SUPPLEMENT

REVISTA DE Biología Tropical

https://doi.org/10.15517/2q2fzb88

Echinoderm (Echinodermata) species richness in Cozumel Reefs National Park and the northern part of the island, Mexican Caribbean

Laura Georgina Calva-Benítez[1]*; https://orcid.org/0000-0003-4973-6388
Rebeca Granja-Fernández[2]; https://orcid.org/0000-0001-7119-0567

1. Laboratorio de Ecosistemas Costeros. Departamento de Hidrobiología, Universidad Autónoma Metropolitana Iztapalapa, Av. San Rafael Atlixco 186, Leyes de Reforma 1ra Secc, Iztapalapa, 09340 Ciudad de México, México; cblg@xanum.uam.mx (Correspondence)
2. Laboratorio de Ecología del Bentos, Departamento de Hidrobiología, Universidad Autónoma Metropolitana Iztapalapa, Av. San Rafael Atlixco 186, Leyes de Reforma 1ra Secc, Iztapalapa, 09340 Ciudad de México, México; beckygranja@gmail.com

Received 30-V-2026. Corrected 01-IX-2026. Accepted 07-X-2026.

ABSTRACT

Introduction: Echinoderms are essential to coral reefs, yet a checklist focused on this ecosystem had not yet documented their species richness on Cozumel Island.

Objective: Determine the current species richness and present an annotated checklist of echinoderm species from the northern part of the island and Cozumel Reefs National Park (PNAC).

Methods: We conducted survey dives using free diving and SCUBA between 2018 and 2025. We covered depths from 0 to 32 m at 14 reefs within the PNAC and in the northern area (Santa Pilar). We recorded substrates and organisms via *in situ* video.

Results: A total of 29 species belonging to five classes were recorded during fieldwork. The Echinoidea class (31 %) and the Ophiuroidea class (28 %) were the most prevalent. Sea urchins of the species *Echinometra lucunter* and *Diadema antillarum* were the most numerous. The sea cucumber *Holothuria* (*Halodeima*) *mexicana* was the most common species, found at 10 reefs. A total of 19 species were identified in the PNAC, and 18 species were recorded in the northern region of the island. Six new records were documented on the island: the crinoid *Davidaster discoideus*, the sea star *Luidia alternata alternata*, the sea urchin *Leodia sexiesperforata*, and the sea cucumbers *Actinopyga agassizii*, *Astichopus multifidus*, and *Holothuria* (*Thymiosycia*) *impatiens*.

Conclusions: When the species richness found during fieldwork is combined with that previously reported in the literature, a total of 39 species of echinoderms are identified in the coral reefs of Cozumel (25 in the northern area and 30 in the PNAC; 13 species are common to both areas). The species richness of echinoderms in Cozumel is lower than in the Mexican Caribbean. However, the area harbors ecologically critical populations and commercial resources that lack adequate regulation. Given the alarming population decline of these organisms, it is imperative to implement a specific monitoring program.

Key words: annotated checklist; new records; protected natural area; coral systems; benthic organisms.

RESUMEN

Riqueza de especies de equinodermos (Echinodermata) en el Parque Nacional Arrecifes de Cozumel y en la parte norte de la isla, Caribe mexicano

Introducción: Los equinodermos son esenciales para los arrecifes coralinos, pero su riqueza de especies en la isla Cozumel carecía de un listado enfocado en este ecosistema.

Objetivo: Determinar la riqueza de especies actual y presentar un listado comentado de especies de equinodermos de la zona norte de la isla y del Parque Nacional Arrecifes de Cozumel (PNAC).
Métodos: Se realizaron censos errantes mediante buceo libre y autónomo (SCUBA) entre 2018 y 2025, abarcando profundidades entre 0 a 32 metros en 14 arrecifes del PNAC y en la zona norte (Santa Pilar), registrando sustratos y a los organismos mediante video *in situ*.
Resultados: Se registraron 29 especies pertenecientes a cinco clases durante el trabajo de campo. Las clases Echinoidea (31 %) y Ophiuroidea (28 %) fueron las más representativas. Los erizos *Echinometa lucunter* y *Diadema antillarum* fueron los más numerosos. El pepino de mar *Holothuria* (*Halodeima*) *mexicana* fue la especie más frecuente, registrada en 10 arrecifes. Se identificó un total de 19 especies en el PNAC y 18 especies en la región norte de la isla. Se documentaron seis nuevos registros para la isla: el crinoideo *Davidaster discoideus*, el asteroideo *Luidia alternata alternata*, el equinoideo *Leodia sexiesperforata* y los holoturoideos *Actinopyga agassizii*, *Astichopus multifidus* y *Holothuria* (*Thymiosycia*) *impatiens*.
Conclusiones: Al sumar la riqueza de especies encontrada durante nuestro trabajo de campo más la reportada previamente en la literatura, se suman 39 especies de equinodermos en los arrecifes coralinos de Cozumel (24 en la zona norte y 28 en el PNAC; 13 especies en común entre ambas áreas). La riqueza de equinodermos en Cozumel es inferior a la del Caribe mexicano. No obstante, resguarda poblaciones ecológicamente críticas y recursos comerciales sin regulación adecuada. Ante la alarmante disminución poblacional de estos organismos, es imperativo implementar un programa de monitoreo específico.

Palabras clave: listado comentado; registros nuevos; área natural protegida; sistemas coralinos; organismos bentónicos.

INTRODUCTION

Echinoderms are a conspicuous group on coral reefs in shallow tropical waters (Birkeland, 1989). The activity of these organisms exerts a significant influence on the structure and functioning of coral reef ecosystems, thereby altering the composition of benthic species (Birkeland, 1989; Sobha et al., 2023). Mexico's coral reefs are home to 214 species of echinoderms, of which 127 are found in the Gulf of Mexico and 83 in the Caribbean Sea; notably, some of these species are found in both regions (Granja-Fernández et al., in press).

Specifically, the Caribbean Sea is home to the world's second-largest barrier reef, the Mesoamerican Reef System (Asociación Interamericana para la Defensa del Ambiente, 2014). This system includes the coral reefs surrounding Cozumel Island, where the Cozumel Reefs National Park (PNAC) was established in 1996 to protect the coral formations surrounding the island (Diario Oficial de la Federación, 1996; Arroyo-Arcos et al., 2018). The island is significant for two reasons. First, it is one of the primary reef structures in the Mexican Caribbean. Second, it serves as a habitat for diverse species of flora and fauna, supporting the local tourism-dependent economy (Dutra et al., 2021). The island's status as a premier international destination for recreational diving, snorkeling, and marine activities has contributed to its economic vitality. Presently, Cozumel leads Mexico in cruise ship arrivals (Administración Portuaria Integral de Quintana Roo, 2026).

The echinoderms of Cozumel have been the focus of extensive research within the island's anchialine cave system, leading to the description of new species (e.g., Mejía-Ortiz et al., 2007; Solís-Marín & Laguarda-Figueras, 2010; Hernández-Díaz et al., 2013; Márquez-Borrás et al., 2016; Bribiesca-Contreras et al., 2019). Some records from deep waters (> 200 m) have also been reported in the channel between Yucatán and the island (Solís-Marín & Laguarda-Figueras, 2007). However, the species richness of echinoderms in coral reefs has been mentioned sporadically and in isolation only for a few sites, such as Arrecife Paraíso (e.g., Pawson & Caycedo, 1980; Instituto Nacional de Ecología, 1998; Solís-Marín & Laguarda-Figueras, 2007). Additionally, various records of echinoderm species on the island are listed under the generic name "Cozumel",

without specifying the ecosystem (e.g., Hendler et al., 1995; Laguarda-Figueras et al., 2009; Kuk-Dzul et al., 2019).

To date, the total number of echinoderm species present on Cozumel Island remains to be determined. Therefore, the objective of this study was to determine the current echinoderm richness in the coral reefs of the northern part of the island and the PNAC. This manuscript comprises an updated and annotated list of species, which is based on information gathered during the present fieldwork and on previous records reported on the island.

MATERIALS AND METHODS

Study area: The island of Cozumel is recognized as the third-largest island in Mexico. It is situated east of the Yucatán Peninsula, off the coast of the state of Quintana Roo, and its dimensions are 48 km by 16 km (Arroyo-Arcos et al., 2018). The island is characterized by a short insular shelf along its western margin, which extends to a depth of between 20 and 30 m. Beyond this shelf is the island slope, which descends at an almost vertical angle to depths exceeding 400 m (Comisión Nacional de Áreas Naturales Protegidas [CONANP], 2016).

The PNAC is located in the south-central part of the island (Fig. 1), extending from the northern tip of the Paraíso Reef (20°35'22" N, 86°43'46" W) to the southern tip of the island, and continuing northward to Punta Chiqueros on the east coast (20°16'11" N, 86°59'26" W) (Diario Oficial de la Federación, 1996). The primary motivation behind the establishment of the PNAC was the preservation of coral reefs, a region of particular concern due to their high biological diversity (Carrillo, 2011). This region constitutes a nearly continuous system comprising approximately 24 fringing reefs—structures characterized by a 3–4 m high

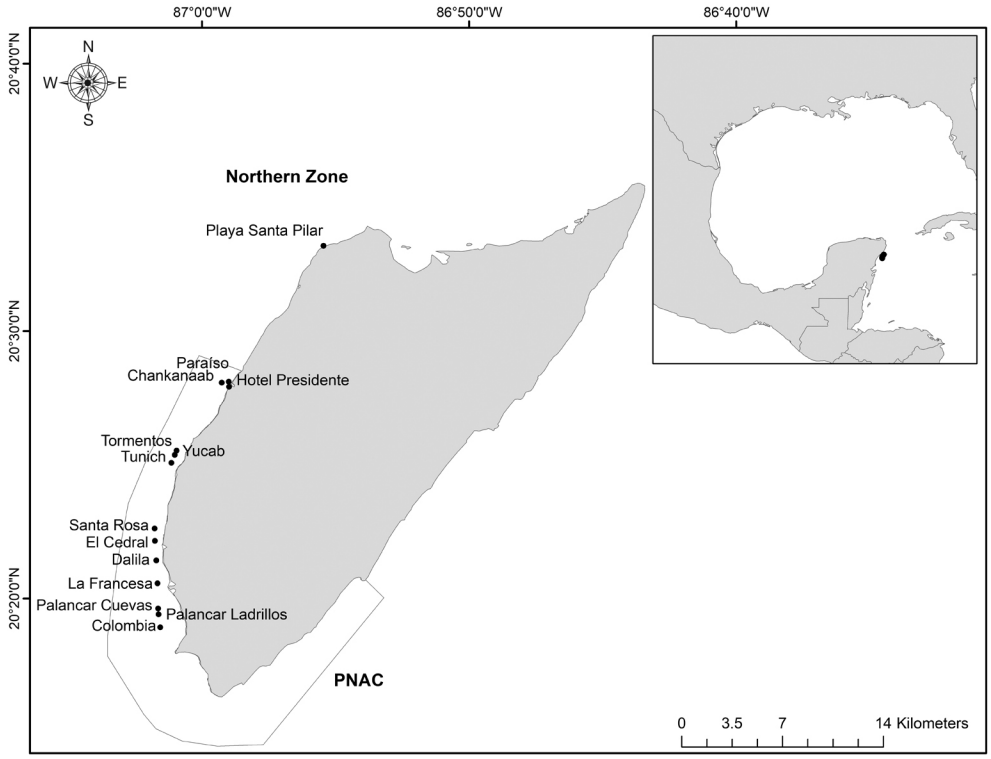


Fig. 1. Study area, northern Cozumel Island and Parque Nacional Arrecifes de Cozumel (PNAC).

crest along the slope's edge—and platform reefs, which are formations exhibiting minimal relief (Gutiérrez-Carbonell et al., 2005; Carranza-Ramirez et al., 2023).

In the northernmost part of the island, outside the PNAC protected area, there are several coastal lagoons (e.g., Laguna Ciega) surrounded by extensive mangroves. These have been designated as a Ramsar site (Secretaría de la Convención sobre los Humedales, 2009) due to their ecological importance and their contribution of nutrients to the surrounding reefs.

Fieldwork: Visual surveys were conducted in the PNAC using SCUBA diving during October and November of 2018, August of 2021, July of 2019, 2022, 2023, 2024, and 2025, December of 2024, and October of 2025. The dives were conducted at depths ranging from 7 to 32 m at the following reefs: Paraíso (14 m max.), Chankanaab (16 m max.), Hotel Presidente (10 m max.), Tormentos (18 m max.), Yucab (18 m max.), Tunich (18 m max.), Santa Rosa (32 m max.), El Cedral (17 m max.), Dalila (20 m max.), La Francesa (19 m max.), Palancar Cuevas (22 m max.), Palancar Ladrillos (26 m max.), and Colombia (30 m max.) (Fig. 1). In August of 2021, a survey was carried out in the intertidal zone and down to a depth of 7 m off the beach in front of the Hotel Presidente using freediving techniques.

In the northern part of Cozumel, surveys were conducted via freediving in October and November of 2018, in July of 2021, 2022, 2023, and 2024, as well as in December of 2024. In this area, the Santa Pilar Beach reef was the only site surveyed, encompassing the area from the intertidal zone to 5 m depth out to 200 m offshore.

In both areas, the average census was completed within a time frame of 60 minutes. Two observers were present at the PNAC and four were in the northern area. Surveys were carried out during daytime hours (9:00 to 14:00 hrs) at all sites, with the exception of Paraíso Reef, at which a night dive (19:30 to 21:00 hrs) was also conducted. Surveys were conducted in both areas via drift diving, a method entailing the systematic exploration of all potential substrates within the reefs (e.g., coral, rock, sand, and algae) for echinoderms. The substrates and associated epibiont invertebrates were systematically documented.

The observed echinoderm species were not collected; rather, they were identified taxonomically in situ according to the morphological descriptions provided by Hendler et al. (1995), Benavides-Serrato et al. (2011), and Borrero-Pérez et al. (2012). This study only includes conspicuous and easily identifiable species in the field. For species that were difficult to identify, however, photographs were taken using a Garmin Virb XE high-definition camera and some sent to taxonomic experts for double-checking.

Checklist: An annotated list of species is presented in accordance with the information collected during the fieldwork and previously published references on the coral reefs of Cozumel (Hendler et al., 1995; Instituto Nacional de Ecología, 1998; Solís-Marín & Laguarda-Figueras, 2007; Laguarda-Figueras et al., 2009; Arriaga-Ochoa & Solís-Marín, 2011; Kuk-Dzul et al., 2019). Taxonomic classification and accepted species names are based on World Register of Marine Species (2026).

RESULTS

A total of 29 species of echinoderms were identified, belonging to five classes, 13 orders, 16 families, and 21 genera (Table 1). Representative *in situ* photographs of the selected species obtained during this study are presented in Fig. 2, Fig. 3, and Fig. 4. The classes Echinoidea (nine species) and Ophiuroidea (eight species) were the most observed, accounting for 31 and 28 % of the total, respectively, followed by the class Holothuroidea with 24 % (seven species). The least observed classes were Asteroidea (10 %, three species) and Crinoidea (7 %, two species).

The most frequently observed species were the holothuroid *Holothuria* (*Halodeima*) *mexicana* (10 reefs), the crinoid *Davidaster*

Table 1

Occurrence of echinoderms on Cozumel Island between 2018 and 2025. The number of organisms observed is listed with the year of observation in parentheses.

	Northern Zone				Parque Nacional Arrecifes de Cozumel (PNAC)									
	Playa Santa Pilar	Paraíso	Chankanaab	Hotel Presidente	Tormentos	Yucab	Tunich	Santa Rosa	El Cedral	Dalila	La Francesa	Palancar Cuevas	Palancar Ladrillos	Colombia
Crinoidea														
Davidaster discoideus						1 (2022)		1 (2022)						
Davidaster rubiginosus	1 (2018)		1 (2018)		1 (2018)			1 (2018)	1 (2018)	1 (2022)		2 (2025)		
								1 (2022)						
Asteroidea														
Luidia alternata alternata	1 (2022)													
Linckia guildingi	1 (2023)							1 (2025)						
	1 (2024)													
Oreaster reticulatus	2 (2018)													
	8 (2022)													
	2 (2023)													
	1 (2024)													
	1(2025)													
Ophiuroidea														
Astrophyton muricatum		1 (2024)												
Ophioderma appressum				1 (2021)										
Ophioderma brevispinum	2 (2023)													
Breviturma paucigranulata	2 (2018)													
	3 (2022)													
	4 (2024)													
	9 (2025)													
Ophiocoma echinata	2 (2018)			1 (2021)	1 (2018)									
	2 (2023)													
	2 (2024)													
	9 (2025)													
Ophiothrix (*Acanthophiothrix*)					1 (2019)					1 (2024)			1 (2024)	
suensonii					1 (2023)									
Ophiothrix (*Ophiothrix*) *angulata*												2 (2025)		
Ophiothrix (*Ophiothrix*) *oerstedii*							1 (2018)	1 (2025)						

	Northern Zone			Parque Nacional Arrecifes de Cozumel (PNAC)									
	Playa Santa Pilar	Paraíso	Chankanaab	Hotel Presidente	Tormentos	Yucab	Tunich	Santa Rosa	El Cedral	Dalila	La Francesa	Palancar Cuevas	Palancar Ladrillos	Colombia
Echinoidea														
Eucidaris tribuloides	1 (2022)			1 (2021)										
	1 (2024)													
	3 (2018)													
	3 (2025)													
Astropyga magnifica	1 (2025)													
Diadema antillarum	6 (2018)	1 (2024)		5 (2021)				1 (2018)	1 (2018)					
	2 (2021)													
	1 (2022)													
	15 (2023)													
	6 (2024)													
	3 (2025)													
Echinometra lucunter	18 (2018)													
	1 (2022)													
	11 (2023)													
	13 (2024)													
	5 (2025)													
Echinometra viridis	1 (2018)			1 (2021)										
	4 (2023)													
Lytechinus variegatus variegatus	1 (2021)													
Tripneustes ventricosus	6 (2022)			1 (2021)						1 (2018)				
	2 (2024)													
	1 (2025)													
Meoma ventricosa	2 (2024)													
Leodia sexiesperforata	1 (2021)													
Holothuroidea														
Actinopyga agassizii	1 (2022)												1 (2022)	
	1 (2023)													
Holothuria (*Halodeima*) *mexicana*		3 (2024)		2 (2021)	2 (2019)	1 (2018)	2 (2018)	2 (2022)	1 (2018)	1 (2022)	1 (2018)		1 (2022)	
					2 (2023)	1 (2025)			2 (2025)	2 (2025)			1 (2024)	
Holothuria (*Theelothuria*) *princeps*	1 (2021)													
Holothuria (*Thymiosycia*) *impatiens*				1 (2021)										
Holothuria (*Thymiosycia*) *thomasi*		1 (2024)								1 (2025)				
Astichopus multifidus														1 (2024)
Isostichopus badionotus		3 (2024)				1 (2018)			1 (2025)					1 (2018)
		2 (2025)												

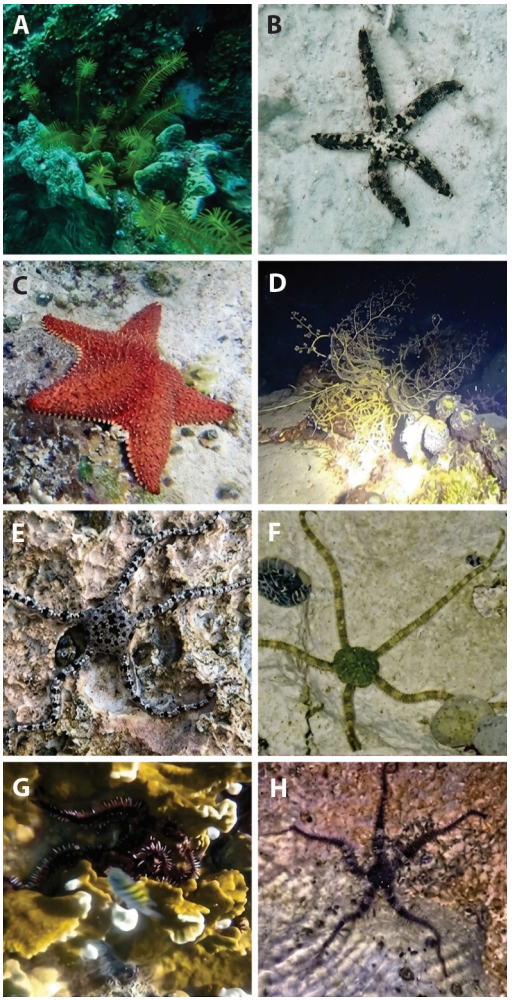


Fig. 2. A) *Davidaster rubiginosus*; B) *Luidia alternata alternata*; C) *Oreaster reticulatus*; D) *Astrophyton muricatum*; E) *Ophioderma appressum*; F) *Ophioderma brevispinum*; G) *Breviturma paucigranulata*; H) *Ophiocoma echinata*. Photographs by L.G. Calva Benítez.

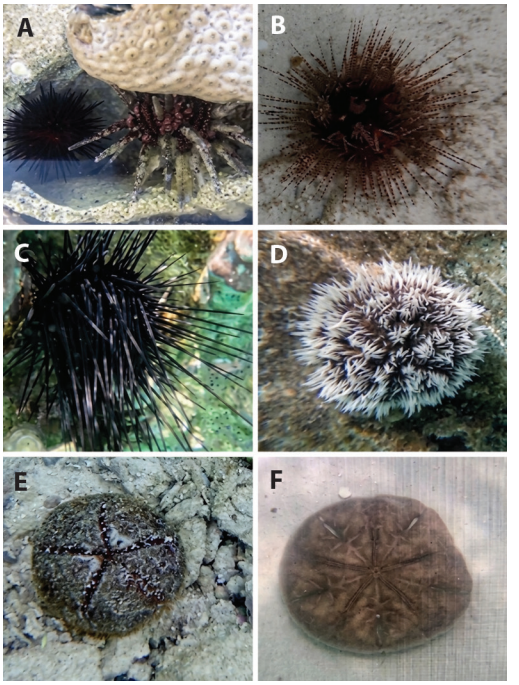


Fig. 3. A) *Echinometra lucunter* and *Eucidaris tribuloides*; B) *Astropyga magnifica*; C) *Diadema antillarum*; D) *Tripneustes ventricosus*; E) *Meoma ventricosa ventricosa*; F) *Leodia sexiesperforta*. Photographs by L.G. Calva Benítez.

rubiginosus (seven reefs), and the echinoid *Diadema antillarum* (five reefs). In terms of the number of organisms observed, the echinoid *Echinometra lucunter* (48 organisms) had the highest numbers, followed by the echinoid *Diadema antillarum* (41 organisms), the holothurian *H.* (*Halodeima*) *mexicana* (24 organisms), and the ophiuroids *Breviturma paucigranulata* (18 organisms) and *Ophiocoma echinata* (17 organisms). Nine species were observed with only a single organism (Table 1).

A total of 19 species were identified in the PNAC, and 18 species were recorded in the northern region of the island. At the site level, the Santa Pilar Beach reef had the greatest species richness (18), followed by Hotel Presidente (eight species), the Paraíso reef (five species), and the Dalila reef (five species). Only one species was recorded at the Chankanaab and La Francesa reefs, respectively.

The following is an annotated list of the 29 species observed during the fieldwork. Among the notable species are the crinoid *D. discoideus*, the asteroid *Luidia alternata alternata*, the echinoid *Leodia sexiesperforata*, and the holothuroids *Actinopyga agassizii*, *Holothuria* (*Thymiosycia*) *impatiens*, and *Astichopus multifidus*.

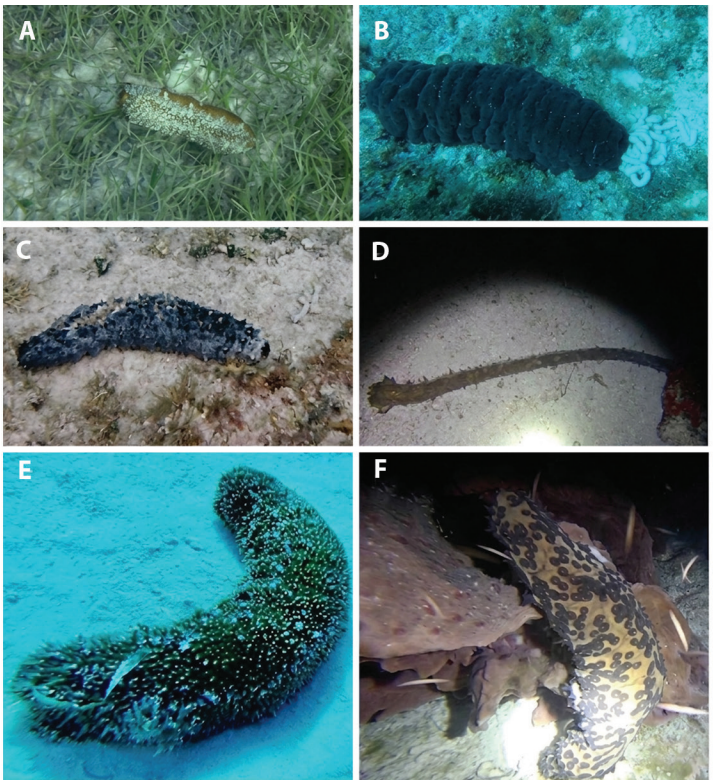


Fig. 4. A) *Actinopyga agassizii* in heterospecific grasslands of *Thalassia testudinum* and *Syringodium filiforme*; B) *Holothuria* (*Halodeima*) *mexicana* with its pellets; C) *Holothuria* (*Thymiosycia*) *impatiens*; D) *Holothuria* (*Thymiosycia*) *thomasi*; E) *Astichopus multifidus*; F) *Isostichopus badionotus*. Photographs by L.G. Calva Benítez.

These species represent the first records for Cozumel Island.

Phylum Echinodermata Klein, 1778
Class Crinoidea Miller, 1821
Order Comatulida Clark, 1908
Family Comatulidae Fleming, 1828
Genus *Davidaster* Hoggett and Rowe, 1986
Davidaster discoideus
(Carpenter, 1888)

In the study area, it exhibited a pale yellow-beige color that contrasted with the more striking color of their congener, *Davidaster rubiginosus*. This cryptic species was rarely observed during the sampling period, with only two specimens recorded at two reefs in the PNAC (Yucab and Santa Rosa). Although it is distributed throughout the Gulf of Mexico (Durán-González et al., 2005; Gabino-García et al., 2021) and the Caribbean Sea (Meyer et al., 1978), it had not been reported in the coral reefs of the Mexican Caribbean (Granja-Fernández et al., in press), making this the first record for the reefs of this region and for Cozumel.

Davidaster rubiginosus
(Pourtalès, 1869)

Despite its cryptic nature, the species is readily identifiable by its bright yellow coloration (Hendler et al., 1995; Benavides-Serrato et al., 2011) (Fig. 2A). This species has previously been recorded in the Gulf of Mexico (Durán-González et al., 2005; Gabino-García et al., 2021) and the Mexican Caribbean (Granja-Fernández et al., in press). The presence of this species was documented at Santa Pilar Beach

and on various reefs within the PNAC, including Chankanaab, Tormentos, Santa Rosa, El Cedral, Dalila, and Palancar Cuevas.

Class Asteroidea de Blainville, 1830
Order Paxillosida Perrier, 1884
Family Luidiidae Sladen, 1889
Genus *Luidia* Forbes, 1839
Luidia alternata alternata
(Say, 1825)

White coloration with darker spots was observed on the dorsal surface and in its arms (Fig. 2B); the ventral surface was yellow. The species was found exclusively on Santa Pilar Beach, where it was discovered on a sandy substrate. The presence of the species has been documented in the Gulf of Mexico (Gabino-García et al., 2021) and the Caribbean Sea (Solís-Marín et al., 2013; Granja-Fernández et al., in press), yet this is the first documentation of its occurrence in Cozumel.

Order Valvatida Perrier, 1884
Family Ophidiasteridae Verrill, 1867
Genus *Linckia* Nardo, 1834
Linckia guildingi
Gray, 1840

It is mottled gray in color (Benavides-Serrato et al., 2011). In Cozumel this sea star showed since light orange red, and brown colors. A limited number of specimens were observed in 2023 and 2024 on Santa Pilar Beach, both on sandy substrates and on rocks. In 2025, only a single specimen with six arms was recorded on the sandy bottom of the Santa Rosa Reef within PNAC. The presence of the species has been documented in the Gulf of Mexico (Gabino-García et al., 2021).

Family Oreasteridae Fisher, 1908
Genus *Oreaster* Müller and Troschel, 1842
Oreaster reticulatus
(Linnaeus, 1758)

This species is large and robust, and its coloration varies, but it is primarily yellow, orange (Fig. 2C), or brown. It has tubercles of different colors (Benavides-Serrato et al., 2011). This asteroid is emblematic of Cozumel, particularly the site known as "El Cielo," located within the PNAC. This shallow region offers visitors the opportunity to snorkel and observe the local marine life. Previous reports indicated the presence of this species in Arrecife Paraíso (PNAC) (Instituto Nacional de Ecología, 1998; Solís-Marín & Laguarda-Figueras, 2007). However, during the sampling procedure, it was only observed in the northern part of the island (Santa Pilar Beach). In 2022, the highest number of organisms was detected at depths ranging from 0.8 to 3 m and extending from the intertidal zone out to 200 m offshore. The water in which the specimen was observed exhibited a greenish hue, a phenomenon likely attributable to the influence of water flowing from the mangroves in the northern area, where La Ciega Lagoon is situated. The seabed in this area is distinguished by the presence of heterospecific seagrass meadows comprising *Thalassia testudinum* and *Syringodium filiforme*, along with a predominance of macroalgae, primarily chlorophytes and rhodophytes. In 2024, a single individual was observed at a depth of 5 m, characterized by total water transparency, water temperatures of 28 °C, and a sandy substrate covered by yellow cyanobacteria. The asteroid's diet consists of sediments, seagrasses, and algae (Scheibling, 1982), as well as some small invertebrates found in the substrates where it was observed during this study. On the island of Cozumel, the sea star is commonly found in the form of decorative figurines, ranging in size from a few cm to over 15 cm. These figurines are widely available in the main popular markets and on some beaches, such as Chen Río. Regrettably, there are no regulations in place to prevent its overexploitation on the island. The presence of the species has been documented in the Gulf of Mexico (Durán-González et al., 2005; Gabino-García et al., 2021).

Class Ophiuroidea Gray, 1840
Order Euryalida Lamarck, 1816
Family Gorgonocephalidae Ljungman, 1867

Genus *Astrophyton* Fleming, 1828
Astrophyton muricatum
(Lamarck, 1816)

This is an ophiuroid with branched arms that range in color from brown to gray (Hendler et al., 1995) (Fig. 2D). The specimen was discovered exclusively on Paraíso Reef, situated within the uppermost, most visible portion of a rocky mound. This reef is among the closest to the coast and has an average depth of 7 m. The species was observed exclusively during nocturnal hours (19:30 to 21:00 hrs). According to Hendler et al. (1995), diurnal activity is characterized by crevice-based concealment during daylight hours, with subsequent emergence occurring at dusk. The presence of the species has been documented in the Gulf of Mexico (Durán-González et al., 2005; Gabino-García et al., 2021) and the Mexican Caribbean (Laguarda-Figueras et al., 2009).

Order Ophiacanthida O'Hara, Hugall, Thuy, Stöhr and Martynov, 2017
Family Ophiodermatidae Ljungman, 1867
Genus *Ophioderma* Müller and Troschel, 1840
Ophioderma appressum
(Say, 1825)

The coloration of this species is extremely variable (Hendler et al., 1995). However, the only specimen observed had dark brown dorsal coloration resembling a harlequin pattern (Fig. 2E). Previously reported in the Gulf of Mexico (Durán-González et al., 2005; Gabino-García et al., 2021) and the Mexican Caribbean (Laguarda-Figueras et al., 2009). During daylight hours, this species was observed in the tide pools at Hotel Presidente in proximity to *Nerita* spp. gastropods and some *Acanthopleura granulata* periwinkles.

Ophioderma brevispinum
(Say, 1825)

It has covered radial shields, long banded arms, and a variety of color combinations (Hendler et al., 1995) (Fig. 2F). These characteristics were all observed with the naked eye in adult specimens. Previously reported in the Gulf of Mexico (Durán-González et al., 2005; Gabino-García et al., 2021) and the Mexican Caribbean (Laguarda-Figueras et al., 2009). Two individuals were found on Santa Pilar Beach. As with *O. appressum*, the specimen was observed in tide pools adjacent to the reef, coexisting with mollusks and periwinkles.

Family Ophiocomidae Ljungman, 1867
Genus *Breviturma* Stöhr, Boissin and Hoareau, 2013
Breviturma paucigranulata
(Devaney, 1974)

Its large size, long spines on its arms, and blackish-brown dorsal coloration (Fig. 2G) make this species easy to identify in the field (Hendler et al., 1995). It has been reported in the Gulf of Mexico (Durán-González et al., 2005; Gabino-García et al., 2021) and the Mexican Caribbean (Laguarda-Figueras et al., 2009). The species was observed exclusively at the pier at Santa Pilar beach, with a depth range of 0.2 to 1 m. Within the study area, it has been documented as a nocturnal species, exhibiting a preference for hiding alongside decapod crustaceans of the genus *Plagusia depressa* and *Percnon gibbesi*, as well as various species of cnidarians, particularly *Millepora* spp. Additionally, it has been observed cohabiting with a diverse array of echinoids, including *Echinometra lucunter*, *Echinometra viridis*, and *Eucidaris tribuloides*, along with *Diadema antillarum* and *Tripneustes ventricosus*, though to a lesser extent.

Genus *Ophiocoma* L. Agassiz, 1836
Ophiocoma echinata
(Lamarck, 1816)

A robust species with a black-brown color (Fig. 2H) and bulbous dorsal arm spines (Hendler et al., 1995). It has been reported in the Gulf of Mexico (Durán-González et al., 2005; Gabino-García et al., 2021) and the Mexican Caribbean (Laguarda-Figueras et al., 2009).

Within the PNAC, the species was observed in Tormentos, the Hotel Presidente, and the northern zone, where it was more numerous. In the latter area, it was found in tide pools a few centimeters deep, cohabiting with other invertebrates such as the polyplacophore mollusk *Acanthopleura granulata* and small gastropods. In a similar manner, Santa Pilar Beach has been observed to contain a number of diminutive specimens measuring less than 2 cm among the thalli of the chlorophyte *Udotea flabellum*. The specimens associated with this macroalgae were found to be concealed among the green thalli. A similar coloration was also observed in the *O. echinata* specimens, which exhibited a green hue with beige undertones.

Order Amphilepidida O'Hara, Hugall, Thuy, Stöhr and Martynov, 2017
Family Ophiotrichidae Ljungman, 1867
Genus *Ophiothrix* Müller and Troschel, 1840
Ophiothrix* (*Acanthophiothrix*) *suensonii
Lütken, 1856

This species is easily identifiable by its glassy appearance and the very distinct dark line running along its dorsal arms (Hendler et al., 1995). The observation of this species was restricted to the PNAC during the day, as an endobiont of the sponge *Niphates digitalis*. The organism generally hides on the inner surface of the sponge, although it can occasionally be seen on the outer surface. This specimen was identified as the most prevalent species of *Ophiothrix* in Cozumel. The presence of the species has been documented in the Gulf of Mexico (Durán-González et al., 2005; Gabino-García et al., 2021) and the Mexican Caribbean (Laguarda-Figueras et al., 2009).

Ophiothrix* (*Ophiothrix*) *oerstedii
Lütken, 1856

A species with variable coloration, but with distinct bands on its arms that are interrupted by thin, light-colored lines, each bordered by a black line (Hendler et al., 1995). Two specimens were documented within the PNAC (Tunich Reef and Santa Rosa Reef), where, consistent with *O.* (*Acanthophiothrix*) *suensonii*, it was found to be associated with *N. digitalis*. The presence of the species has been documented in the Gulf of Mexico (Gabino-García et al., 2021) and the Mexican Caribbean (Laguarda-Figueras et al., 2009).

Ophiothrix* (*Ophiothrix*) *angulata
(Say, 1825)

A reddish orange ophiuroid of diminutive size (< 4 cm) was discovered among the macroalgae on the Palancar Cuevas Reef. Documented in the Gulf of Mexico (Gabino-García et al., 2021) and the Mexican Caribbean (Laguarda-Figueras et al., 2009). This is one of the most common brittle stars in the Caribbean shallow waters (Hendler et al., 1995).

Class Echinoidea Schumacher, 1817
Order Cidaroida Claus, 1880
Family Cidaridae Gray, 1825
Genus *Eucidaris* Pomel, 1883
Eucidaris tribuloides
(Lamarck, 1816)

Light brown to reddish-brown body (Fig. 3A) and sturdy spines (Borrero-Pérez et al., 2012). The species inhabits both the PNAC and the northern part of the island, where it was more numerous. Its presence has been documented in the Gulf of Mexico and the Mexican Caribbean (Durán-González et al., 2005; Laguarda-Figueras et al., 2005; Gabino-García et al., 2021).

Order Diadematoida Duncan, 1889
Family Diadematidae Gray, 1855
Genus *Astropyga* Gray, 1825
Astropyga magnifica
A.H. Clark, 1934

Its coloration exhibited a distinctive pattern of bright purple and reddish hues in the central region (Fig. 3B). The dorsal side of the specimen displayed five prominent reddish triangles and spines, accompanied by purple

and beige bands. This specimen is likely to be a juvenile, as indicated by its morphological characteristics. This observation was made in 2024 at Santa Pilar Beach, at a depth of approximately 2 m, on a sandy substrate, approximately two meters away from the rocky substrate where the species is typically found. The sea urchin observed in this study exhibited a diameter ranging from 10 to 15 cm. The presence of the species has been documented in the Gulf of Mexico (Durán-González et al., 2005; Laguarda-Figueras et al., 2005; Gabino-García et al., 2021).

Genus *Diadema* Gray, 1825
Diadema antillarum
(Philippi, 1845)

It is easily recognizable by its large size, long spines, and black color (Borrero-Pérez et al., 2012) (Fig. 3C). This iconic sea urchin is among the most numerous species and has been observed in both the northern part of the island but very scarce in the PNAC. The presence of the species has been documented in the Gulf of Mexico (Durán-González et al., 2005; Laguarda-Figueras et al., 2005; Gabino-García et al., 2021) and the Mexican Caribbean (Bravo-Tzompantzi et al., 1999).

Order Camarodonta Jackson, 1912
Family Echinometridae Gray, 1855
Genus *Echinometra* Gray, 1825
Echinometra lucunter
(Linnaeus, 1758)

Its body ranges in color from black to reddish and is covered with pointed (Fig. 3A), thin spines at the tips (Hendler at al., 1995). This species was exclusively observed in the northern region of Cozumel Island, where it is typically one of the most prevalent sea urchins. The presence of the species has been documented in the Gulf of Mexico (Durán-González et al., 2005; Gabino-García et al., 2021) and the Mexican Caribbean (Bravo-Tzompantzi et al., 1999).

Echinometra viridis
A. Agassiz, 1863

The body is reddish to brown, and the spines are brown, with the distal 10 % or so uniformly olive green, featuring a white ring at the base and a purple tip (Hendler at al., 1995). In contrast to *E. lucunter*, this species is not as numerous in Cozumel; however, it has been documented in the northern part of the island and in the PNAC. The presence of the species has been documented in the Gulf of Mexico (Durán-González et al., 2005; Gabino-García et al., 2021) and the Mexican Caribbean (Bravo-Tzompantzi et al., 1999).

Family Toxopneustidae Troschel, 1872
Genus *Lytechinus* A. Agassiz, 1863
Lytechinus variegatus variegatus
(Lamarck, 1816)

A sea urchin with short, dark green spines that is very rare, as it was only found in 2021 in the tide pools of Santa Pilar Beach. The presence of the species has been documented in the Gulf of Mexico (Durán-González et al., 2005; Gabino-García et al., 2021)–and the Mexican Caribbean (Bravo-Tzompantzi et al., 1999).

Genus *Tripneustes* L. Agassiz, 1841
Tripneustes ventricosus
(Lamarck, 1816)

A large sea urchin with a brown body and white short spines (Borrero-Pérez et al., 2012) (Fig. 3D). In addition to its presence at Santa Pilar Beach, including the pier and rocky reef, the species was also observed in the PNAC, specifically in the vicinity of the Hotel Presidente and Dalila Reef. In the presence of *Sargassum* spp. strandings and leaves of the seagrass *Thalassia testudinum*, remnants of the macroalgae Ochrophyta (Phaeophyceae) are often observed among the spines of *T. ventricosus*. The presence of the species has been documented in the Gulf of Mexico (Durán-González et al., 2005; Gabino-García et al., 2021) and the Mexican Caribbean (Bravo-Tzompantzi et al., 1999).

Order Spatangoida L. Agassiz, 1840
Family Brissidae Gray, 1855
Genus *Meoma* Gray, 1851
Meoma ventricosa ventricosa
(Lamarck, 1816)

This is a large species with conspicuous, narrow, deep petals that are brown in color (Borrero-Pérez et al., 2012) (Fig. 3E). At Santa Pilar Beach, two specimens were found on a sandy substrate, whereas at the PNAC, only one complete skeleton was observed. The presence of the species has been documented in the Gulf of Mexico (Durán-González et al., 2005; Gabino-García et al., 2021) and the Mexican Caribbean (Bravo-Tzompantzi et al., 1999).

Order Echinolampadacea Mongiardino-Koch, Coppard, Lessios, Briggs, Mooi and Rouse, 2018
Family Mellitidae Stefanini, 1912
Genus *Leodia* Gray, 1851
Leodia sexiesperforata
(Leske, 1778)

This species has a flattened body and six narrow, elongated lunules. Its color varies from yellowish brown to light brown (Hendler et al., 1995) (Fig. 3F). A single specimen of the sea biscuit was documented in the Santa Pilar beach area. This species has been observed inhabiting the reefs of the Mexican Caribbean (Bravo-Tzompantzi et al., 1999); however, this is the first documented instance of its presence on the island of Cozumel.

Class Holothuroidea de Blainville, 1834
Order Holothuriida Miller, Kerr, Paulay, Reich, Wilson, Carvajal and Rouse, 2017
Family Holothuriidae Burmeister, 1837
Genus *Actinopyga* Bronn, 1860
Actinopyga agassizii
(Selenka, 1867)

A species with a thick body wall and a rough texture that ranges in color from light yellow to light brown and is usually mottled (Pawson et al., 2010) (Fig. 4A). This holothuroid is found in the northern part of the island and the PNAC. At Santa Pilar Beach, the species has been observed to inhabit seagrass beds of *Syringodium filiforme* and *T. testudinum*, where it has been documented to climb or stand upright on the leaves. It was the sole holothurian observed in these meadows. This species is widely distributed in the Caribbean Sea and the Gulf of Mexico (Laguarda-Figueras et al., 2001; Gabino-García et al., 2021), yet this is the first documented record for Cozumel. There are both artisanal and commercial fisheries in some areas of the Caribbean (Nicaragua, Panama, and Venezuela) (Purcell et al., 2012).

Genus *Holothuria* Linnaeus, 1767
Holothuria* (*Halodeima*) *mexicana
Ludwig, 1875

This species is characterized by its large size, a thick, very rigid body, and dorsolateral folds or wrinkles. The dorsal surface of these individuals is typically dark gray, brown, or black (Hendler et al., 1995) (Fig. 4B). In the PNAC we observed this species with diverse colors: black on the dorsal side and red on the ventral side, brown on the dorsal side and orange on the ventral side, or dark green and light ventrally. Upon physical contact, *H.* (*Halodeima*) *mexicana* exhibits a pronounced degree of rigidity that persists for a duration of several minutes. It is the most common sea cucumber in Cozumel, as evidenced by its presence in most of the reefs within the PNAC, as well as in the northern area. The sites where the specimens were found consisted of sandy bottoms with adjacent rocky areas. The species was not sighted in deep reefs (26–30 m) such as Palancar Jardines, Palancar Herradura, Palancar Cuevas, or Colombia. On the Tunich reef, on the ventral side, one of the specimens exhibited small patches of the colonial tunicate *Tridemnum solidum*, a species previously documented in the PNAC by Lazo-Carrillo (2023). In the study conducted at Tormentos and Tunich, individuals of these sea cucumber were observed to have macroalgae (Clorophyta) attached to its dorsal side. Pellets, exhibiting a

high degree of similarity in size, were observed in some specimens, suggesting their significance in sediment removal and nutrient recycling. The presence of the species has been documented in the Gulf of Mexico and the Mexican Caribbean (Laguarda-Figueras et al., 2001; Gabino-García et al., 2021). Harvested by hand collection in artisanal, often illegal fisheries in the Gulf of Mexico and the Caribbean (Purcell et al., 2012; Rivera-Téllez et al., 2021).

Holothuria* (*Theelothuria*) *princeps
Selenka, 1867

Its brown and white spots and light and dark concentric rings around the base of its dorsal papillae distinguish this species (Hendler et al., 1995). It was discovered at a depth of 4 m on Santa Pilar Beach, exhibiting its characteristic coloration (brown with whitish dorsal papillae at the base) and measuring no more than 10 cm in length. The presence of the species has been documented in the Gulf of Mexico and the Caribbean Sea (Borrero-Pérez et al., 2012; Gabino-García et al., 2021).

Holothuria* (*Thymiosycia*) *impatiens
(Forsskål, 1775)

It is characterized by rough, heavily wrinkled skin and a mottled appearance in shades of gray, brown, or purple (Hendler et al., 1995) (Fig. 4C). It was only observed in the sandy part of Hotel Presidente Beach at a depth of 5 m. The species is found in the Caribbean Sea and the Gulf of Mexico (Laguarda-Figueras et al., 2001; Gabino-García et al., 2021), but this represents its first record for the island of Cozumel. Commercially exploited in Mexico (Rivera-Téllez et al., 2021).

Holothuria* (*Thymiosycia*) *thomasi
Pawson and Caycedo, 1980

Its elongated body, smooth skin, and brown coloration with white dorsal papillae are the characteristics that define it (Pawson & Caycedo, 1980) (Fig. 4D). To the touch, this species is characterized by an exceptionally soft texture, complete flaccidity, and an immediate response to contact, which manifests as a slight retraction. This species was observed during a night dive at Paraíso Reef and a daytime dive at Dalila Reef. The organism observed during the night was brown, while the one observed at day was green. In both cases, the holothurians were observed to be active, albeit with half their bodies exposed on the sand and the other half beneath a rock. The presence of the species has been documented in the Gulf of Mexico and the Mexican Caribbean (Laguarda-Figueras et al., 2001; Gabino-García et al., 2021).

Order Synallactida Miller, Kerr, Paulay, Reich, Wilson, Carvajal and Rouse, 2017
Family Stichopodidae Haeckel, 1896
Genus *Astichopus* Clark, 1922
Astichopus multifidus
(Sluiter, 1910)

Colloquially designated as the hairy sea cucumber, exhibited a body measuring approximately 40 cm in length and 10 cm in width. The findings reported by Borrero-Pérez et al. (2012) suggest that the body coloration of the holothurian is chocolate brown, dark gray, or slightly greenish. However, the holothurian at the Colombia Reef (PNAC) exhibited a bottle-green coloration on the dorsal side and was entirely white on the ventral side (Fig. 4E). Furthermore, a portion of the ambulacral feet exhibited a reduction in length across three-quarters of the dorsal surface. In the remaining quarter, towards the oral end, the podia extended, forming conical, fleshy papillae that measured approximately 1 cm in length. These papillae were characterized by a transparent and light brown pigmentation. On the ventral side, the presence of numerous short white ambulacral feet was notable. The lateral-ventral portion of the specimen exhibited white ambulacral feet of a greater size compared to those observed on the dorsal side of the body, accompanied by black spots at the base of each podium. In terms of its texture, the body is soft but not flaccid, a characteristic that distinguishes

it from *H*. (*Thymiosycia*) *thomasi*. This species has been described as remaining buried in the sediment during the day and emerging at night to feed (Borrero-Pérez et al., 2012). However, the present study revealed that it was active during the day at a depth of 15 m in a completely open area, devoid of nearby rocks, and on sediment of medium-to-fine grain. Its distribution encompasses the Gulf of Mexico and the Caribbean Sea (Laguarda-Figueras et al., 2001; Gabino-García et al., 2021), yet this constitutes its inaugural record for Cozumel. Commercially exploited in Mexico (Rivera-Téllez et al., 2021).

Genus *Isostichopus* Deichmann, 1958
Isostichopus badionotus
(Selenka, 1867)

This species of sea cucumber displays considerable color variation in the Cozumel region. Its body coloration may exhibit a light brown hue accompanied by dark warts, a dark brown body with light warts, or a dark brown body with small orange warts (Fig. 4F). This extensive spectrum of color variation has also been documented in other regions of the species' distribution (Borrero-Pérez et al., 2024). This observation was made in both the northern part of the island and the PNAC. At Paraíso Reef, the species was documented during nocturnal dives (19:30 to 21:00 hrs) at depths not exceeding 7 m. It has been documented in both the Gulf of Mexico and the Mexican Caribbean region (Laguarda-Figueras et al., 2001; Gabino-García et al., 2021). In the Caribbean, it is one of the most important commercial species (Purcell et al., 2012), including Mexico (Rivera-Téllez et al., 2021).

Previously, 10 additional species (Ophiuroidea: *Ophiocomella pumila*, *Ophiomastix wendtii*, *Ophiolepis elegans*, *Ophionereis reticulata*, *Ophiopsila hartmeyeri*, and *Ophiopsila riisei*; Echinoidea: *Arbacia punctulata*, *Clypeaster rosaceus,* and *Echinoneus cyclostomus*; Holothuroidea: *Euapta lappa*) were reported for the Paraíso Reef, Punta Molas, or the PNAC (Hendler et al., 1995; Instituto Nacional de Ecología, 1998; Solís-Marín & Laguarda-Figueras, 2007). Based on these numbers (field and literature), it is concluded that the coral reefs of Cozumel harbor a total of 39 species of echinoderms, of which 25 inhabit the northern zone and 30 the PNAC (Table 2).

Table 2
Echinoderms from coral reefs in the Northern Zone (Muelle, Punta Molas, and Playa Santa Pilar) and the Cozumel Reefs National Park (PNAC) in the Mexican Caribbean on Cozumel Island. * = species recorded during this study. The references cited are to previous records of the species in the study area.

Species	Northern Zone	PNAC	References
Phylum Echinodermata Klein, 1778			
Class Crinoidea Miller, 1821			
Order Comatulida Clark, 1908			
Family Comatulidae Fleming, 1828			
Genus *Davidaster* Hoggett and Rowe, 1986			
Davidaster discoideus (Carpenter, 1888) *		X	
Davidaster rubiginosus (Pourtalès, 1869) *	X	X	Instituto Nacional de Ecología, 1998; Solís-Marín & Laguarda-Figueras, 2007
Class Asteroidea de Blainville, 1830			
Order Paxillosida Perrier, 1884			
Family Luidiidae Sladen, 1889			
Genus *Luidia* Forbes, 1839			
Luidia alternata alternata (Say, 1825) *	X		
Order Valvatida Perrier, 1884			
Family Ophidiasteridae Verrill, 1867			

Species	Northern Zone	PNAC	References
Genus *Linckia* Nardo, 1834			
Linckia guildingi Gray, 1840 *	X	X	Solís-Marín & Laguarda-Figueras, 2007
Family Oreasteridae Fisher, 1908			
Genus *Oreaster* Müller and Troschel, 1842			
Oreaster reticulatus (Linnaeus, 1758) *	X	X	Instituto Nacional de Ecología, 1998; Solís-Marín & Laguarda-Figueras, 2007
Class Ophiuroidea Gray, 1840			
Order Euryalida Lamarck, 1816			
Family Gorgonocephalidae Ljungman, 1867			
Genus *Astrophyton* Fleming, 1828			
Astrophyton muricatum (Lamarck, 1816) *		X	Instituto Nacional de Ecología, 1998; Solís-Marín & Laguarda-Figueras, 2007
Order Ophiacanthida O'Hara, Hugall, Thuy, Stöhr and Martynov, 2017			
Family Ophiodermatidae Ljungman, 1867			
Genus *Ophioderma* Müller and Troschel, 1840			
Ophioderma appressum (Say, 1825) *		X	Instituto Nacional de Ecología, 1998; Laguarda-Figueras et al., 2009; Kuk-Dzul et al., 2019
Ophioderma brevispinum (Say, 1825) *	X		Solís-Marín & Laguarda-Figueras, 2007
Family Ophiocomidae Ljungman, 1867			
Genus *Breviturma* Stöhr, Boissin and Hoareau, 2013			
Breviturma paucigranulata (Devaney, 1974) *	X		Laguarda-Figueras et al., 2009
Genus *Ophiocoma* L. Agassiz, 1836			
Ophiocoma echinata (Lamarck, 1816) *	X	X	
Genus *Ophiocomella* A.H. Clark, 1939			
Ophiocomella pumila (Lütken, 1856)	X		Solís-Marín & Laguarda-Figueras, 2007; Laguarda-Figueras et al., 2009
Genus *Ophiomastix* Müller and Troschel, 1842			
Ophiomastix wendtii (Müller and Troschel, 1842)	X		Solís-Marín & Laguarda-Figueras, 2007; Laguarda-Figueras et al., 2009
Order Amphilepidida O'Hara, Hugall, Thuy, Stöhr and Martynov, 2017			
Family Ophiolepididae Ljungman, 1867			
Genus *Ophiolepis* Müller and Troschel, 1840			
Ophiolepis elegans Lütken, 1859	X		Solís-Marín & Laguarda-Figueras, 2007; Laguarda-Figueras et al., 2009
Family Ophionereididae Ljungman, 1867			
Genus *Ophionereis* Lütken, 1859			
Ophionereis reticulata (Say, 1825)		X	Instituto Nacional de Ecología, 1998
Family Ophiopsilidae Matsumoto, 1915			
Genus Ophiopsila Forbes, 1843			
Ophiopsila hartmeyeri Koehler, 1913		X	Hendler et al., 1995; Solís-Marín & Laguarda-Figueras, 2007
Ophiopsila riisei Lütken, 1859	X	X	Hendler et al., 1995; Solís-Marín & Laguarda-Figueras, 2007
Family Ophiotrichidae Ljungman, 1867			
Genus *Ophiothrix* Müller and Troschel, 1840			
Ophiothrix* (*Acanthophiothrix*) *suensonii Lütken, 1856 *		X	Instituto Nacional de Ecología, 1998

Species	Northern Zone	PNAC	References
Ophiothrix* (*Ophiothrix*) *angulata (Say, 1825) *		X	Solís-Marín & Laguarda-Figueras, 2007
Ophiothrix* (*Ophiothrix*) *oerstedii Lütken, 1856 *		X	Solís-Marín & Laguarda-Figueras, 2007
Class Echinoidea Schumacher, 1817			
Order Cidaroida Claus, 1880			
Family Cidaridae Gray, 1825			
Genus *Eucidaris* Pomel, 1883			
Eucidaris tribuloides (Lamarck, 1816) *	X	X	Solís-Marín & Laguarda-Figueras, 2007
Order Diadematoida Duncan, 1889			
Family Diadematidae Gray, 1855			
Genus *Astropyga* Gray, 1825			
Astropyga magnifica A.H. Clark, 1934 *	X		Instituto Nacional de Ecología, 1998
Genus *Diadema* Gray, 1825			
Diadema antillarum (Philippi, 1845) *	X	X	Instituto Nacional de Ecología, 1998; Solís-Marín & Laguarda-Figueras, 2007
Order Arbacioida Gregory, 1900			
Family Arbaciidae Gray, 1855			
Genus Arbacia Gray, 1835			
Arbacia punctulata (Lamarck, 1816)		X	Solís-Marín & Laguarda-Figueras, 2007
Order Camarodonta Jackson, 1912			
Family Echinometridae Gray, 1855			
Genus *Echinometra* Gray, 1825			
Echinometra lucunter (Linnaeus, 1758) *	X	X	Instituto Nacional de Ecología, 1998; Solís-Marín & Laguarda-Figueras, 2007
Echinometra viridis A. Agassiz, 1863 *	X	X	Solís-Marín & Laguarda-Figueras, 2007
Family Toxopneustidae Troschel, 1842			
Genus *Lytechinus* A. Agassiz, 1863			
Lytechinus variegatus (Lamarck, 1816) *	X	X	Instituto Nacional de Ecología, 1998
Genus *Tripneustes* L. Agassiz, 1841			
Tripneustes ventricosus (Lamarck, 1816) *	X	X	Instituto Nacional de Ecología, 1998
Order Clypeasteroida A. Agassiz, 1872			
Family Clypeasteridae L. Agassiz, 1835			
Genus *Clypeaster* Lamarck, 1801			
Clypeaster rosaceus (Linnaeus, 1758)		X	Solís-Marín & Laguarda-Figueras, 2007
Order Spatangoida L. Agassiz, 1840			
Family Brissidae Gray, 1855			
Genus *Meoma* Gray, 1851			
Meoma ventricosa ventricosa (Lamarck, 1816) *	X	X	Instituto Nacional de Ecología, 1998; Solís-Marín & Laguarda-Figueras, 2007
Order Echinolampadacea Mongiardino-Koch, Coppard, Lessios, Briggs, Mooi and Rouse, 2018			
Family Mellitidae Stefanini, 1912			
Genus *Leodia* Gray, 1851			
Leodia sexiesperforata (Leske, 1778) *	X		
Order Echinoneoida H.L. Clark, 1925			
Family Echinoneidae L. Agassiz and Desor, 1847			
Genus *Echinoneus* Leske, 1778			
Echinoneus cyclostomus Leske, 1778	X	X	Solís-Marín & Laguarda-Figueras, 2007

Species	Northern Zone	PNAC	References
Class Holothuroidea de Blainville, 1834			
Order Holothuriida Miller, Kerr, Paulay, Reich, Wilson, Carvajal and Rouse, 2017			
Family Holothuriidae Burmeister, 1837			
Genus *Actinopyga* Bronn, 1860			
Actinopyga agassizii (Selenka, 1867) *	X	X	
Genus *Holothuria* Linnaeus, 1767			
Holothuria* (*Halodeima*) *mexicana Ludwig, 1875 *	X	X	Instituto Nacional de Ecología, 1998; Solís-Marín & Laguarda-Figueras, 2007; Arriaga-Ochoa & Solís-Marín, 2011
Holothuria* (*Theelothuria*) *princeps Selenka, 1867 *	X		
Holothuria* (*Thymiosycia*) *impatiens (Forsskål, 1775) *		X	
Holothuria* (*Thymiosycia*) *thomasi Pawson and Caycedo, 1980 *		X	Solís-Marín & Laguarda-Figueras, 2007
Order Synallactida Miller, Kerr, Paulay, Reich, Wilson, Carvajal and Rouse, 2017			
Family Stichopodidae Haeckel, 1896			
Genus *Astichopus* Clark, 1922			
Astichopus multifidus (Sluiter, 1910) *		X	
Genus *Isostichopus* Deichmann, 1958			
Isostichopus badionotus (Selenka, 1867) *		X	Solís-Marín & Laguarda-Figueras, 2007
Order Apodida Brandt, 1835			
Family Synaptidae Burmeister, 1837			
Genus *Euapta* Östergren, 1898			
Euapta lappa (J. Müller, 1850)	X	X	Instituto Nacional de Ecología, 1998; Solís-Marín & Laguarda-Figueras, 2007

DISCUSSION

A total of 81 species of shallow- and deep-water echinoderms have been documented for Cozumel Island (Solís-Marín & Laguarda-Figueras, 2007) and 27 for its anchialine systems (Bribiesca-Contreras et al., 2013; Bribiesca-Contreras et al., 2019). However, this is the first time a checklist has been presented specifically for its coral reefs. In addition, 21 species of shallow-water echinoderms have been recorded for the island (Ophiuroidea: *Amphiodia pulchella*, *Amphiodia riisei*, *Amphipholis squamata*, *Ophiactis quinqueradia*, *Ophiactis rubropoda*, *Ophiactis savignyi*, *Ophioderma brevicaudum*, *Ophioderma cinereum*, *Ophiolepis ailsae*, *Ophiolepis gemma*, *Ophiolepis impressa*, *Ophiolepis paucispina*, *Ophionereis squamulosa*, *Ophionereis vittata*, *Ophiostigma isocanthum*, *Schizostella bifurcata*; Echinoidea: *Encope michelini*; Holothuroidea: *Chiridota rotifera*, *Holothuria* (*Halodeima*) *floridana*, *Parathyone suspecta*, *Synaptula hydriformis*) (Hendler et al., 1995; Solís-Marín & Laguarda-Figueras, 2007; Laguarda-Figueras et al., 2009; Kuk-Dzul et al., 2019). Although most of these species have been reported in coral reefs of the Gulf of Mexico and the Caribbean Sea (Hendler et al., 1995; Granja-Fernández et al., in press), the references for Cozumel do not specify the site or the ecosystem under study. This prevents determining whether the sightings occurred in coral reefs. It is highly likely that these and other species inhabit the island's coral reef systems, but a systematic sampling effort is required for validation.

During our fieldwork, 29 species of echinoderms were observed on Cozumel Island,

of which the crinoid *Davidaster discoideus*, the asteroid *Luidia alternata alternata*, the echinoid *Leodia sexiesperforata*, and the holothurians *Actinopyga agassizii*, *Holothuria* (*Thymiosycia*) *impatiens*, and *Astichopus multifidus* represent new records for the island, although they had previously been reported in the Mexican Caribbean (Solís-Marín et al., 2013; Granja-Fernández et al., in press). The discovery of these new records for the island may be attributable to the fact that fieldwork was conducted at 14 reef sites on an ongoing basis from 2018 to 2025, with the exception of 2020. Conducting regular surveys may have increased the probability of identifying a greater number of species. A synthesis of the data gathered during the fieldwork, including the new records of this study, with previously published research (Hendler et al., 1995; Instituto Nacional de Ecología, 1998; Solís-Marín & Laguarda-Figueras, 2007; Laguarda-Figueras et al., 2009; Arriaga-Ochoa & Solís-Marín, 2011; Kuk-Dzul et al., 2019) reveals that Cozumel Island is home to 39 species of echinoderms (25 in the northern region and 30 in the PNAC).

In the context of this particular study, it is noteworthy that during fieldwork, the number of species identified in the PNAC (19 species) closely matched the number observed in the northern zone (18 species). This observation is particularly intriguing in light of the fact that the PNAC encompassed a greater number of reef sites (13 vs. 1). The higher species richness observed in the northern zone can be attributed to the greater availability of substrates for echinoderms, such as seagrass beds of *T. testudinum*, *S. filiforme*, and *Halodule wrightii*, as well as rhodophyte, chlorophyte, and Ochrophyta algae, and extensive rocky and coralline areas. However, further research is necessary to elucidate the ecological and diversity-related factors that influence these spatial patterns.

A notable aspect of the echinoderm fauna of Cozumel pertains to the paucity of research conducted on the species with respect to their morphology or distribution patterns on the island. A review of the literature reveals that there are only two studies on the ecology of these species in the form of theses (González-Azcárraga, 2009; Güemez-Pérez, 2015), and no formally published data are available. The generation of this information is imperative due to the climatic events that have occurred on the island in recent years. These events include hurricanes such as Hurricane Michael (Category 5), which was the most intense tropical cyclone in the Atlantic in 2018 (Beven & Hagen, 2019) and macroalgal blooms attributed to the recent anomalous warming events in 2023 that resulted in coral bleaching and mass mortality in the Mexican Caribbean and the Gulf of Mexico (Saavedra, 2023; López-Pérez et al., 2024), among others. However, a precise evaluation of the impact of these events on the island's local benthic fauna remains to be conducted.

In recent years, we have observed a decline in the number of individuals of the echinoids *D. antillarum* and *Echinometra* spp. Furthermore, there is evidence of structural damage to the sponge *N. digitalis*, which is characterized by basal holes and fractures or tears in the middle and upper sections. As these sponges serve as the habitat for the ophiuroids *O.* (*Acanthophiothrix*) *suensonii* and *O.* (*Ophiothrix*) *oerstedii*, their structural deterioration could have deleterious effects on these epibiont ophiuroids, given the high specificity of their symbiotic relationship. Presently, the ecological impacts of these events in Cozumel have not been quantitatively assessed, necessitating the urgent undertaking of systematic studies to address this critical research gap.

The species richness of echinoderms on Cozumel Island (39 species) is lower than that reported for the coral reefs of the Mexican Caribbean (83 species; Granja-Fernández et al., in press). However, the island also serves as a habitat for species of ecological and commercial importance, including the sea star *O. reticulatus*, which is harvested for the informal handicraft trade due to the absence of local regulations. Similarly, five species of sea cucumbers (A. *agassizii*, A. *multifidus*, *H.* (*Halodeima*) *mexicana*, *H.* (*Thymiosicia*) *impatiens*, and *I. badionotus*) are documented, which are commercially exploited in the Gulf of Mexico and

the Mexican Caribbean and they lack protected status (Purcell et al., 2012; Rivera-Téllez et al., 2021). However, their low population densities in Cozumel preclude their current exploitation by fisheries. It is imperative to acknowledge the absence of formal research on the exploitation of echinoderms on the island. Conducting such a study is therefore crucial.

The primary author of this article has been conducting regular visits to the island of Cozumel for the past 10 years and has observed a substantial decline in the number of organisms over the last five years. Notably, in reefs where she had previously documented echinoderms, including Palancar Herradura and Palancar Jardines, no echinoderms were observed during the present study. It is concluded that, given the alarming decline in the number of echinoderm organisms in Cozumel and their significant role in the reef ecosystem, it is imperative to establish a specific monitoring program, primarily within the PNAC.

Ethical statement: The authors declare that they all agree with this publication and made significant contributions; that there is no conflict of interest of any kind; and that we followed all pertinent ethical and legal procedures and requirements. All financial sources are fully and clearly stated in the acknowledgments section. A signed document has been filed in the journal archives.

ACKNOWLEGMENTS

We would like to thank Gabriel Nayar, Gabriel Escalera Jr., Josué Tuz, and Adolfo Hernández of the "Scuba Du" diving center for their logistical support during the field trips. We would like to express our gratitude to the Comisión Nacional de Áreas Naturales, Cozumel for granting the permits to visit the Cozumel Reefs National Park (PNAC). Thanks to Brenda Maya for creating the map and the expert taxonomists for confirming the identities of some species. This research is part of the Coastal Ecosystems Laboratory at the Universidad Autónoma Metropolitana (UAM), and it was funded by the UAM, with the allocation of funds to LGCB. We would like to express our gratitude to the anonymous reviewers and the editor for their invaluable comments, which have significantly enhanced the quality of this manuscript.

REFERENCES

Arriaga-Ochoa, J. A., & Solís-Marín, F. A. (2011). Pepinos de mar. In C. Pozo de la Tijera (Ed.), *Riqueza Biológica de Quintana Roo: un análisis para su conservación* (Tomo II, pp. 148–152). Gobierno del Estado de Quintana Roo, Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO), Colegio de la Frontera Sur (ECOSUR), Gobierno del Estado de Quintana Roo y Programa de Pequeñas Donaciones-México. http://www.conabio.gob.mx/institucion/proyectos/resultados/InfZ002.pdf

Arroyo-Arcos, L., Segrado, R., Frausto, O., Baca, C., & Colín-Olivares, O. (2018). Organización territorial y aprovechamiento turístico sustentable en el Parque Nacional Arrecifes de Cozumel, México. *Revista Geográfica de América Central, 3*, 237-261. https://dx.doi.org/10.15359/rgac.61-3.12.

Asociación Interamericana para la Defensa del Ambiente. (2014). *La protección de los arrecifes de coral en México: Rescatando la biodiversidad marina y sus beneficios para la humanidad*. México, CDMX. https://aida-americas.org/sites/default/files/featured_pubs/informe_corales_mexico.pdf.

Administración Portuaria Integral de Quintana Roo. (2026). *Portal de Estadística*. https://servicios.apiqroo.com.mx/estadistica/.

Benavides-Serrato, M., Borrero-Pérez, G. H., & Díaz-Sánchez, C. M. (2011). *Equinodermos del Caribe colombiano I: Crinoidea, Asteroidea y Ophiuroidea*. Instituto de Investigaciones Marinas y Costeras (INVEMAR). https://aquadocs.org/items/469fb6e7-bbe1-4356-b349-915b5cb0e63d.

Beven, J. L. R. B., & Hagen, A. (2019). *Tropical cyclone report hurricane Michael (AL142018)*. National Hurricane Center.

Birkeland, C. H. (1989). The influence of echinoderms on coral reef communities. In M. Jangoux & J. M. Lawrence (Eds.), *Echinoderm Studies* (Vol. 3, pp. 1–79). A. A. Balkema. https://www.researchgate.net/profile/Charles-Birkeland/publication/284657222_The_influence_of_echinoderms_on_coral-reef_communities/links/56b4c6d308aebbde1a7793c7/The-influence-of-echinoderms-on-coral-reef-communities.pdf.

Borrero-Pérez G. H., Benavides-Serrato, M., & Díaz-Sánchez, C. M. (2012). *Equinodermos del Caribe colombiano II: Echinoidea y*

Holothuroidea. Instituto de Investigaciones Marinas y Costeras (INVEMAR). https://aquadocs.org/items/32e1dc70-71fe-4cde-a434-fc440cac8802.

Borrero-Pérez, G. H., Solís-Marín, F. A., & Lessios, H. (2024). Understanding the color variability and resolving taxonomic confusion in the sea cucumber *Isostichopus badionotus* (Echinodermata, Holothuroidea): a revision of the genus *Isostichopus*. *European Journal of Taxonomy*, *949*(1), 1–96. https://doi.org/10.5852/ejt.2024.949.2641.

Bravo-Tzompantzi, D., Solís-Marín, F. A., Laguarda-Figueras, A., Abreu-Pérez, M., & Durán-González, A. (1999). Equinoideos (Echinodermata: Echinoidea) del Caribe Mexicano: Puerto Morelos, Quintana Roo, México. *Avicennia, 10*(11), 43–72.

Bribiesca-Contreras, G., Pineda-Enríquez, T., Márquez-Borrás, F., Solís-Marín, F. A., Verbruggen, H., Hugall, A. F., & O'Hara, T. D. (2019). Dark offshoot: Phylogenomic data sheds light on the evolutionary history of a new species of cave brittle star. *Molecular Phylogenetics and Evolution*, *136*, 151-163. https://doi.org/10.1016/j.ympev.2019.04.014.

Bribiesca-Contreras, G., Solís-Marín, F. A., Laguarda-Figueras, A., & Zaldívar-Riverón, A. (2013). Identification of echinoderms (Echinodermata) from an anchialine cave in Cozumel Island, Mexico, using DNA barcodes. *Molecular Ecology Resources*, *13*(6), 1137-1145. https://doi.org/10.1111/1755-0998.12098.

Carranza-Ramirez, A., Calva-Benítez, L. G., & Núñez-Resendiz, M. L. (2023). Taxonomic composition and substrate affinity of conspicuous marine macroalgae of the Parque Nacional Arrecifes de Cozumel, Quintana Roo, Mexico. *Acta Botánica Mexicana*, *130,* e2249. https://doi.org/10.21829/abm130.2023.2249.

Carrillo, N. (2011). *Atlas de Riesgos del Municipio de Cozumel 2011*. Ayuntamiento de la Isla de Cozumel; Secretaría de Desarrollo Social. https://rmgir.proyectomesoamerica.org/PDFMunicipales/2011/vr_23001_AR_COZUMEL.pdf.

Comisión Nacional de Áreas Naturales Protegidas. (2016). *Programa de Manejo Área de Protección de Flora y Fauna la porción norte y la franja costera oriental, terrestres y marinas de la Isla de Cozumel*. Secretaría de Medio Ambiente y Recursos Naturales. https://simec.conanp.gob.mx/pdf_libro_pm/32_libro_pm.pdf.

Diario Oficial de la Federación. (1996). Decreto por el que se declara área natural protegida, con el carácter de Parque Marino Nacional, la zona conocida como Arrecifes de Cozumel, ubicada frente a las costas del Municipio de Cozumel, Estado de Quintana Roo, con una superficie total de 11,987-87-50 hectáreas. https://www.dof.gob.mx/index_111.php?year=1996&month=07&day=19#gsc.tab=0.

Durán-González, A. D., Laguarda-Figueras, A., Solís-Marín, F. A., Buitrón-Sánchez, B. E., Ahearn, C. G., & Torres-Vega, J. (2005). Equinodermos (Echinodermata) de las aguas mexicanas del Golfo de México. *Revista de Biología Tropical*, *53*(3), 53-68. https://www.redalyc.org/pdf/449/44919815004.pdf.

Dutra, L. X. C., Haywood, M. D. E., Singh, S., Ferreira, M., Johnson J. E., Veitayaki, J. S., Kininmonth, Morris, C. W., & Piovano, S. (2021). Synergies between local and climate-driven impacts on coral reefs in the Tropical Pacific: A review of issues and adaptation opportunities. *Marine Pollution Bulletin*, *164*, 1-17. https://doi.org/10.1016/j.marpolbul.2020.111922.

Gabino-García M. T., Villanueva-Sousa, V., & Ramírez-Villalobos, A. J. (2021). Lista actualizada de los Equinodermos del Golfo de México. *Revista de Zoología, 32*, 19-90.

Saavedra, D. (2023, 28 de agosto). Muerte masiva de corales en arrecifes mexicanos. *Gaceta UNAM*, (*5409*), 18. https://www.gaceta.unam.mx/muerte-masiva-de-corales-en-arrecifes-mexicanos/.

González-Azcárraga, A. (2009). *Estructura de las asociaciones y diversidad morfológica de erizos de mar (Echinoidea) en los Parques Nacionales Sistema Arrecifal Veracruzano y Arrecifes de Cozumel, México* [Master´s Thesis, Universidad Nacional Autónoma de México]. UNAM. https://hdl.handle.net/20.500.14330/TES01000641274.

Granja-Fernández, R., Sotelo-Casas, R. C., Hermosillo-Núñez, B. B., Maya-Alvarado, B., Solís-Marín, F. A., Durán-González, A., Hernández-Díaz, Y. Q., Galván-Villa, C. M., Herrero-Pérezrul, M. D., Hernández-Morales, A., Rodríguez-Zaragoza, F. A., López-Pérez, A., Simões, S., Rodríguez-Troncoso, A. P., Cupul-Magaña, A. L., Álvarez-Filip, L., Pérez-España, H., Calderon-Aguilera, L. E., & Reyes-Bonilla, H. (in press). Echinoderms (Echinodermata) from Mexican coral reefs. In J. E. Arias-González (Ed.), *Coral reefs of México*. Springer

Güemez-Pérez, V. E. (2015). *Estructura comunitaria de equinodermos del Golfo de México y Mar Caribe* [Master´s Thesis, Instituto Tecnológico de Chetumal]. Repositorio Institucional del TecNM.

Gutiérrez-Carbonell, D., García-Beltrán, G., Soto, M., & Loreto-Viruel, Rosa. (2005). Caracterización de los Arrecifes Coralinos del Sur de Quintana Roo, México. *Sian Ka´an Serie Documentos, 6*, 1-32. https://www.researchgate.net/publication/305941909_Caracterizacion_de_los_Arrecifes_Coralinos_del_Sur_de_Quintana_Roo_Mexico.

Hendler, G., Miller, J. E., Pawson, D. L., & Kier, P. M. (1995). *Sea stars, sea urchins, and allies: Echinoderms of Florida and the Caribbean.* Smithsonian Institution Press. https://doi.org/10.1017/S0025315400031568.

Hernández-Díaz, Y. Q., Solís-Marín, F. A., Simões, N., & Sanvicente-Añorve, L. (2013). First record of *Ophioderma ensiferum* (Echinodermata: Ophiuroidea) from

the southeastern continental shelf of the Gulf of Mexico and from an anchialine cave. *Revista Mexicana de Biodiversidad*, *84*, 676–681. https://doi.org/10.7550/rmb.30737.

Instituto Nacional de Ecología. (1998). *Programa de Manejo Parque Marino Nacional Arrecifes de Cozumel, Quintana Roo*. Secretaría de Medio Ambiente, Recursos Naturales y Pesca. https://simec.conanp.gob.mx/pdf_libro_pm/30_libro_pm.pdf.

Kuk-Dzul, J. G., Solís-Marín, F. A., Herrera-Dorantes, M. T., & Ardisson, P. L. (2019). Brittle stars (Echinodermata: Ophiuroidea) of coastal lagoons from the northern Yucatán Peninsula, Mexico. *Revista Mexicana de Biodiversidad*, *90*. https://doi.org/10.22201/ib.20078706e.2019.90.2698.

Laguarda-Figueras, A., Gutiérrez-Castro, A. I., Solís-Marín, F. A., Durán-González, A., & Torres-Vega, J. (2005). Equinoideos (Echinodermata: Echinoidea) del Golfo de México. *Revista de Biología Tropical*, *53*(3), 69–108. https://www.redalyc.org/pdf/449/44919815005.pdf.

Laguarda-Figueras, A., Hernández-Herrejón, L. A., Solís-Marín, F. A., & Durán-González, A. (2009). *Ofiuroideos del Caribe Mexicano y Golfo de México*. Instituto de Ciencias del Mar y Limnología (ICML-UNAM); Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO). https://www.researchgate.net/publication/316494355_Los_ofiuroideos_del_Caribe_Mexicano_y_Golfo_de_Mexico.

Laguarda-Figueras, A., Solís-Marín, F. A., Durán-González, A., Hernández Pliego, P., & Del-Valle-García, R. (2001). Holoturoideos (Echinodermata: Holothuroidea) del Caribe Mexicano: Puerto Morelos. *Avicennia, 14,* 7–46. https://www.https://www.researchgate.net/publication/286335595_Holoturoideos_Echinodermata_Holothuroidea_del_Caribe_Mexicano_Puerto_Morelos

Lazo-Carrillo, F. P. (2023). *Presencia de Trididemnum spp. en arrecifes de coral del Parque Nacional Arrecifes de Cozumel (PNAC)* [Tesis de Maestría, Universidad Autónoma Metropolitana]. Repositorio Institucional BINDANI https://doi.org/10.24275/uami.bn9997391.

López-Pérez, A., Granja-Fernández, R., Ramírez-Chávez, E., Valencia-Méndez, O., Rodríguez-Zaragoza, F. A., González-Mendoza, T., & Martínez-Castro, A. (2024). Widespread coral bleaching and mass mortality of reef-building corals in Southern Mexican Pacific reefs due to 2023 El Niño warming. *Oceans*, *2*, 196–209. https://doi.org/10.3390/oceans5020012.

Márquez-Borrás, F., Solís-Marín, F. A., Bribiesca-Contreras, G., & Laguarda-Figueras, A. (2016). First record of *Ophiura ljungmani* (Echinodermata: Ophiuroidea) from an anchialine cave in the Mexican Caribbean. *Revista Mexicana de Biodiversidad*, *87*, 1127–1130. https://doi.org/10.1016/j.rmb.2016.07.006.

Mejía-Ortiz, L. M., Yáñez, G., & López-Mejía, M. (2007). Echinoderms in an anchialine cave in Mexico. *Marine Ecology*, *28*, 31–34. https://doi.org/10.1111/j.1439-0485.2007.00174.x.

Meyer, D. L., Messing C. G., & Macurda, D. B. J. (1978). Biological Results of the University of Miami, Deep Sea Expeditions. 129. Zoogeography of tropical western Atlantic Crinoidea (Echinodermata). *Bulletin of Marine Science*, *28*(3), 412–441. https://docserver.ingentaconnect.com/deliver/connect/umrsmas/00074977/v28n3/s2.pdf?expires=1785643421&id=0000&titleid=10983&checksum=9FF03BF43A24DF4B9BE390EC5FE84272&host=https://www.ingentaconnect.com

Pawson, D. L., & Caycedo, I. E. (1980). *Holothuria (Thymiosycia) thomasi* new species, a large Caribbean coral reef inhabiting sea cucumber (Echinodermata: Holothuroidea. *Bulletin of Marine Science*, *30*(2), 454–459. https://docserver.ingentaconnect.com/deliver/connect/umrsmas/00074977/v30n2/s8.pdf?expires=1785643469&id=0000&titleid=10983&checksum=497F9E5A9EC04B728CC115A6ECF4C573&host=https://www.ingentaconnect.com

Pawson, D. L., Pawson D. J., & King, R. A. (2010). A taxonomic guide to the Echinodermata of the South Atlantic Bight, USA: 1. Sea cucumbers (Echinodermata: Holothuroidea). *Zootaxa*, *2449*(1), 1–48. https://doi.org/10.11646/zootaxa.2449.1.1.

Purcell, S. W., Samyn Y., & Conand, C. (2012). Commercially important sea cucumbers of the world. FAO Species Catalogue for Fishery Purposes No. 6. *Food and Agriculture Organization of the United Nations, 256*, https://doi.org/10.4060/cc5230en.

Rivera-Téllez, E., López-Segurajáuregui, G., Fernández, T., Vásquez, B., & Mosig, B. (2021). *Guía de identificación de los pepinos de mar de interés comercial en México*. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad.

Scheibling, R. E. (1982). Feeding habits of *Oreaster reticulatus* (Echinodermata: Asteroidea). *Bulletin of Marine Science*, *32*(2), 504–510. https://docserver.ingentaconnect.com/deliver/connect/umrsmas/00074977/v32n2/s11.pdf?expires=1785643665&id=0000&titleid=10983&checksum=2B9260DE256A33DFD24A0F0B03354069&host=https://www.ingentaconnect.com

Secretaría de la Convención sobre los Humedales. (2009, 2 de febrero). *Manglares y Humedales del Norte de Isla Cozumel* (Sitio Ramsar N.º 1921). Servicio de Información sobre Sitios Ramsar. https://rsis.ramsar.org/es/ris/1921.

Sobha, T. R., Vibija, C. P., & Fahima, P. (2023). Coral reef: a hot spot of marine biodiversity. In S. T. Sukumaran, T. R. Keerthi TR (Eds.), *Conservation and sustainable utilization of bioresources* (pp. 171-194). Springer. https://doi.org/10.1007/978-981-19-5841-0_8.

Solís-Marín, F. A., & Laguarda-Figueras, A. (2007). Equinodermos. In L. M. Mejía-Ortíz (Ed.), *Biodiversidad acuática de la isla de Cozumel* (pp. 187-214). Universidad de Quintana Roo.

Solís-Marín, F. A., & Laguarda-Figueras, A. (2010). Una especie nueva de estrella de mar (Echinodermata: Asteroidea) de una caverna anquialina en el Caribe mexicano. *Revista Mexicana de Biodiversidad*, *81*, 663–668. https://doi.org/10.22201/ib.20078706e.2010.003.638.

Solís-Marín, F. A., Alvarado, J. J., Abreu-Pérez, M., Aguilera, O., Ali, J., Bacallado-Aránega, J. J., Barraza, E., Benavides-Serrato, M., Benítez-Villalobos, F., Betancourt-Fernández, L., Borges, M., Brandt, M., Brogger, M. I., Borrero-Pérez, G. H., Buitrón-Sánchez, B. E., Campos, L. S., Cantera, J., Clemente, S., Cohen-Renjifo, M., & Williams, S. M. (2013). Appendix. In J. J. Alvarado-Barrientos & F. A. Solís-Marín (Eds.), *Echinoderm research and diversity in Latin America* (pp. 543–658). Springer-Verlag. https://doi.org/10.1007/978-3-642-20051-9_16.

World Register of Marine Species. (2026). *Echinodermata*. WoRMS https://www.marinespecies.org/aphia.php?p=taxdetails&id=1806 on 2026-07-0.