Seasonal changes in the density and species composition of the epifaunal echinoderms recorded from the southwestern Gulf of Mexico

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Abstract: The distribution and relative abundance of epifaunal echinoderms in the Southwestern region of the Gulf of Mexico based on 181 collections by the use of an Otter Trawl during different years are described. A total of 59 species were recorded, and represent the following five classes; Asteroidea 25 species, Ophiuroidea 15 species; Echinoidea 14 species, Crinoidea 4 species, and Holothuroidea 1 species. The most frequently encountered single species was *Luidia clathrata* found at 68 % of all the stations sampled. Furthermore*, Astropecten nitidus Astropecten duplicatus*, *Mellita quienquiesperforata, Brissopsis atlantica, Brissopsis elongata, Astropecten articulatus, Luidia alternata*, *Comactinia meridionalis*, *Astropecten alligator, Astropecten cingulatus, Tethyaster grandis,* and *Clypeaster ravenelii*, were species less abundant and frequent and accounted for 13% of the remaining percentage of the echinoderms collected and identified. The starfish *Luidia clathrata* was the largest species size collected on the Campeche Bank at 16 m depth. The highest seasonal density of the echinoderms was recorded in Autumn on carbonate substrate, whereas the highest species richness was found in summer. Rev. Biol. Trop. 56 (Suppl. 3): 297-310. Epub 2009 January 05.

Key words: Echinoderms, Macrobenthic, Species Composition, Seasonal Distribution, Density, Southwestern Gulf of Mexico.

Echinoderms are a dominant group of invertebrates found on and in many soft and hard bottom marine community assemblages. They play an important role in the structure of marine benthic communities (Vázquez-Bader 1986, 1996, Vázquez-Bader and Gracia 1994). The Phylum Echinodermata contains a variety of trophic groups, including detritivorous, filter-feeders, grazers, scavengers and active predators that compete for food resources with demersal fish. They prey on commercially important bivalves; however, they are a major food source for fishes (e.g. Dare 1982, Packer *et al*. 1994). Additionally, they may be useful as indicators of pollution (Portocali *et al*. 1997) and physical disturbance (Kaiser 1996). Lastly, holothuroids (e.g. *Isostichopus fuscus*) are commercially exploited (Conand and Sloan 1989).

One of the problems in determining the relative abundance of epifaunal echinoderms on the substrates of the Southwestern Gulf of Mexico is the fact that previous benthic surveys may have used benthic grabs to provide quantitative data. Such sampling gears may be inappropriate for sampling larger epibenthic echinoderms. Epibenthic echinoderms are more accurately surveyed by dredge, trawl or diving census (Larsson 1968, Skjaeveland 1973, Kaiser *et al*. 1994, Dyer *et al*. 1982).

Previous studies on the biodiversity of echinoderms occurring in the Gulf of Mexico waters may be found in taxonomic lists and they have been documented by Durán-González *et al*. (2005), and Laguarda *et al*. (2005a, b).

This study is the first approach to analyze different year seasonal changes in echinoderms density and species composition. It covers a wide area sampled during the last 23 years, conducted on the continental shelf and upper slope of the Southwestern Gulf of Mexico.

MATERIALS AND METHODS

Site Description: Campeche Bank - Campeche Bank**:** is an extensive carbonate bank located to the north of the Yucatan Peninsula (Ordonez 1936). The bank extends from the Yucatan Straits at the east to the Tabasco-Campeche. Basin in the west and includes Arrecife Alacran. This region shares many similarities with the south Florida shelf and some evidence suggests that the two ancient reef systems may have had the same origin. Continental drift and erosion processes have both been theorized to have played a role in the separation of the two geologically similar carbonate shelves (Antoine and Ewing 1963, Uchupi and Emery 1968).

Bay of Campeche - Bay of Campeche**:** is an isthmian embayment extending from the western edge of Campeche Bank to the offshore regions just east of Veracruz (~96° W). The Sierra Madre Oriental constitutes the south-southwestern border, and the associated coastal plain is similar to the Texas-Louisiana coast in the northern Gulf. The bottom topography is characterized by long ridges parallel to the exterior of the basin. Salt domes are prevalent in the region, and the upward migration of salt is theorized to be a cause of the complex bottom profiles. Similar to the northern Gulf, large quantities of oil are produced here, and thick terrigenous sediments predominate. The Bay and Campeche Bank are part of the Southwestern quadrant (subdivision proposed by Pequegnat and Pequegnat 1970).

Sampling Period: The echinoderms were recorded from Otter Trawl sampling during 16 surveys conducted by the use of the research vessel R/V "Justo Sierra" UNAM, with a total of 181 otter trawl samples (Spring, 56 hauls; summer, 64 hauls; Autumn, 37 hauls; and Winter, 24 hauls) (Table 1). Samples were taken at 15 to 600 m depth (Fig. 1). The gear used was an 18 m semi-commercial otter trawl with a stretched 2 cm mesh cod-end. Tows were of 30 min of duration, resulting in an approximate sampling area of 2.9 hectare. Smaller catches were sorted in their entirety, whereas larger catches were weighed, and a sub sample of known weight was sorted and then individual species abundances and weights were standardized to the total catch. All data were subsequently converted to "individuals/ hectare" (ind/ha).

RESULTS

A total of 35208 echinoderms were collected throughout the 181 hauls and fifty-nine species were identified. These echinoderms were dominated by the Asteroidea (25 species), and they were followed in numerical sequence by Ophiuroidea (15 species), Echinoidea (14), Crinoidea (4), and Holothuroidea (1) (Table 2). Ten species occurred in all seasons: *Luidia clathrata*; *Astropecten nitidus*, *Astropecten duplicats*, *Astropecten alligator*, *Astropecten cingulatus*, *Luidia alternata*, *Tethyaster grandis*, *Comactinia meridionalis*, *Brissopsis elongata*, and *Clypeaster ravenelii*; four species were observed only in Spring: *Asteroschema spp*, *Clypeaste*r *rosaceus*, *Clypeaster subdepressus*, *Echinaster serpentarius*; and six species in Summer: *Asteroschema elongatum, Brissus unicolor, Conolampas sigsbei, Ophiothrix aristulata, Oreaster reticulatus,* and *Peltaster placenta*; three species in Autumn: *Ophioderma brevispinum, Ophiothrix angulata, Ophiura (Ophiura) ljungmani;* and eight species in Winter: *Brisaster fragilis, Cidaris abyssicola*, *Echinaster echinoporus*, *Lytechinus variegatus, Narcissia trigonaria, Ophiothrix lineata,*

TABLE 1
Oceanographic surveys by season and year.[1]

CUADRO 1
Campañas oceanográficas por periodo climático y año.[2]

Season/ Survey	Spring		Summer		Autumn		Winter	
	Survey Name (year) /	No. Hauls	Survey Name (year) /	No. Hauls	Survey Name (year) /	No. Hauls	Survey Name (year) /	No. Hauls
Progmex *	1 (1983)	23	3 (1984)	31	-	-	-	-
Mopeed *	1 (1992)	7	2 (1992)	8	3 (1992)	7	4 (1992)	7
	5 (1993)	7	6 (1993)	7	7 (1993)	7	8 (1993)	7
Impacto *	-	-	-	-	1 (1998)	14	-	-
Bato *	-	-	1 (1999)	9	-	-	-	-
SGM *	11 (2006)	19	9 (2004)	9	8 (2003)	9	10 (2005)	10

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[1] (No. Hauls= hauls in which echinoderms occurred).
[2] (Núm. Arrastres = arrastres en los cuales se recolectaron equinodermos).

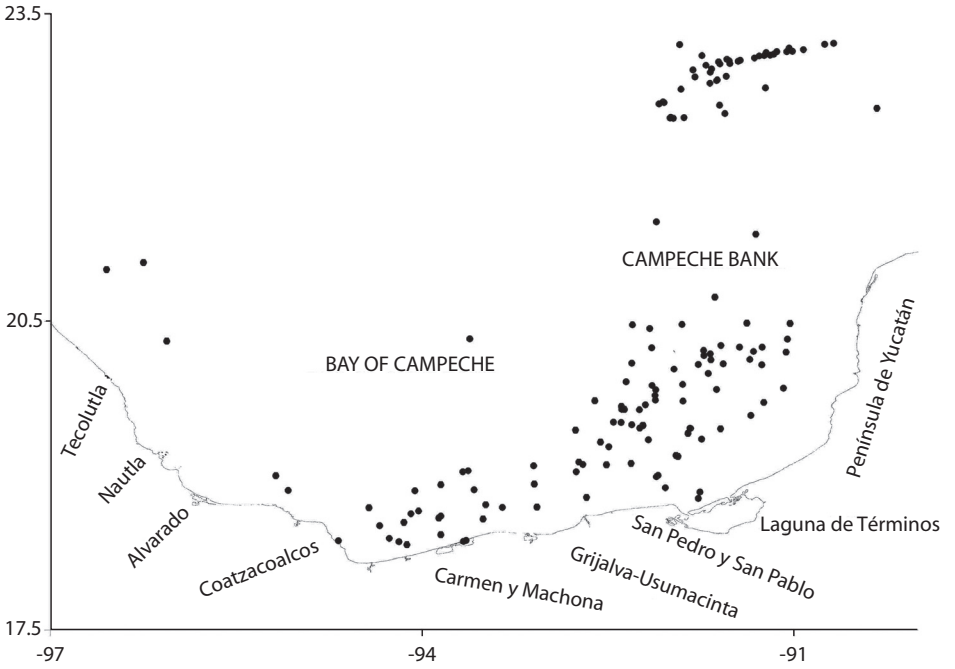

Fig. 1. Sites Sampled in the Southwestern Gulf of Mexico.

Fig. 1. Sitios de muestreo en el suroeste del Golfo de México.

TABLE 2
Taxonomic list of echinoderms collected in the Southwestern Gulf of Mexico

CUADRO 2
Lista taxonómica de los equinodermos colectados en el Suroeste del Golfo de México

Class	Family	Species
Crinoidea	Antedonidae	*Trichometra cubensis*
	Charitometridae	*Crinometra brevipinna*
	Comasteridae	*Comactinia echinoptera*
		Comactinia meridionalis
Ophiuroidea	Asteronychidae	*Asteronyx loveni*
	Asteroschematidae	*Asteroschema* sp. 1
		Asteroschema sp. 2
		Asteroschema elongatum
	Gorgonocephalidae	*Astrocyclus caecilia*
	Ophiochitonidae	*Ophiochiton ternispinus*
	Ophiodermatidae	*Bathypectinura heros*
		Ophioderma brevispinum
	Ophiothricidae	*Ophiothrix angulata*
		Ophiothrix aristulata
		Ophiothrix lineata
		Ophiothrix suensonii
	Ophiuridae	*Ophiomusium acuferum*
		Ophiomusium serratum
		Ophiura (Ophiura) ljungmani
Asteroidea	Astropectinidae	*Astropecten alligator*
		Astropecten americanus
		Astropecten articulatus
		Astropecten cingulatus
		Astropecten comptus
		Astropecten duplicatus
		Astropecten nitidus
		Persephonaster echinulatus
		Tethyaster grandis
	Benthopectinidae	*Cheiraster (Christopheraster) blakei*
		Cheiraster (Christopheraster) mirabilis
		Echinaster echinophorus
		Echinaster (Othilia) paucispinus
	Echinasteridae	*Echinaster serpentarius*
		Echinaster spinulosus

TABLE 2 (Continued)
Taxonomic list of echinoderms collected in the Southwestern Gulf of Mexico

CUADRO 2 (Continuación)
Lista taxonómica de los equinodermos colectados en el Suroeste del Golfo de México

Class	Family	Species
	Goniasteridae	*Anthenoides piercei*
		Goniaster tessellatus
		Peltaster placenta
		Pseudarchaster gracilis
	Luidiidae	*Luidia alternata*
		Luidia clathrata
	Ohidiasteridae	*Narcissia trigonaria*
		Tamaria floridae
	Oreasteridae	*Oreaster reticulatus*
	Zoroasteridae	*Zoroaster fulgens*
Echinoidea	Brissidae	*Brissopsis elongata*
		Brissopsis atlantica
		Brissus unicolor
	Cidaridae	*Cidaris abyssicola*
		Eucidaris tribuloides tribuloides
		Stylocidaris affinis
	Clypeasteridae	*Clypeaster ravenelii*
		Clypeaster rosaceus
		Clypeaster subdepressus
	Echinolampadidae	*Conolampas sigsbei*
	Mellitidae	*Encope michelini*
		Mellita quinquiesperforata
	Schizasteridae	*Brisaster fragilis*
	Toxopneustidae	*Lytechinus variegatus*
Holothuroidea	Holothuriidae	*Holothuria (Cystipus) occidentalis*

Ophiothrix suensonii, and Tamaria floridae (Table 3).

The largest catches recorded for all seasons in the Bay of Campeche and Campeche Bank, were for *Luidia clathrata,* 20753 individuals, and represent the 59% of the total capture of echinoderms. This starfish was collected on the Bay of Campeche and Campeche Bank (Veracruz to Campeche) in a depth range from 14 to 190 m, also this species was the most frequent (68% of occurrences). The second species in rank of density was *Astropecten nitidus* 5895 individuals, and accounted for 17% of the total capture of echinoderms, but with only 7% of occurrence. This asteroid was collected in the Campeche Bank area (Tabasco to Campeche) from 15 to 183 m of depth. The density of *Astropecten duplicatus* was of 1686

TABLE 3
Densities (D %), and Occurrences (%O) of the Echinoderms encountered in each Season

CUADRO 3
Densidad (D%) y Frecuencia (O%) de los equinodermos colectados en cada periodo climático

Spring			Summer			Autumn			Winter		
Species	% D	O %	Species	%D	O%	Species	%D	O%	Species	%D	O%
Asteroschema sp. 1	0.057	2	*Anthenoides piercei*	*	3	*Anthenoides piercei*	*	2	*Astropecten alligator*	*	4
Asteroschema sp. 2	*	2	*Asteronyx loveni*	0.4	5	*Astropecten alligator*	0.1	6	*Astropecten cingulatus*	2.8	29
Astropecten alligator	1.584	14	*Asteroschema elongatum*	*	2	*Astropecten americanus*	*	2	*Astropecten duplicatus*	0.1	8
Astropecten articulatus	0.090	7	*Astrocyclus caecilia*	*	2	*Astropecten articulatus*	5.9	16	*Astropecten nitidus*	61.4	21
Astropecten cingulatus	0.995	13	*Astropecten alligator*	5.3	13	*Astropecten cingulatus*	0.4	12	*Brissopsis atlantica*	3.9	8
Astropecten comptus	*	4	*Astropecten articulatus*	5.9	22	*Astropecten comptus*	0.1	10	*Brissopsis elongata*	*	4
Astropecten duplicatus	12.863	25	*Astropecten cingulatus*	0.2	9	*Astropecten duplicatus*	11.9	22	*Brisaster fragilis*	*	4
Astropecten nitidus	1.142	11	*Astropecten comptus*	*	3	*Astropecten nitidus*	0.1	6	*Cidaris abyssicola*	*	4
Brissopsis atlantica	0.226	2	*Astropecten duplicatus*	5.6	23	*Brissopsis elongata*	*	2	*Clypeaster ravenelli*	0.3	8
Brissopsis elongata	0.158	4	*Astropecten nitidus*	*	2	*Clypeaster ravenelli*	0.1	4	*Comactinia meridionalis*	0.1	8
Clypeaster ravenelii	0.113	5	*Bathypectinura heros*	0.1	2	*Comactinia meridionalis*	0.3	4	*Echinaster echinophorus*	*	4
Clypeaster rosaceus	*	2	*Brissopsis atlantica*	0.2	3	*Echinaster (Othilia) sentus*	*	2	*Echinaster (Othilia) paucispinus*	0.1	4
Clypeaster subdepressus	*	2	*Brissopsis elongata*	1.5	5	*Luidia alternata*	3.5	6	*Encope michelini*	*	4
Comactinia echinoptera	0.780	7	*Brissus unicolor*	0.1	3	*Luidia clathrata*	71.8	56	*Goniaster tessellatus*	*	4
Comactinia meridionalis	*	2	*Cheiraster (Christopheraster) blakei*	*	2	*Melita quinquesperforata*	5.3	4	*Holothuria (Cystipus) occidentalis*	*	4
Crinometra brevipinna	0.192	4	*Cheiraster (Christopheraster) mirabilis*	*	2	*Ophioderma brevispinum*	*	2	*Luidia alternata*	0.4	13
Echinaster serpentarius	*	4	*Clypeaster ravenelli*	0.1	5	*Ophiura (Ophiura) ljungmani*	0.3	2	*Luidia clathrata*	30.5	46
Echinaster spinulosus	*	2	*Comactinia echinoptera*	1.0	6	*Ophiothrix angulata*	*	2	*Narcissia trigonaria*	*	4
Encope michelini	*	2	*Comactinia meridionalis*	2.8	3	*Stylocidaris affinis*	*	2	*Ophiothrix lineata*	*	4
Eucidaris tribuloides tribuloides	*	2	*Conolampas sigsbei*	0.4	2	*Tethyaster grandis*	*	4	*Ophiothrix suensonii*	*	4
Luidia alternata	0.144	7	*Echinaster spinolosus*	0.3	5				*Tamaria floridae*	*	13

TABLE 3 (Continued)
Densities (D %), and Occurrences (%O) of the Echinoderms encountered in each Season

CUADRO 3 (Continuación)
Densidad (D%) y Frecuencia (O%) de los equinodermos colectados en cada periodo climático

Spring			Summer			Autumn			Winter		
Species	% D	O %	Species	%D	O%	Species	%D	O%	Species	%D	O%
Luidia clathrata	79.236	61	*Echinaster (Othilia) paucispinus*	*	3				*Tethyaster grandis*	0.1	4
Mellita quinquiesperforata	*	2	*Encope michelini*	0.4	3						
Tethyaster grandis	2.183	21	*Eucidaris tribuloides tribuloides*	*	3						
Echinaster serpentarius	*	2	*Goniaster tessellatus*	*	2						
			Holothuria (Cystipus) occidentalis	0.8	3						
			Luidia alternata	*	2						
			Luidia clathrata	72.7	36						
			Ophiochiton ternispinus	*	2						
			Ophiomusium acuferum	0.2	5						
			Ophiomusium serratum	*	2						
			Ophiothrix aristulata	*	2						
			Oreaster reticulatus	0.1	5						
			Peltaster placenta	*	3						
			Persephonaster echinulatus	0.5	6						
			Pseudarchaster gracilis	*	3						
			Stylocidaris affinis	*	2						
			Tethyaster grandis	1.1	9						
			Trichometra cubensis	0.1	2						
			Zoroaster fulgens	*	2						

individuals and accounted for 5% of the total capture of echinoderms), and was collected in the Bay of Campeche and Campeche Bank (Veracruz to Campeche) in a depth range from 17 to 184 m, this species was the second in rank of occurrence (19%). Even though, *Astropecten alligator, Astropecten cingulatus, Luidia alternata Tethyaster grandis, Comactinia meridionalis, Brissopsis elongata,* and *Clypeaster raveneli,* were caught in all seasons they had small abundances (< 500 individuals). Despite the fact that, *Astropecten articulatus, Brissopsis atlantica,* and *Mellita quinquiesperforata,* were not observed in all seasons they had the greatest catches in only one trawl. (Fig. 2). The multivariate analysis (ANOVA) showed that there were not differences ($p<0.05$) among density values for the different seasons (Fig. 3).

The Campeche Bank was the area with the largest catch 32, 286 individuals (mean catch 88 ind/ha) and number of species observed (41), the greatest densities in this area were collected off Terminos Lagoon (15 to 23 m of depth) on carbonate sand substrate; whereas, the Bay of Campeche had a density of 2, 922 individuals (mean catch 15 ind/ha) belonging to 26 species, the greatest densities were observed off Rivers San Pedro and San Pablo (48 to 80 m of depth) on transitional silt-lime substrate (Fig. 4). The following species, *Astrocyclus caecilia, Asteronyx loveni, Bathypectinura heros, Cheiraster (Christopheraster) blakei, Cheiraster (Christopheraster) mirabilis, Ophiochiton ternispinus, Ophiomusium acuferum, Ophiomusium serratum, Persephonaster echinulatus, Pseudarchaster gracilis,*

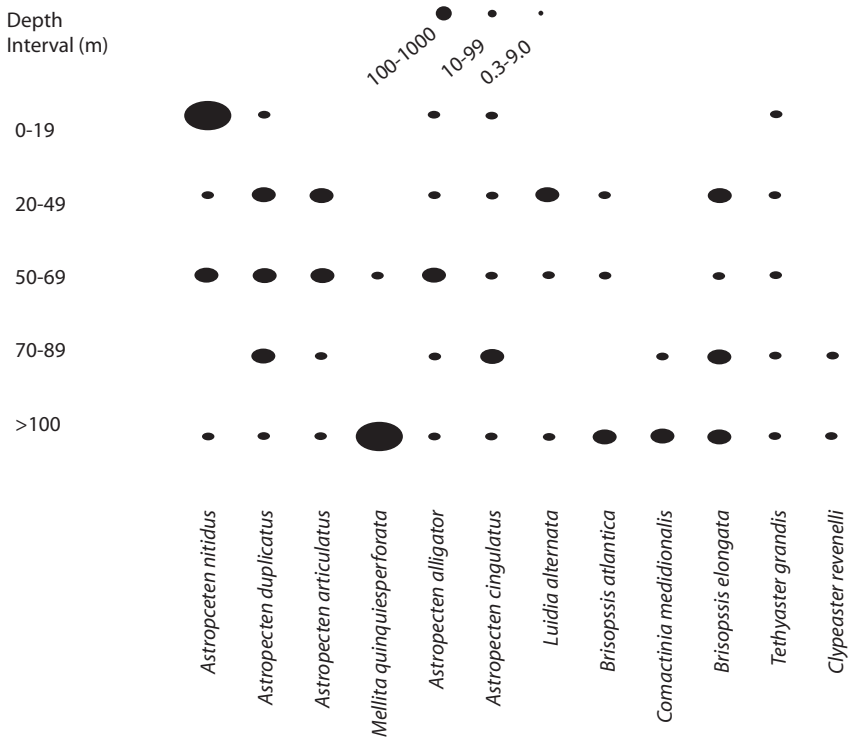

Fig. 2. Density values of the most abundant and frequent echinoderm species by depth interval (mean catch ind/ha).

Fig. 2. Densidad de las especies de equinodermos más abundantes y frecuentes por intervalo batimétrico (densidad promedio ind/ha).

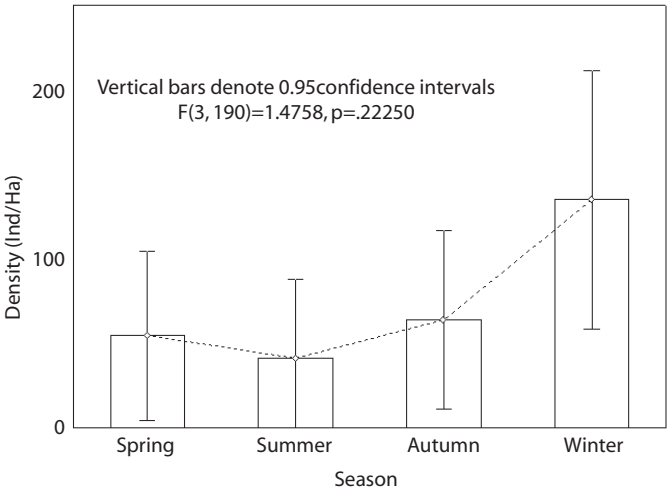

Fig.3. Density values by Season (ind/ha).

Fig. 3. Densidad (ind/ha) por estación climática.

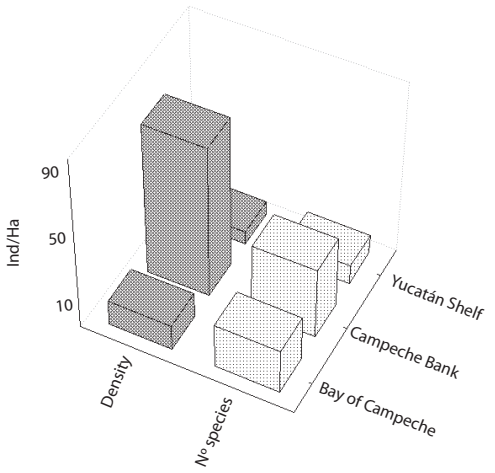

Fig. 4. Echinoderm species number and density values (mean catch ind/ha) registered in the Bay of Campeche, the Campeche Bank, and Yucatan shelf.

Fig. 4. Número de especies y densidad de equinodermos registrados en la Bahía y Banco de Campeche así como en la plataforma continental de Yucatán (valores promedio ind/ha).

Trichometra cubensis, and Zoroaster fulgens, had a restricted bathymetrical distribution (300 to 600 m) and were collected in front of the Yucatan Peninsula on mud substrates (Fig. 6).

In the spring season, the total number of species collected was 25 with a mean catch of 54.4 ind//ha (Figs. 3, 5). The asteroids were the dominant component, and accounted for approximately 98% of the density. The largest catch was for *L. clathrata* (mean catch 71 ind/ha) and greatest percentage of occurrence (64%). This starfish had a broad bathymetric range (16-190 m) in the Bay of Campeche and the Campeche Bank, although, the maximum catches were observed in the Campeche Bank (off Terminos Lagoon, on carbonate substrates) at 16 m depth (569 ind/ha), and at 18 m (483 ind/ha). Densities lower than 100 ind/ha were observed in the area of the Bay of Campeche at the deepest locations (Fig. 7).

A. duplicatus, was less abundant (mean catch 28 ind/ha) and frequent (25%), and was mainly collected in the area of the Campeche

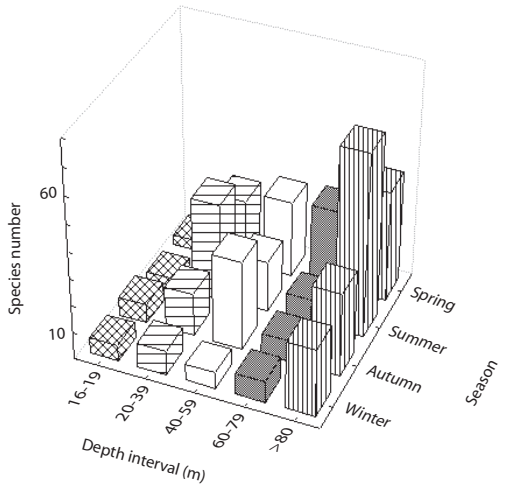

Fig. 5. Echinoderm species number by season and depth interval.

Fig. 5. Número de especies de equinodermos por estación climática e intervalo batimétrico.

Bank between 20 to 184 m of depth. This species also had a maximum in front of Terminos Lagoon (216 ind/ha), on carbonate substrates, at 47 m of depth.

In the Summer seasons, the density of echinoderms was comparatively smaller than the Spring, Autumn and Winter, in which we only recorded a mean catch of 41 ind/ha, however, this season had the greatest number of species (40) (Figs. 3, 5). The half of total species collected belonged to Asteroidea, and they accounted for 92% of the total catch of echinoderms. The Echinoidea and Ophiuroidea had 8 species each one, but with densities smaller than 50 ind/ha.

The greatest densities (mean catch 83 ind/ha), and percentage of occurrence (36%) were for *L. clathrata*. This starfish had a broad bathymetric range (19-152 m) in the Bay of Campeche and the Campeche Bank, even though, the maximum densities (883

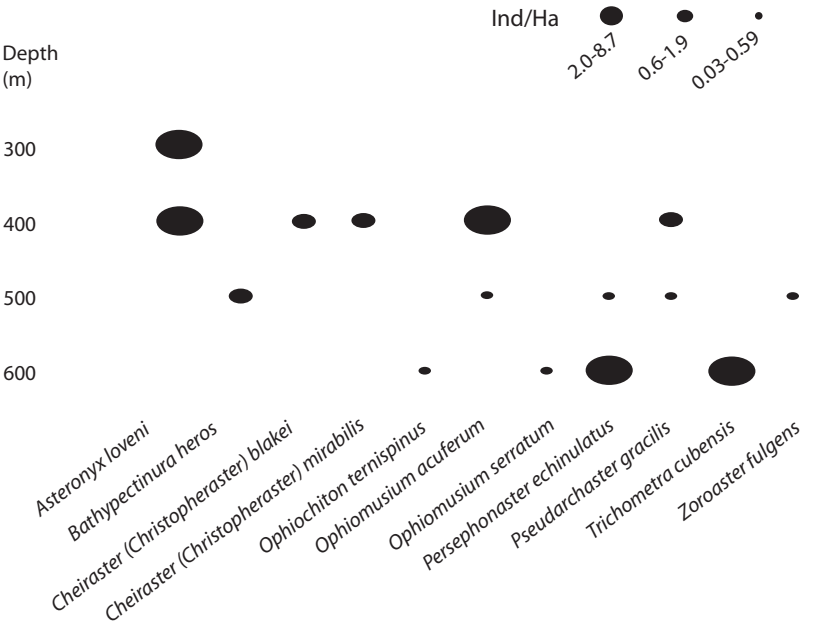

Fig. 6. Density values of the echinoderm species encountered in the Yucatan Shelf (mean catch ind/ha)

Fig. 6. Densidad de las especies de equinodermos recolectadas en la plataforma continental de Yucatán (valores promedio ind/ha).

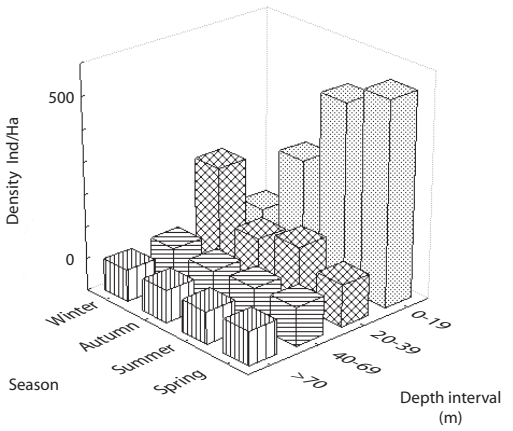

Fig. 7. Density values of *Luidia clathrata* (mean catch ind/ha) by season and depth interval.

Fig. 7. Densidad de *Luidia clathrata*(valores promedio ind/ha) por intervalo batimétrico, en los diferentes estaciones climáticas.

ind/ha, and 479 ind/ha) were observed in the Campeche Bank (off Terminos Lagoon, on carbonate substrates), at 21 m depth and at 19 m depth Densities lesser than 100 ind/ha were observed in the Bay of Campeche at the deepest stations sampling (Fig. 7).

A. articulatus, in this season, was the second species ranked in abundance (mean catch 11 ind/ha). This asteroid was collected in the Bay of Campeche and the Campeche Bank, in a depth interval from 20 to 190 m. A maximum density of 106 ind/ha was observed at 21 m in the Campeche Bank area (off Terminos Lagoon) on carbonate substrates. *A. duplicatus* had a mean catch of 10 ind/ha, with a maximum of 109 ind/ha at 20 m off Terminos Lagoon and on carbonate substrate.

Autumn was the season with the fewest species recorded (20), however, the mean catch was larger than in the Spring and the Summer seasons (63 ind/ha) (Fig. 3, 5). In this season more than half of total species recorded belonged to Asteroidea, which represented approximately the 94% of the total catch of echinoderms. The Echinoidea and Ophiuroidea had 4 and 3 species respectively, although, they had small densities. *L. clathrata* represented the largest mean catches (81 ind/ha) and the greatest occurrence percentage at 55 %. This species was observed in a broad bathymetric range (14-167 m) in the Bay of Campeche and the Campeche Bank, even though, the maximum catches were found in the Campeche Bank (off Terminos Lagoon, on carbonate substrates), at 16 m depth (mean catch 637 ind/ha), and at 23 m (624 ind/ha). Densities lower than 100 ind/ha were observed in the area of the Bay of Campeche at the deepest stations sampled (Fig. 7).

A. duplicatus, was the second species ranked in abundance, mean catch 35 ind/ha, and 20% of occurrence. This asteroid was recorded in the Bay of Campeche and the Campeche Bank, in a depth range from 24 to 155 m. The maximum density (223 ind/ha) was observed at 67 m in the Bay of Campeche area (off Coatzacoalcos River on silt substrates). *A. articulatus*, in this season, was the third species ranked in abundance (mean catch 23 ind/ha). The highest density value of 71 ind/ha was found at 46 m in front of Terminos Lagoon. On the other hand, the irregular echinoid *Mellita quinquiesperforata,* even though, it had few occurrences (5.4%), presented the greatest densities in this season (mean catch 85 ind/ha). In fact, its highest densities (169 ind/ha) were accounted by one haul at 80.4 m depth, near to Carmen-Machona Lagoons, on terrigenous substrate.

During the Winter seasons, the largest catches were observed (mean catch 135 ind/ha) with a total of 22 species collected. (Fig. 3, 5). As in the other seasons, the Asteroidea was the most abundant, the 13 species recorded accounted for 96 % of the catch, while the echinoids and ophiuroids had low densities and few species. *A. nitidus* was recorded mainly in the Campeche Bank in a broad bathymetrical range (15-167 m). This species registered the highest catches in the Winter season (mean catch 398 ind/ha). The maximum of 1762 ind/ha was observed off the Terminos Lagoon on sand carbonate substrate, at 15 m. *L. clathrata*, was the second species in abundance (mean

catch 90 ind/ha). A maximum of 823 ind/ha was found on carbonate sand in front of the Terminos Lagoon, at 22 m, (Fig. 7) whereas *A. duplicatus* had the lowest densities (mean catch 2.4 ind/ha), and *A. articulatus* was not present. Other species like *B. atlantica,* and *A. cingulatus* had a small occurrence percentage, but compared with the other seasons presented the highest densities (mean catch 62 ind/ha and 13 ind/ha, respectively).

DISCUSSION

Despite their ecological importance, the broad-scale patterns of the relative abundance of epibenthic echinoderms around the Southwestern Gulf of Mexico are previously little known. During this combined survey, 59 species were observed, and the order of dominant classes is Asteroidea, followed by Ophiuroidea, Echinoidea, Crinoidea, and Holothuroidea.

The Campeche Bank was the area with the largest densities and species richness compared to Bay of Campeche, certainly the wide shelf of the Campeche Bank enclose more areas suitable for trawling that result in an uneven trawl effort between these two sites. Even so, the results presented here give the most widespread quantitative study of macroepibenthic echinoderms around the Southwestern Gulf of Mexico.

The echinoderms in the Bay of Campeche and the Campeche Bank were characterized by many species with low density as well as few species with high density and occurrence. Most of the species had a broad bathymetric distribution, although their abundance varied with depth and season.

High catch rates of *L. clathrata* in all seasons were recorded in the Campeche Bank area at narrow depth range (16-23 m) on carbonate substrate. Furthermore, the catches and occurrence of *L. clathrata* showed little change throughout all the seasons. Their occurrence and largest catches were found in front of Terminos Lagoon at 16 m in Spring and Autumn, and at 21 m in Summer and Winter. Moreover, concerning this species, the highest densities per hectare were found during the Autumn seasons, whereas the smallest value was found in Winter.

A. nitidus, the second most abundant echinoderm, had a maximum density in one haul in the Winter season (in front of the Terminos Lagoon, at 15 m depth on carbonate substrate). *A. duplicatus* had their maximum values recorded in the Spring season and Autumn at 48 m depth on carbonate substrate in front of Terminos Lagoon.

The species richness was greatest in Summer, certainly in this season, we made the deepest hauls that increased the number of species of echinoderm. In the others seasons the species richness presented little changes. The sites with the highest densities were recorded at shallow depths, in front of the Terminos Lagoon, and Grijalva-Usumacinta Rivers on carbonate substrate, and in front of the San Pedro and San Pablo Rivers, and Coatzacoalcos River on silt substrates and transitional silt-lime substrate

The maximum catches of the dominant species may be indicative of the aggregating nature of echinoderms (Pawson 1976, Nybakken *et al*. 1998). This behavior has been reported to be associated with the abundance of food (Grassle *et al*. 1975, Billett and Hansen 1982) or reproductive requirements (Smith and Hamilton 1983, Vadas *et al*. 1986). Asteroid species are found to have abundant and narrow centers of distribution with much wider total depth ranges. This might result from competition for resources or be related to the occurrence of favorable habitats at particular depths. The Campeche Bank is an area with enormous river overflow that may supply a great amount of food and sediments from the continent. We suggest that this event could result in a major spatial heterogeneity. If this proves to be true, then it may have influence on the predator-prey interactions, in addition to the distribution and abundance of the species encountered. Thus, centers of distribution may be skewed.

In this area studied (from Veracruz to Campeche) we recorded 59 species of

echinoderms collected by benthic trawls, a small number compared to Laguarda-Figueras *et al*. (2005), who recorded 209 species, but in this last study they sampled an area much longer (from Tampico to Yucatan), and recorded echinoderms collected by different gears and in the coastal areas where reef ecosystems are found. *Mellita quinquiesperforata* constitutes a bathymetric range extension (from an earlier 3 m depth recorded by Solís-Marín 1998) to the new depth of 80.4 m.

Even though the otter trawl used in the present study is not a properly accurate gear for the quantitative sampling of infaunal echinoids, ophiuroids and holothurians, we believe that the trawl sampling was effectively in the catch of any epifaunal (surface living) member of the *Echinodermata* (asteroids, crinoids, echinoids, holothuroids, and ophiuroids) with a 5 cm radius.

As we said previously, there are only a few publications on echinoderm assemblages in this area, but Vazquez-Bader (1996), mentioned that *L. clathrata*, *A. articulatus* and *A. nitidus* were dominant components found among crustacean assemblages encountered in the Southwestern Gulf of Mexico. In this case, *L. clathrata* was a dominant component in the shallow depth assemblages (16-45 m), whereas *A. articulatus* and *A. nitidus* were in the medium depth assemblages (50-100 m).

In this study the depth and the substrate were important factors influencing the structure of macroepibenthic assemblages. A preliminary canonical analysis (in process) revealed that the depth and the type of substrate were the most important factors influencing the structure of macroepibenthic echinoderm assemblages.

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RESUMEN

Se analizó la distribución, densidad relativa y frecuencia de los equinodermos epibentónicos recolectados en el suroeste del Golfo de México. Se registró un total de 59 especies pertenecientes a 25 especies de asteroideos, cuatro especies de crinoideos, 15 especies de ofiuroideos, 14 especies de equinoideos y una especie de holoturoideo. *Luidia clathrata* fue la especie más abundante y frecuente a través de todas las estaciones climáticas y representó un total de 68% de la captura total de equinodermos en todas las temporadas climáticas. *Astropecten nitidus Astropecten duplicatus*, *Mellita quienquiesperforata, Brissopsis atlantica, Brissopsis elongata, Astropecten articulatus, Luidia alternata*, *Comactinia meridionalis*, *Astropecten alligator, Astropecten cingulatus, Tethyaster grandis,* and *Clypeaster ravenelii* aunque fueron menos abundantes y frecuentes, contribuyeron con el 13% del total de equinodermos colectados. Las mayores densidades (ind/ha) de *Luidia clathrata,* se recolectaron en el área del Banco de Campeche a 16 m de profundidad, En otoño se registró la mayor densidad de individuos sobre sustratos carbonatados, mientras que la mayor riqueza específica se observó en verano.

Palabras clave: Equinodermos, composición específica, densidad, distribución estacional, Suroeste del Golfo de México.

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