2.36	0.79
	9	2.72	2.11	0.55	3.47	3.29	0.8	1.64	1.65	0.55	1.44	1.5	0.95	2.23	2.25	0.97	1.62	1.87	0.72
	10	3.96	3.62	0.85	0.91	1.33	0.66	2.32	1.82	0.53	3.44	2.99	0.75	2.06	2.24	0.96	1.94	2.29	0.72

	Location	April			May			June			July			August			September		
		D	H'	E	D	H'	E	D	H'	E	D	H'	E	D	H'	E	D	H'	E
North	1							0.91	0.92	0.92	0.96	1.41	0.89	1.56	2.2	0.95	1.44	1.5	0.95
	2				0.62	0.72	0.72	1.01	1.62	0.7	1.67	1.92	0.96				0.62	0.72	0.72
	3				1	1.19	0.6	1.59	1.53	0.54	0.69	0.61	0.39	1.11	1.72	0.86	1.86	2.42	0.81
	4	1.41	1.26	0.54	0.58	0.4	0.25	1.7	1.33	0.44	0.91	0.99	0.62	1.23	1.8	0.7			
Central	5				1.12	1.46	0.92	1.31	1.38	0.53							3.07	2.82	0.68
	6	0.94	1.06	0.53	2.4	2.11	0.67	1	1.32	0.66	0.91	0.92	0.92	0.91	0.92	0.92	3.55	3.26	0.77
	7	0.39	0.39	0.39	0.91	0.92	0.92				0.91	0.99	0.62	1.24	1.37	0.86	2.93	3.3	0.83
South	8	0.62	0.97	0.97	0.91	0.92	0.92	3.34	2.91	0.76	1.12	1.46	0.92	1.44	1	1	2.4	3.04	0.88
	9	2.39	2.26	0.65	1.86	1.97	0.66				2.09	2.3	0.89	2.01	2.52	0.98	2.39	2.86	0.75
	10				1.69	2.31	0.82	1.44	1.5	0.95	1.8	1.94	0.69	1.61	2.05	0.88	1.03	1.15	0.72

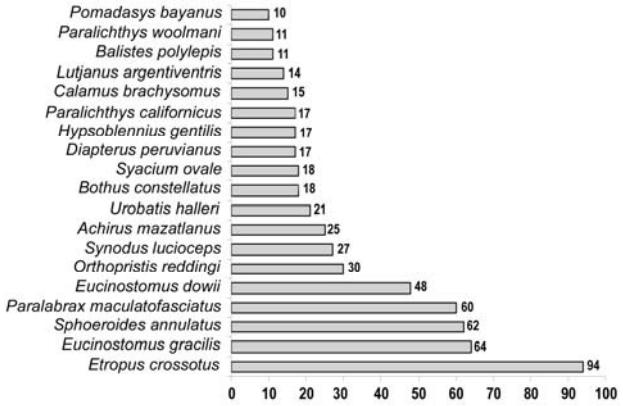

Figure 3. Biological Value Index of the most common fish species at coastal lagoon of Rancho Bueno, Mexico.

Figura 3. Índice de valor biológico de las especies de peces más importantes de la laguna costera de Rancho Bueno, México.

the southern area, which also we found higher fish abundance.

The number of fish species and marine organisms was higher in the southern area of Rancho Bueno, where average water temperature was higher and the bottom was muddy. In contrast to northern locations, the southern locations had fewer fish species and organisms, with sandy bottoms and lower water temperatures. In months with low temperatures, the number of fish species and other organisms was low. During February, we found fewer fish (55) belonging to 15 families; whereas during warmer months, mainly September, we found 937 fish belonging to 19 families. The main species were: *P. maculato-fasciatus*, *S. annulatus*, *E. dowii*, *O. reddingi* and *D. peruvianus*. Of these species, *E. crossotus*, *P. maculatofasciatus* and *S. annulatus* were common during the sampling period.

The fish species found in our study have been reported for the Bahía Magdalena-Almejas lagoon complex (Torres-Orozco & Castro-Aguirre, 1992; De La Cruz-Agüero *et al*., 1994; Galván-Magaña *et al*., 2000). The importance of our results is the high number of fish species found, and mostly were juveniles (62), which confirm that Rancho Bueno is used as a nursery and feeding area by fish species with commercial importance.

The coastal lagoon of Rancho Bueno had a high number of fish species comparing with other locations in Baja California Sur. Rodríguez *et al*., 1998 and Gutiérrez-Sánchez *et al.* (2007) also found a high number of fish species; however De La Cruz (2004) found only 25 fish species in four estuarine areas from Bahía de la Paz. The abundance and relative biomass analysis showed that the main fish species (*E. crossotus*, *P. maculatofasciatus* and *S. annulatus*) represented over 70% of the total relative abundance and almost 37% of the relative biomass. This indicates that, in spite of being the most numerous species, their small size affects their biomass. The southern locations from the Rancho Bueno lagoon had the highest relative abundance, almost 40%.

The highest species richness values occurred during the warm months, and the lowest values during the cold months. Gutiérrez-Sánchez *et al*. (2007) reported in Bahia Magdalena, Mexico, the highest values of species richness between February and July, as a consequence of the mix of fish species with different zoogeographic affinities. In Bahía Concepción (Gulf of California), Rodríguez-Romero *et al*. (1998) found the highest species richness in September and the lowest in February. The species richness in the southern Bahia Concepcion was also influenced by the muddy substrate, because locations with several habitat types increase the species richness (Krebs, 1978; Blaber, 1985; Rodríguez-Romero *et al.*, 1994), because there are prey from different habitats which are consumed by fishes. We found the highest diversity during the warm months, with the highest value (3.6 bits ind^{-1}) in October and the lowest in April (0.4), which agrees with the diversity changes associated to sampling location, fishing method, fish dynamics, biology of each fish species, feeding relationships, and environmental conditions (Margalef, 1974).

The Rancho Bueno coastal lagoon could be considered as a mature fish community, considering the high diversity found with little disturbance (Odum, 1972). The locations in the southern area are apparently uniform, because they are in the most protected area; however, these shallow areas are associated with high changes in water temperature and salinity, and with the highest diversity and evenness.

Seasonal changes in diversity are associated with changes in water temperature, which also affect the presence of fish, diversity and abundance (Rodríguez-Romero *et al.*, 1998, 2005). De La Cruz (2004) studied fish assemblages in four mangroves areas close to Bahía de La Paz (Gulf of California), he found the highest values of abundance and diversity during the warm months and the lowest during cold months; whereas Acevedo (1997) in Laguna Ojo de Liebre (western coast of Baja California) registered that locations in the north coastal lagoon had the highest water temperatures and the highest fish diversity. Also Horn & Allen (1985), found that fish communities in bays and estuaries in southern California, are influenced by oceanic waters and had

Table 4. Biological Value Index of fish species found at Rancho Bueno, Mexico. Species with (*) have commercial importance.

Tabla 4. Índice de Valor Biológico de las especies de peces registradas en Rancho Bueno, México. Las especies marcadas con asterisco (*) tienen importancia comercial.

Species	1993			1994								
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Achirus mazatlanus	25	12	7	35	8	39	18	32	13	24	9	26
*Arius platypogon**									5			
*Balistes polylepis**	27	21	22	17	10	8			6			11
Bothus constellatus	32			9	9	9		9			9	5
*Calamus brachysomus**	29	13	22	21								24
*Caranx caninus**		2	6									
*Centropomus medius**	9											
*Chaetodipterus zonatus**	7		7			9						
Chaetodon humeralis	15											
*Cyclopsetta panamensis**	8	10	18			5	15					
*Cynoscion parvipinnis**	14	9										
Dactylagnus mundus	7									8		9
*Diapterus peruvianus**	9	14	8	6				14				29
Diodon holocanthus	8					8			7			
Diodon hystrix			7			7					14	
*Diplectrum pacificum**	13		6									
*Epinephelus analogus**	15	5			7							
Etropus crossotus	62	34	77	65	40	87	40	70	78	77	47	39
*Eucinostomus dowii**	21	20		15	7	19	19	16	10			34
*Eucinostomus gracilis**	65	19	66	16						20	8	45
*Eugerres axillaris**	10											
Fistularia commersonii										7		
*Gerres cinereus**	10											
*Gymnura marmorata**			7		10		9		20	8	9	1
*Haemulon steindachneri**									7		15	3
*Haemulopsis leuciscus**		12	7				15	9	15			3
*Haemulopsis nitidus**												3
Hippocampus ingens	4		10			13						15
*Hoplopagrus guntheri**		10								7		18
Hypsoblennius gentilis	8								8	9	17	
*Hypsopsetta guttulata**				7								
*Lutjanus aratus**								10			10	7
*Lutjanus argentiventris**	8	15	16	14				9		17		29
*Lutjanus colorado**	4											
*Lutjanus novemfasciatus**	5											
*Menticirrhus undulatus**											10	
*Microlepidotus inornatus**												4
*Micropogonias ectenes**						9			6			
*Orthopristis cantharinus**		8		10								
*Orthopristis reddingi**	22	4	18	7		9						30
*Paralabrax maculatofasciatus**	72	14	81	70	16	16	14	16	52	19	47	22
*Paralabrax nebulifer**				9								
*Paralichthys californicus**	45	9	9	19	16	5	15	23	15	7	35	
*Paralichthys woolmani**	38				9					26	8	

Species	1993					1994						
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Pleuronichthys ritteri						8		9				
*Pomadasys bayanus**				4								20
Pomadasys macracanthus	2								6		7	
*Pomadasys panamensis**			6									4
Prionotus ruscarius	11	9		8		22	6	5	5			
Pseudupeneus grandisquamis		12	19	5		12	7		5			
*Scarus perrico**									7			
Scorpaena russula			8				6					1
Sphoeroides angusticeps	4											1
*Sphoeroides annulatus**	24	32	40	24	10	36	17	34	40	26	27	53
Syacium ovale	42			7		9						
Symphurus atramentatus	4				28	4	6	31	21	27	14	
Symphurus fasciolaris									18			
Synodus lucioceps		2	63	38	25	55	9	26	24	9		12
Urobatis halleri	6	10	8	4	19			17	22	10	9	8
Urobatis maculatus	8											
Urotrygon asterias			7	12	9							
Xenistius californiensis												2

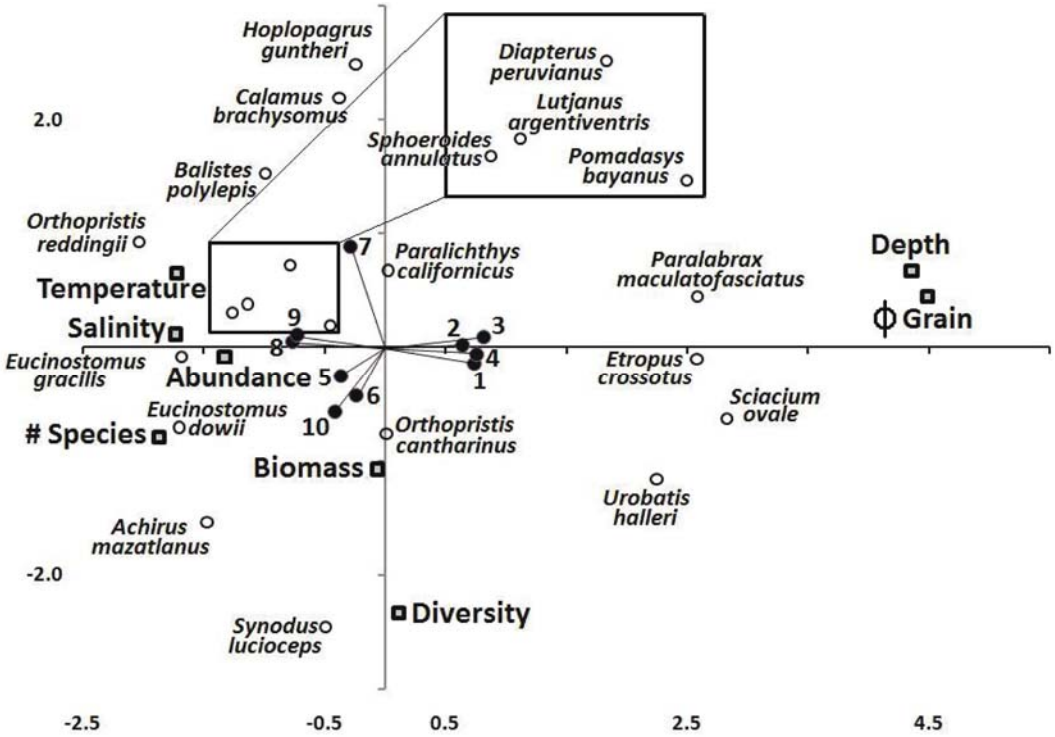

Figure 4. Spatial Principal Component Analyses associated with water temperature, salinity, depth, substrate (grain type) total abundance, biomass, fish dominant species and sampling locations (1 to 10).

Figura 4. Análisis espacial de componentes principales asociado a la temperatura del agua, salinidad, profundidad, substrato, abundancia total, biomasa, especies de peces dominantes y localidades de muestreo (1 a 10).

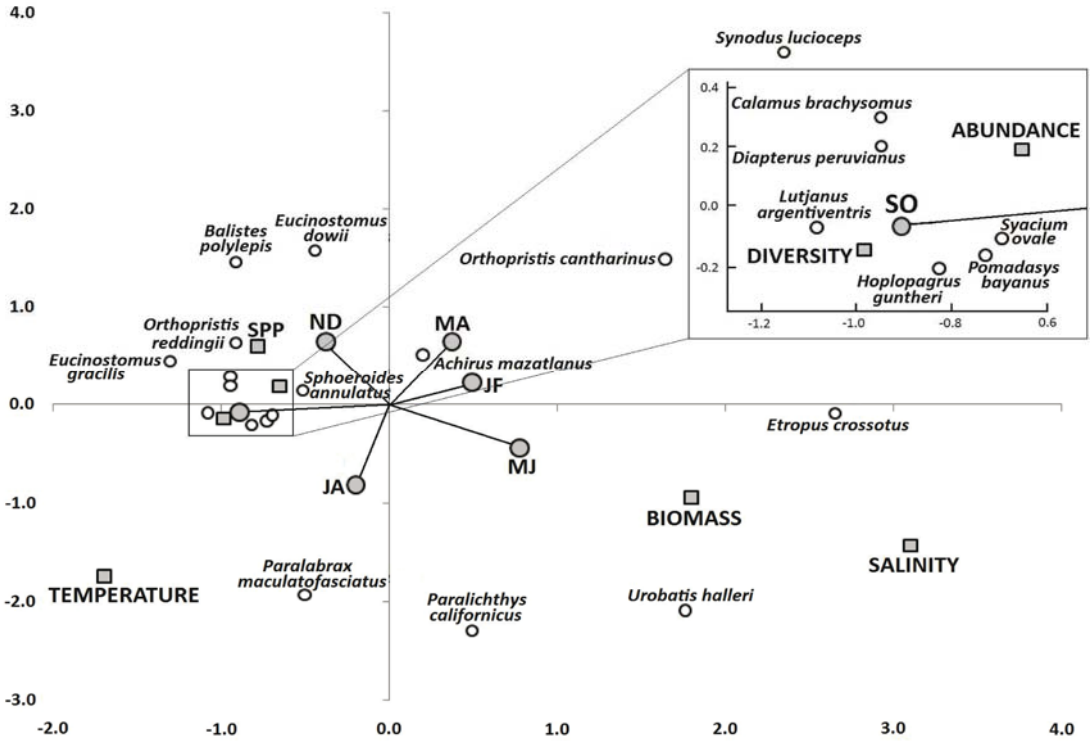

Figure 5. Monthly Principal Component Analyses associated with water temperature, salinity, biomass, number of fish species (SPP), diversity, total abundance. JF: January-February, MA: March-April, MJ: May-June, JA: July-August, SO: September-October, NO: November-December.

Figura 5. Análisis mensual de componentes principales asociado a temperatura del agua, salinidad, biomasa, numero de especies de peces, diversidad, abundancia total. JF: enero-febrero. MA: marzo-abril, MJ: mayo-junio, JA: julio-agosto, SO: septiembre-octubre, NO: noviembre-diciembre.

seasonal changes in abundance and diversity. The biological value index showed that *E. crossotus*, *E. gracilis, S. annulatus, P. maculatofasciatus* and *E. dowii* were the most important fish species in the Rancho Bueno coastal lagoon. Their dominance might be attributed to their high occurrence during all sampling.

In the upper Gulf of California, Pérez-Mellado & Findley (1985) found that *E. crossotus* and *Citharichthys* spp. were the most abundant species in the shrimp trawl by-catch, followed by *Diplectrum pacificum* and *Scorpaena sonorae*; whereas Rodríguez-Romero *et al*. (1998) in Bahía Concepción (central Gulf of California) found that *P. maculatofasciatus*, *E. crossotus*, *Urobatis halleri* and *Sphoeroides lispus* were the most important fish species.

Our PCA and cluster analysis indicated that two groups characterized the fish assemblage in the Rancho Bueno coastal lagoon. In the northern area with deeper water, the highest biomass was represented by few fish species with high importance; larger fish were more frequent and these species had temperate zone affinity or were widely distributed, such as *P. californicus, Orthopristis cantharinus*, *E. crossotus*, *Sciacium ovale* and *Urobatis halleri.*

In the southern area, we found high abundance and diversity, with more fish of small size (mostly juveniles). Juveniles were common in protected areas associated to mangroves. The most common species were: *E. dowii*, *B. polylepis*, *H. guntheri*, *Sphoeroides annulatus*, *E. gracilis*, *Lutjanus argentiventris*, *Syacium ovale*, *Diapterus peruvianus* and *O. reddingi,* which are from temperate-tropical habitats or are widely distributed (Robertson & Allen, 2002). Baja California Sur is a biogeographically transition zone (Castro-Aguirre & Torres-Orozco, 1993), where tropical, sub-tropical, and temperate fish coexist. Changes in spatial and seasonal fish composition are associated to fluctuating environmental conditions in this transition zone. Galván-Magaña *et al.* (2000) confirmed that northwestern Mexico is one of the most diverse areas in terms of tropical, temperate and tropical-temperate transition marine species.

The west coast of Baja California Sur is a tropical-temperate transition zone, where seasonal gradients

are influenced by the cold California Current and the Eastern Pacific Equatorial Current (Bizzarro, 2008). The water temperature changes, substrate type, and feeding habitats were the most influential environmental elements affecting the fish assemblages in this area. The monthly PCA also indicated two distinct periods, dominated by water temperature: winter-spring and summer-autumn (Fig. 6). The water temperature, habitat type and primary productivity are important for ecosystem productivity (Mendoza-Salgado & Lechuga-Devéze, 1995).

In conclusion, the Rancho Bueno coastal lagoon supports nursery and feeding areas for juvenile fish with high commercial importance, such as snappers, groupers, mojarras and flatfishes. Also is a reproduction area for many commercial fish species from temperate and tropical affinities. We found seasonal changes in the fish assemblages of this coastal lagoon based on changes in water temperature, substrate type and depth. The highest species richness and diversity were found during the warmer months, and the highest number of organisms was found in the southern area, where high water temperature and muddy bottoms included *Sargassum* spp. and mangrove roots; whereas the northern area had few fish species, the bottom was sandy and had low water temperature.

ACKNOWLEDGEMENTS

We thank Mario Cota-Castro and Juan José Ramírez for helping with sampling. Financial support was provided by the Centro de Investigaciones Biológicas del Noroeste project "Estructura y función de comunidades de peces en el Estero de Rancho Bueno, B.C.S. Mexico". FGM and FJGS thank the Instituto Politécnico Nacional (COFAA and EDI fellowships). We thank Laura Sampson for editing the English version of this manuscript.

REFERENCES

Acevedo, C.A. 1997. Caracterización ecológica de la comunidad íctica de la Laguna Ojo de Liebre, B.C.S. MSc. Thesis. CICIMAR-IPN. La Paz, B.C.S., 108 pp.

Bizzarro, J.J., 2008. A review of the physical and biological characteristics of the Bahía Magdalena lagoon complex (Baja California Sur, Mexico). Bull. Southern Calif. Acad. Sci., 107(1): 1-24.

Bizzarro, J.J., W.D. Smith, J.F. Márquez-Farías & R.E. Hueter. 2007. Artisanal fisheries and reproductive biology of the golden cownose ray, *Rhinoptera steindachneri* Evermann & Jenkins, 1891, in the northern Mexican Pacific. Fish. Res., 84(2): 137-146.

Blaber, S.J. 1985. The ecology of fishes of estuaries and lagoons of the Indopacific with particular reference to Southeast Africa, Chap. 12. In: A. Yáñez-Arancibia (ed.). Fish community ecology in estuaries and coastal lagoons: towards and ecosystem integration. Universidad Nacional Autónoma de México, pp. 247-266.

Castro-Aguirre, J.L. & R. Torres-Orozco. 1993. Consideraciones acerca del origen de la ictiofauna de Bahía Magdalena-Almejas, un sistema lagunar de la costa occidental de Baja California Sur, México. An. Esc. Nac. Cienc. Biol., 38: 67-73.

De la Cruz-Agüero, J., F. Galván-Magaña, L.A. Abitia-Cárdenas, J. Rodríguez-Romero & F.J. Gutiérrez-Sánchez. 1994. Lista sistemática de los peces marinos de Bahía Magdalena, Baja California Sur. Cienc. Mar., 20: 17-31.

De la Cruz, S.J.A. 2004. Caracterización íctica de la composición, diversidad y abundancia en cuatro esteros de La Bahía de La Paz, B.C.S., México. Bachelor Thesis. Universidad Autónoma de Baja California Sur, La Paz, B.C.S., 57 pp.

Galván-Magaña, F., F.J. Gutiérrez-Sánchez, L.A. Abitia-Cárdenas & J. Rodríguez- Romero. 2000. The distribution and affinities of the shore fishes of Baja California Sur lagoons. In: M. Munawar, S.G. Lawrence, I.F. Munawar & D.F. Malley (eds.). Aquatic ecosystems of Mexico. Ecovision world monograph series. Backhuys Publishers, Leiden, pp. 383-398.

Gutiérrez-Sánchez, F.J., F. Galván-Magaña, L.A. Abitia-Cárdenas & J. Rodríguez-Romero. 2007. Peces demersales de Bahía Magdalena. In: R.R. Funes, J. Gómez & R. Palomares (eds.). Estudios ecológicos en Bahía Magdalena. Gobierno del Estado. de Baja California del Sur. SeTur. De B.C.S., Fondo para la protección de los recursos marinos de B.C.S., CICIMAR-IPN, pp. 241-250.

Horn, M.H. & L.G. Allen. 1985. Fish community ecology in southern California bays and estuaries. In: A. Yáñez-Arancibia (ed.). Fish community ecology in estuaries and coastal lagoons: towards ecosystem integration. Universidad Nacional Autónoma de México, México City, pp. 169-190.

Krebs, C.J. 1978. Ecology the experimental analysis of distribution and abundance, Harper International, New York, 800 pp.

Lluch-Belda, D. 2000. Centros de actividad biológica en la costa occidental de Baja California Sur. In: D. Lluch-Belda, J. Elorduy-Garay, S.E. Lluch-Cota & G. Ponce-Díaz (eds.). BAC: Centros de actividad biológica del Pacífico mexicano. CIBNOR, La Paz, B.C.S., pp. 49-64.

Margalef, R. 1969. Perspective in ecological theory. University of Chicago Press, Chicago, 111 pp.

Margalef, R. 1974. Ecología. Ediciones Omega, Barcelona, 991 pp.

Mendoza-Salgado, R.A. & C.H. Lechuga-Devéze. 1995. Diagnóstico ambiental preliminar de Rancho Bueno, Bahía Magdalena, B.C.S. CIBNOR Reports. La Paz, B.C.S., 78 pp.

Odum, E.P. 1972. Ecología. Nueva Editorial Interamericana, México D.F., 639 pp.

Pérez-Mellado, J. & L.T. Findley. 1985. Evaluación de la ictiofauna acompañante del camarón capturado en las costas de Sonora y norte de Sinaloa, México. In: A. Yáñez-Arancibia (ed.). Recursos pesqueros potenciales de México: la pesca acompañante del camarón. PUA, ICM y L., UNAM/IPN, pp. 201-254.

Pielou, E.C. 1966. Shannon formula as a measure of specific diversity: its use and misuse. Am. Nat., 100: 463-465.

Ramírez, R.M. & C.U. Gutiérrez. 1987. Importancia relativa y variación temporal de catorce especies de peces en el área de Bahía Magdalena, B.C.S., México. In: M. Ramírez (ed.). Memorias del Simposium sobre investigación en biología y oceanografía pesquera en México. La Paz, B.C.S., pp. 103-109.

Robinson, C.J., J. Gómez-Gutiérrez, R. Félix-Uraga & V. Arenas-Fuentes. 2000. Seasonal hydro-acoustical observations of small pelagic fish behaviour in Bahía Magdalena, Mexico. Aquat. Living Resour., 13(1): 11-18.

Robertson, D.R. & G.R. Allen. 2002. Shore fishes of the tropical eastern Pacific: an information system. CD-ROM. Smithsonian Trop. Res. Inst., Balboa, 54(3): 861-871.

Received: 12 July 2010; Accepted: 29 April 2011

Rodríguez-Romero, J., L.A. Abitia-Cárdenas, F. Galván-Magaña & H. Chávez-Ramos. 1994. Composición, abundancia y riqueza específica de la ictiofauna de Bahía Concepción, Baja California Sur. Cienc. Mar., 20: 321-350.

Rodríguez-Romero, J., L.A. Abitia-Cárdenas, F. Galván-Magaña, F.J. Gutiérrez-Sánchez, B. Aguilar-Palomino & J. Arvizu-Martínez. 1998. Ecology of fish communities from the soft bottoms of Bahía Concepción. Arch. Fish. Mar. Res., 46(1): 61-76.

Rodríguez-Romero, J., F. Galván-Magaña, A. Abitia-Cárdenas, A. Muhlia-Melo, F.J. Gutiérrez-Sánchez & V. Gracia-López 2005. Fish assemblages around Espiritu Santo Island and Espiritu Santo seamount in the lower Gulf of California. Bull. Mar, Sci., 77(1): 33-50.

Rodríguez-Romero, J., D.S. Palacios-Salgado, J. López-Martínez, S. Hernández-Vázquez & G. Ponce-Díaz. 2008. Composición y zoogeografía de los peces demersales de la costa occidental de Baja California Sur, México. Rev. Biol. Trop., 56(4): 1765-1783.

Rodríguez-Romero, J., S. Hernández-Vázquez & J. López-Martínez. 2009. Desarrollo potencial de peces desaprovechados. In: Diversidad Marina. Ciencia y Desarrollo. CONACYT, México, 35: 45-51.

Sanders, H.L. 1960. Benthic studies in Buzzards Bay. III. The structure of the soft-bottom community. Limnol. Oceanogr., 5: 138-153.

Torres-Orozco, R.E. & J.L. Castro-Aguirre. 1992. Registros nuevos de peces tropicales en el complejo lagunar de Bahía Magdalena-Bahía Almejas, Baja California Sur, México. An. Inst. Biol. UNAM. Ser. Zool., 63: 281-286.