







*Research Article*

## New records of elasmobranchs (Vertebrata: Elasmobranchii) from the southwestern Gulf of Mexico

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**ABSTRACT.** We present information about new records of 11 species of chondrichthyans in the southern Gulf of Mexico, adding information about new specimens and occurrence of the species in Mexican waters. The second record of the *Bathytoshia centroura*, *Mustelus sinuomexicanus*, *Mobula hypostoma* and *Squalus clarkae* species for Mexico is presented, as well as new records in marine areas and the Lagoon Alvarado system corresponding to *Hexanchus vitulus*, *Heptranchias perlo*, *Scyliorhinus retifer* and *Squalus cubensis*. In this paper increase the number of records for species of elasmobranchs to the southwestern region of the Gulf of Mexico, increase the distribution range and knowledge about the chondrichthyofauna of Mexico.

**Keywords:** Batoidei; skates; sharks; distribution; Mexican waters

### INTRODUCTION

Elasmobranchs have played a very important role in the trophic ecology and evolution of marine life, both in the past and in the present, managing to shape and influence marine community dynamics (Heithaus et al. 2010). In the face of ecological changes and overfishing, it is essential to understand the consequences of the loss of these organisms, such as the effects of trophic cascades, since they are considered one of the main marine predators (Myers et al. 2007, Heithaus et al. 2008). Likewise, climate change is another factor that can directly influence their distribution (Birkmanis et al. 2020), even changes in temperature in the ocean

over geological time are correlated with the extinction and diversification of shark groups in the past (Condamine et al. 2019).

According to the last census, approximately 1,188 species of cartilaginous fish are registered worldwide, which include representatives of the current class Elasmobranchii and Holocephali (Weigmann 2016). In the jurisdictional waters of Mexico, approximately 206 species of elasmobranchs and eight holocephalians have been recorded (Del Moral-Flores et al. 2015). Of these, 118 species (55.1%) are distributed in the Atlantic coast, which includes the Gulf of Mexico and the Caribbean Sea (Del Moral-Flores et al. 2016).

However, there is a great lack of information about the distribution patterns of many of the species in country waters.

One of the main factors that influences this lack of information is the scarce and inconclusive fishing records that occur in the southern coast of the Gulf of Mexico, where the data is obtained mainly by artisanal fishing, which is characterized by being in small-scale, multispecific and heterogeneous activity in its catches (Pérez-Jiménez & Mendez-Loeza 2015, Pérez-Jiménez et al. 2016). In this type of fishery the different species of rays are grouped in the category of “manta” or “aleta”, and that includes several large species, mainly those of the genera *Hypanus* and *Gymnura*; the different species of sharks are classified as “tiburón” when its total length (TL) is greater than 1.2 m or “cazón”, when it is less than 1.2 m TL (Applegate et al. 1979). Thus, these species are reported and included in the fishing statistics of the region resulting in scarce taxonomic information (Castillo-Géniz et al. 1998, CONAPESCA 2018). Another relevant factor is given by the timing of the captures, since in some fishing communities is for subsistence and they alternate it with seasons of fishing for resources of greater commercial value, but sometimes this kind of fishing can be able to capture various species of elasmobranchs that can be considered as incidental (Pérez-Jiménez et al. 2016).

Another information gap is about the elasmobranchs that are distributed in deep waters of Mexico, whose records are sporadic and have not received the adequate attention of their role in the main fisheries of the region (Del Moral-Flores et al. 2015). Recently, through the study and analysis of commercial catches in the southern part of the Gulf of Mexico, the presence of some species considered rare, of pelagic affinity and depth has been pointed out (Del Moral-Flores & Paleo-Delgado, 2018, Wakida-Kusunoki et al. 2018, Del Moral-Flores et al. 2020, 2021). Within this context, information and new records of elasmobranch species, whose presence is considered unusual in the coasts of the southeastern of the Gulf of Mexico are presented. The Fishing Management Plan for Sharks and Rays in the Gulf of Mexico and the Caribbean Sea (PMPTR) was recently published in Mexico, which includes all the target and associated species of elasmobranchs that are captured by small-scale and industrial fleets. In this document the management actions are established, as well as the lines of research that are necessary for the adequate management of the populations of sharks and rays. This new information increases the knowledge of at least four species in the area and supports the

consolidation of the PMPTR, exploitation, and conservation of these resources of ecological and commercial importance.

## MATERIALS AND METHODS

Eleven species of elasmobranchs were obtained as part of the reconnaissance campaigns of the composition of the capture and incidence of these species in the coastal fishing of the south of the states of Veracruz and Tabasco, southwest of the Gulf of Mexico (Fig. 1). These organisms were obtained during two periods of sampling, from January 2011 to December 2013 and September 2016 to December 2021. The specimens collected were fixed with formalin (10%) and preserved in ethyl alcohol (70%), for later incorporate and deposit them in the Ichthyological Collection of the Facultad de Estudios Superiores Iztacala, Universidad Nacional Autónoma de México (CIFI) and Ichthyological Collection of the Colegio de la Frontera Sur, San Cristóbal de las Casas, Chiapas (ECOSC). All organisms were determined using specialized keys (McEachran & Fechhelm 1998, Espinosa-Pérez et al. 2004, Castro 2011). The systematic arrangement follows was that of Van der Laan et al. (2021). The nomenclature was verified using the Catalog of Fishes of the California Academy of Sciences (Fricke et al. 2022). For each record, the number of organisms, total length (TL, in cm), and weight (W, in g) mostly, location, date and depth of capture are presented. The large specimens (*Bathytoshia centroura*, *Carcharhinus plumbeus* and *Galeocerdo cuvier*) were processed by the fishermen, for which size and weight were estimates using a reference scale. In the rest of the specimens, the data was taken in the laboratory.

## RESULTS

A total of 88 specimens belonging to 11 species grouped in eight families and four orders of elasmobranchs were obtained, whose records are listed below:

Class Elasmobranchii

Order Hexanchiformes

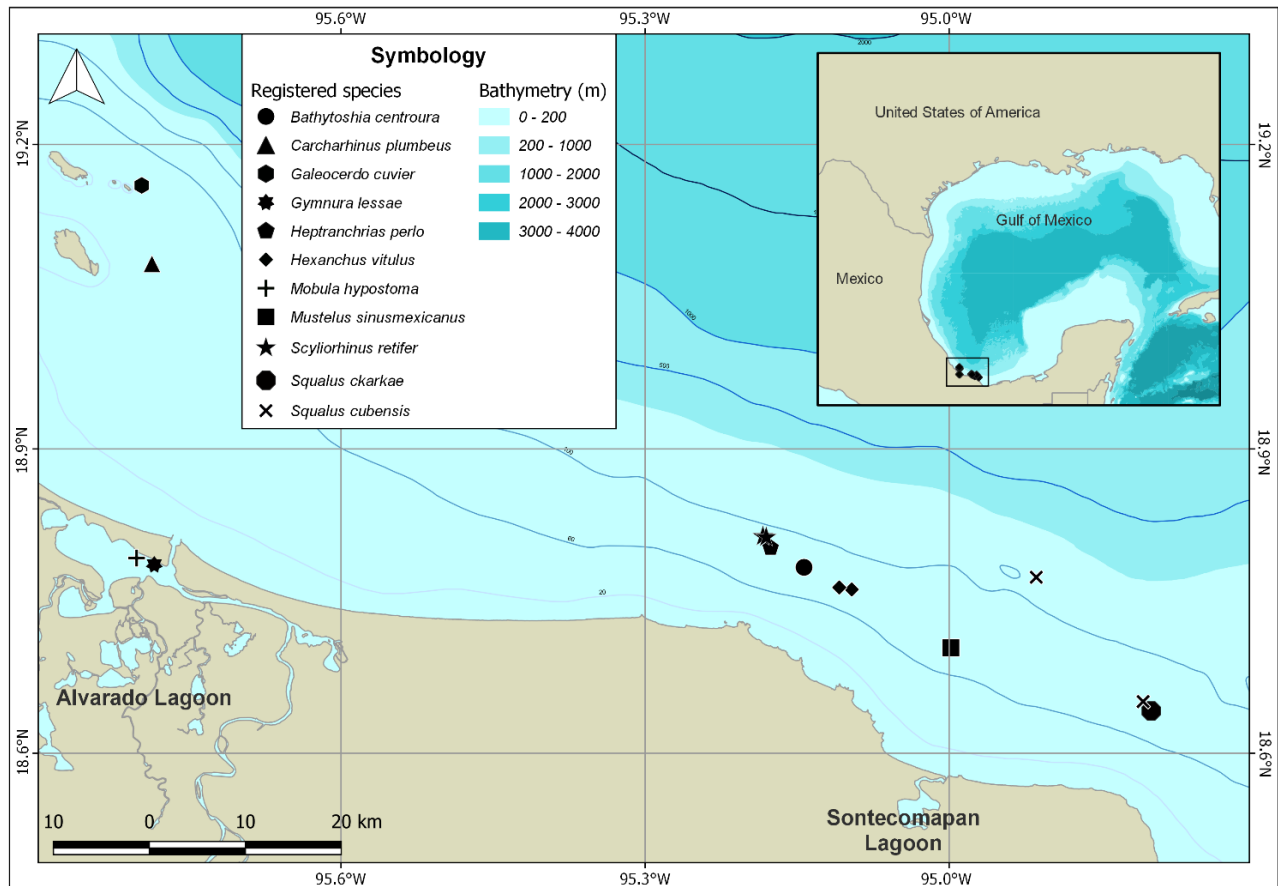
Family Hexanchidae Gray, 1851

*Hexanchus vitulus* Springer & Waller, 1969

Bigeye sixgill shark / Cazón de seis branquias (Spanish)

(Figs. 2a-a )

Taxonomic summary (n = 4). One male specimen of 61.5 cm TL and 565 g (CIFI-1802) collected in the Gulf of Mexico, 18°46'56.7"N, 95°09'40.2"W, 300 m depth,



**Figure 1.** Map of the southwestern of the Gulf of Mexico showing the points of capture of the new records of elasmobranchs.

January 09, 2021. One male specimen of 82.9 cm TL and 1,635 g (CIFI-1810) collected in the Gulf of Mexico, 18°44'28.8"N, 95°04'52"W, 100-150 m depth, January 25, 2021. One female specimen of 90.6 cm TL and 1,940 g (CIFI-1811) collected in the Gulf of Mexico, April 21, 2021. One male specimen of 93.2 cm TL and 2,340 g (CIFI-1824) collected in Gulf of Mexico, ca. 9 km from Playa Hermosa, municipality of Ángel R. Cabada, 18°44'28.8"N, 95°05'36.4"W, 180 m depth, June 24, 2021.

Comments: the organisms were immature, there is no evidence of maturity in the mixopterygians.

*Heptranchias perlo* (Bonnaterre, 1788)

Sharpnose sevengill shark / Tiburón de siete branquias  
(Spanish)  
(Figs. 2b-b')

Taxonomic summary (n = 1). One male specimen of 85.4 cm TL and 1,780 g (CIFI-1803) collected in the Gulf of Mexico, 18°46'56.7"N, 95°09'40.2"W, 300 m depth, January 9, 2021.

Comments: the specimen was in reproductive phase. Evidence of sperm was found in both myxop-terigium, this was flexible and calcified.

Order Carcharhiniformes

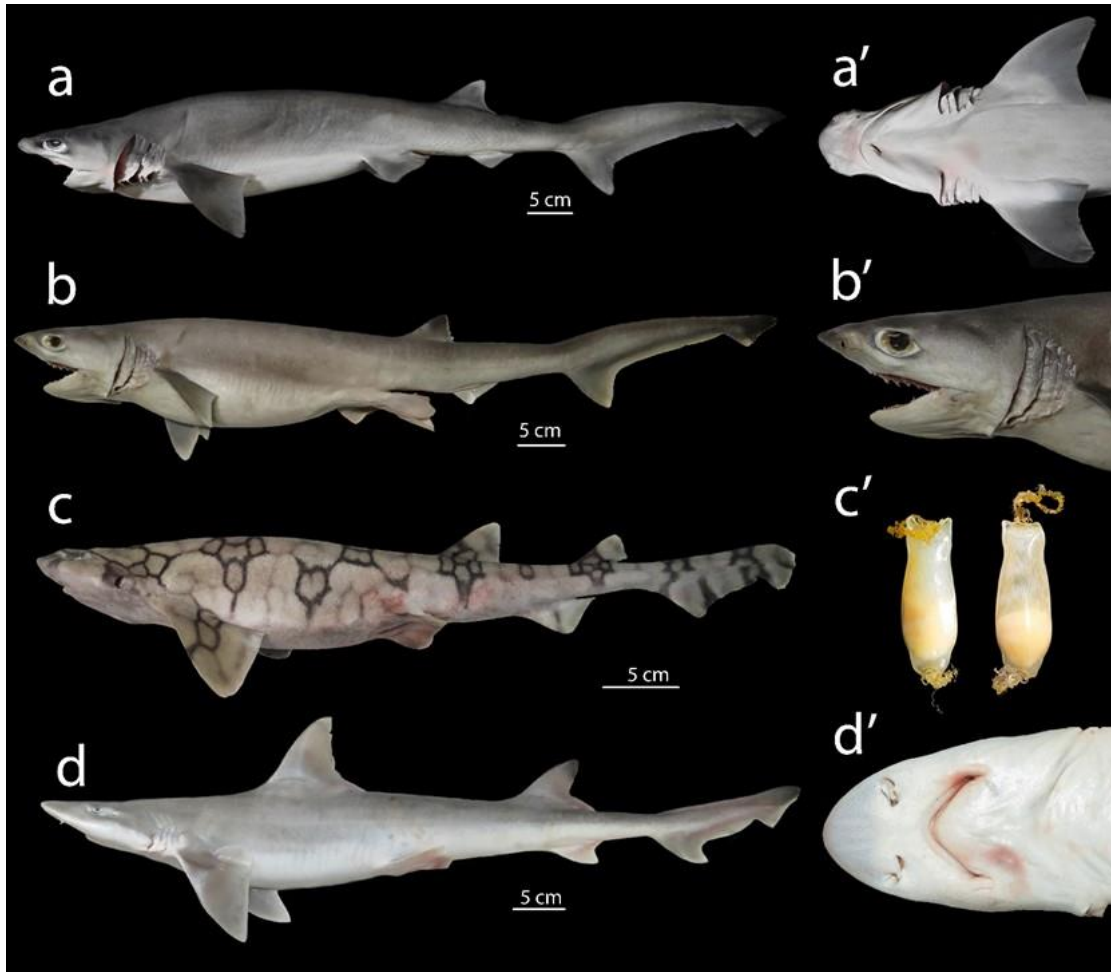
Family Scyliorhinidae Gill, 1862

*Scyliorhinus retifer* (Garman, 1881)

Chain catshark / Alitán mallero, tiburón cadena  
(Spanish)

(Figs. 2c-c')

Taxonomic summary (n = 5). One female specimen of 43 cm of TL and 550 g collected to 54.6 km of Torno Largo, Tabasco, 18°54'17.74"N, 93°21'41.66"W, 180 m depth, January 24, 2013 (ECOSC-7591). One female specimen of 52 cm TL and 550 g (CIFI-1726) collected in the Gulf of Mexico, ca. 11.63 km of Salinas Roca Partida, 18°46'59.51"N, 95°09'51.96"W, 150 m depth, November 10, 2020. One male specimen of 55.7 cm TL and 510 g (CIFI-1731) collected in the Gulf of Mexico, 210 m depth, December 27, 2020. Two specimens: a female of 47.9 cm TL with 365 g, and a male of 49.9



**Figure 2.** Elasmobranchs caught in the southwestern of the Gulf of Mexico: a) lateral and a') ventral cephalic view of *Hexanchus vitulus*; b) lateral and b') lateral cephalic view of *Hepranchias perlo*; c) lateral view and c') eggs of *Scyliorhinus retifer*; d) lateral and d') ventral cephalic view of *Mustelus sinismexicanus*.

cm TL with 420 g (CIFI-1804), both specimens were collected in the Gulf of Mexico, ca. 11.8 km from Punta Puntilla, municipality of Ángel R. Cabada, 18°46'56.7"N, 95°09'40.2"W, 300 m deep, January 09, 2021.

Comments: the female collected on November 10, 2020 (CIFI-1726) had two eggs, one for each uterus (Fig. 2c).

Family Triakidae Gray, 1851

*Mustelus sinismexicanus* Heemstra, 1997

Gulf smoothhound / Cazón del Golfo (Spanish)

(Figs. 2d-d')

Taxonomic summary (n = 1). One male specimen of 79.1 cm of TL and 2,020 g (CIFI-1816) collected in the Gulf of Mexico, 18°41'02.1"N, 94°58'59.7"W, 180 m depth, May 17, 2021.

Comments: the organism presents calcified and mobile mixopterygium.

Family Carcharhinidae Jordan & Evermann, 1896

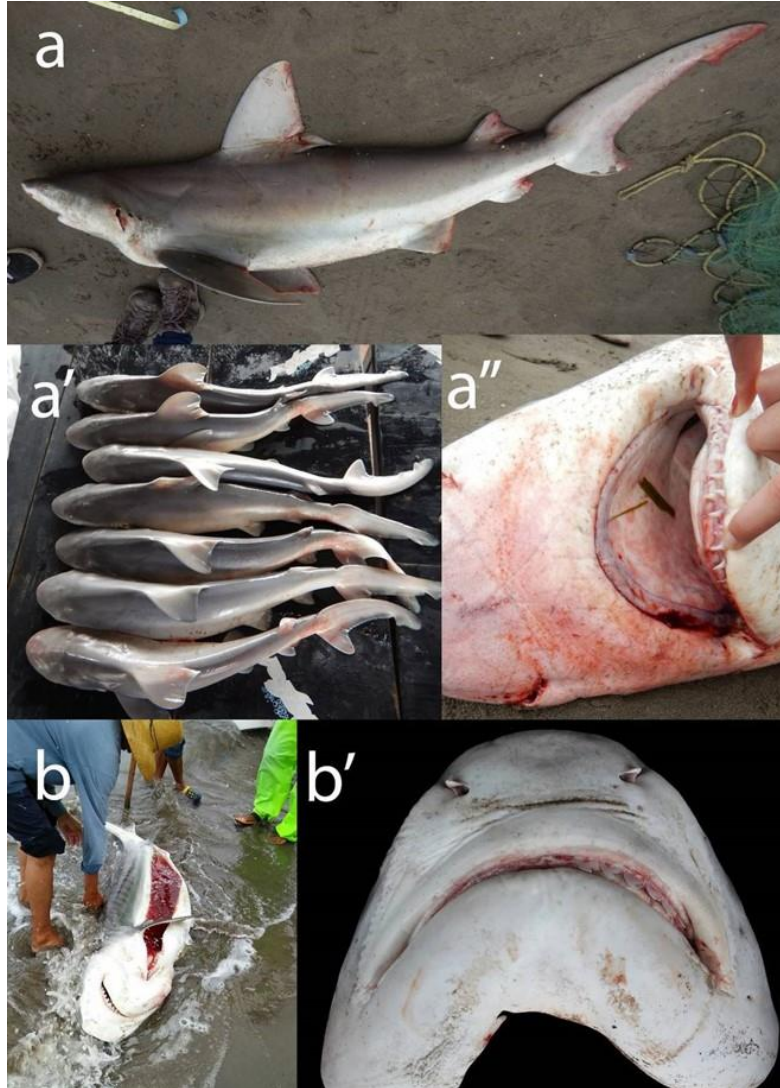
*Carcharhinus plumbeus* (Nardo, 1827)

Sandbar shark / Tiburón aleta de cartón (Spanish)

(Figs. 3a-a')

Taxonomic summary (n = 1). A female specimen pregnant with around 230 cm of TL was collected in the Gulf of Mexico, to 6 km from east Cabezo Reef, Parque Nacional Sistema Arrecifal Veracruzano, Mexico, 19°03'44.8"N 95°46'17.5"W, March 04, 2016.

Comments: this specimen was caught by local fishermen from the town of Antón Lizardo, Alvarado, Veracruz. The specimen was processed by fishermen for its commercialization and six nonates pups were found.



**Figure 3.** Elasmobranchs caught in the southwestern of the Gulf of Mexico: a) lateral view, a') unborn and a'') jaw of *Carcharhinus plumbeus*; b) processing and b') cephalic ventral view of *Galeocerdo cuvier*.

Family Galeocerdonidae Poey, 1875

*Galeocerdo cuvier* (Péron & Lesueur, 1822)

Tiger shark / Tintorera (Spanish)

(Figs. 3b-b')

Taxonomic summary (n = 1). A female specimen of around 260 cm TL, preserved jaw (CIFI-1600), collected in the Gulf of Mexico, out of Isla Anegadilla, Parque Nacional Sistema Arrecifal Veracruzano, 10 m depth, March 4, 2016.

Comments: this tiger shark was caught with longline by local fishermen from the town of Antón Lizardo, Alvarado, Veracruz. The specimen was processed by

fishermen for its commercialization. The jaw was rescued and preserved.

Order Squaliformes

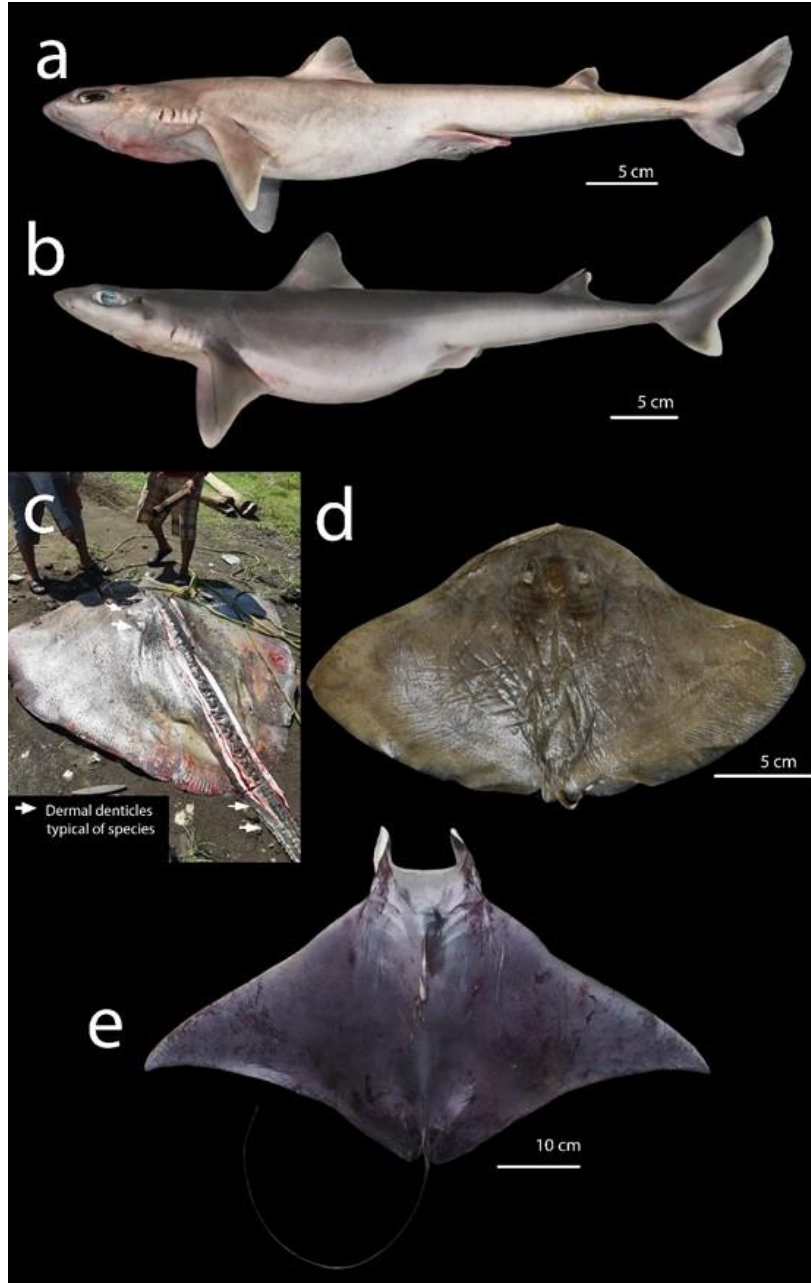
Family Squalidae de Blainville, 1816

*Squalus clarkae* Pflieger, Grubbs, Cotton & Daly-Engel, 2018

Genie's dogfish / Tiburón clavo (Spanish)

(Fig. 4a)

Taxonomic summary (n = 35). One male specimen of 55.3 cm TL and 34 female specimens ranged between 52 to 75 cm TL (CIFI-1904) collected in the Gulf of Mexico, ca. Faro Zapotitlán, Meyacapan,



**Figure 4.** Elasmobranchs caught in the southwestern of the Gulf of Mexico: a) lateral view of *Squalus clarkae*, b) lateral view of *S. cubensis*, c) processing of *Bathytoshia centroura*, d) dorsal view of *Gymnura lessae*, e) dorsal view of *Mobula hypostoma*.

18°37'17.8"N 94°47'08.5"W, 150 to 200 m depth, September 18, 2021.

Comments: these genie's dogfish was caught with deep longline by local fishermen from the town of Salinas Roca Partida, Santiago Tuxtla, Veracruz.

*Squalus cubensis* Howell Rivero, 1936

Cuban dogfish / Cazón aguijón cubano, tiburón clavo cubano (Spanish)

(Fig. 4b)

Taxonomic summary (n = 39). A female specimen with 53 cm TL and 578.3 g (ECOSC-7592) collected to 55.7 km of Torno Largo, Tabasco 18°55'42.13"N, 93°16'51.95"W, 180 m depth, November 11, 2011. Ten

female specimens ranged between 48.2 to 57.8 cm TL (CIFI-1177) was collected in the Gulf of Mexico, ca. Santiaguillo Island, Parque Nacional Sistema Arrecifal Veracruzano, 100 to 150 m depth, March 4, 2016. Twenty three specimens, 20 females and 3 males ranged between 42.5 to 53.5 cm TL (CIFI-1655) collected in the Gulf of Mexico, ca. Salinas Roca Partida, San Andrés Tuxtla, 150 to 200 m depth, February 17, 2019. Five females ranged between 49.1 to 51.8 cm TL (CIFI-1852) collected in the Gulf of Mexico, at the continental slope of the Veracruz, 18°44'39.13"N, 94°53'28.01"W, July 01, 2021.

Comments: these specimens are occasionally caught with bottom longline as part of the artisanal fisheries. The 92% of the specimens were mature, females presented bulging bellies and they were rearing yolk through the cloaca. Embryos were extracted in some dissections. For males, they had a mobile and calcified mixoptergium.

#### Order Myliobatiformes

##### Family Dasyatidae Jordan & Gilbert 1879

*Bathytoshia centroura* (Mitchill, 1815)

Roughtail stingray / Raya látigo isleña (Spanish)

(Fig. 4c)

Taxonomic summary (n = 1). A female specimen of ca. 160 cm of disc length and around 120,000 g collected in the southwestern of the Gulf of Mexico, in open sea off the town of Salinas Roca Partida, 18°45'47.4"N, 95°07'41.6"W, August 20, 2021.

Comments: the specimen was processed by local fishermen and it was sent to market of La Nueva Viga, Mexico City.

##### Family Gymnuridae Fowler, 1934

*Gymnura lessae* Yokota & Carvalho, 2017

Lesser butterfly ray / Raya mariposa menor (Spanish)

(Fig. 4d)

Taxonomic summary (n = 1). A female specimen of 16.2 cm disc length and 90 g (CIFI-1703) collected in the Gulf of Mexico, Alvarado Lagoon, Alvarado, 18°45'56.8"N, 95°46'09.2"W, 1.8 m depth, July 2020.

Comments: this specimen was caught with shrimp net.

##### Family Mobulidae

*Mobula hypostoma* (Bancroft, 1831)

Lesser devil ray / Manta enana, maroma (Spanish)

(Fig. 4e)

Taxonomic summary (n = 1). A female specimen of 40.5 cm disc length and a 4,315 g (CIFI-1733) collected in the Gulf of Mexico, Alvarado Lagoon, Alvarado, 18°46'20.4"N, 95°47'12.1"W, 1.5 m depth, November 18, 2020.

Comments: this specimen was incidentally caught in the shrimp fishery within the lagoon. It is first record of the species within a coastal lagoon system.

## DISCUSSION

The 11 registered species represent 5.3% of the elasmobranchs (111 sharks and 95 rays) present in marine waters of the Mexican Atlantic coast, where there are fewer studies about diversity of this group compared to the Pacific coast of Mexico (Del Moral-Flores et al. 2016). It should be noted that in marine waters of the Gulf of Mexico belonging to the USA there is a greater sampling effort and work in the taxonomic diversity of the group (Jones et al. 2020). There is a high number of inventories concerning of elasmobranch species associated with Mexican fisheries in the Gulf of Mexico and the Caribbean (Castillo-Géniz et al. 1998, Fuentes-Mata et al. 2002, Reyna-Matezans 2015, Blanco-Parra & Niño-Towers 2022). However, the existence of various species has not been verified with photographic or physical evidence or with specimens in scientific collections.

The sixgill shark of the genus *Hexanchus* has a restricted distribution to oceanic regions of temperate and tropical waters, associated with deep waters, they reach a depth of 2500 m (Ebert et al. 2021). These characteristics of habitat and distribution of the Hexanchiformes is part of the cause of their scarce records. Also, in the study area does not have an economic value due to its meat is very fatty and soft, that is why fishermen commonly call them “tiburones leche”.

Daly-Engel et al. (2018) conducted studies of two mitochondrial genes (NADH dehydrogenase 2 and cytochrome oxidase I) and confirmed that sixgill shark from offshore Belize, the northern of the Gulf of Mexico, and the Bahamas correspond to the species *Hexanchus vitulus* Springer & Waller 1969. In Mexico, records of *Hexanchus griseus* and *H. vitulus* are sporadic (Espinosa-Pérez et al. 2004, Del Moral-Flores et al. 2015), while in the territorial waters of the USA there is a more detailed distribution record of the genus *Hexanchus* with records of specimens in the states of Texas, Louisiana, and Florida (Daly-Engel et al. 2018).

According to some catches in the central part of Veracruz, *Heptranchias perlo* is a rare species within the catch (Reyna-Matezans 2015). This is similar to that reported by fishermen in the area of this study. The specimen reported in Ángel R. Cabada corresponds to the adult stage (85.4 cm TL), and according to the presence of sperm and morphology of the mixopterygians. The maturation size agrees with that reported by Correa de Carvalho et al. (2020), with an average size of 84.8 cm TL in mature males (Stage II). Its records in the coasts of the Gulf of Mexico are scarce (Del Moral-Flores et al. 2015) and at the state level this is the second record of the species. It was within its reproductive phase, which may imply the need for studies to evaluate a possible breeding zone.

The area where the specimens of *Scyliorhinus retifer* were captured is similar to the area of the Veracruz Reef System, where two specimens were previously captured (Del Moral-Flores & Peleó-Delgado 2018). Oceanographic and topographic conditions, as well as irregular terrain, may favor and provide them a nursery area (Able & Flescher 1991) or young hatched (Heupel et al. 2007), which could explain the capture of the gravid female. Although it is necessary to evaluate the density of this species, the fidelity and the constant occurrences in the area in order to delimit the possible nursery area (Heupel et al. 2007).

*Mustelus sinuatusmexicanus* is considered an endemic species of the Gulf of Mexico (McEachran & Feckhelm 1998). The first record of the species in the country corresponded to two mature specimens (one female and one male) captured in the north of the port of San Pedro, Centla, Tabasco, and near to the Campeche canyon (González-Acosta et al. 2017). The capture of a male specimen in the state of Veracruz represents the first record for the state and the second for the country.

Despite the fact that the sandbar shark *Carcharhinus plumbeus* and the tiger shark *Galeocerdo cuvier* are part of the fisheries in this area (Fuentes-Mata et al. 2002, Reyna-Matezans 2015) they have not been recorded in the ichthyofaunistic inventories of the Veracruz Reef System (Del Moral-Flores et al. 2013, Robertson et al. 2019). The main reasons for the absence both species in the records of the Veracruz Reef System in the decline of their populations over the years, before they were considered important species in the shark market in the area (Reyna-Matezans 2015), along with a poor determination of the "shark" resource in the official fishing records.

Another species with a capture record in Chachalacas and Tamiahua is *Squalus cubensis*, obtained from February 2013 to April 2014, where a large part of the

captures of this species are represented by adult and sometimes pregnant females (Reyna-Matezans 2015). It has been determined that this area north of Veracruz, at a depth of 162 to 180 m, is a breeding area for the species (Castillo-Géniz 2001). These data are similar to the capture dates of the study, coinciding with the records obtained in the Veracruz Reef (42.8 to 57.8 cm TL) and in Salinas Roca Partida (42.5 to 53.5 cm TL), where the capture of female specimens is similar. The species is characterized by presenting benthic habits during the first stages of life (Salomón-Aguilar 2012). The benthic area, where these specimens were obtained, is characterized by a rocky substrate, which is alternated between sandy patches. In times when it is usually more abundant, it is fished and sent to the La Nueva Viga market for trade (Ballesteros-Hernández et al. 2019).

Pfleger et al. (2018) conducted morphological and morphometric studies, as well as analysis of two mitochondrial genes to describe a new species of the genus *Squalus* from the Gulf of Mexico, *S. clarkae*. They establish this new species as belonging to the Gulf of Mexico, displacing the records of *S. mitsukurii* from this region. Some of its distinctive features that set it apart from others in the genus are a more elongated body, a smaller interorbital space, and a short tail fin. Specimens of *S. clarkae* were caught out off the coast of the northern of the Gulf of Mexico, from Tampa, Florida to Louisiana. The first record for Mexican waters corresponds to 14 specimens captured in the vicinity of Salinas Roca Partida, Veracruz (Del Moral-Flores et al. 2022). This work is the second record of the species in Mexican waters, and due to the record of gravid specimens, it is necessary to study the population of the area and corroborate the possible breeding area of the species in this area.

The first record of *Bathytoshi centroura* in the Mexican waters of the Gulf of Mexico corresponds to an adult female, with a disc length of 181 cm, it was caught arriving in the port of Sánchez Magallanes, Tabasco (Wakida-Kusunoki et al. 2018). In the present study, the capture of an adult female specimen made by fishermen from the town of Salinas Roca Partida, corresponds to the second record of the species for the country. The absence of previous reports in the southwestern of the Gulf of Mexico is possibly due to a poor taxonomic determination of the specimens as a result of the faster processing that large specimens receive before reaching the coast and landing port, since the specimens of the Dasyatidae family from the Gulf of Mexico coast have a high commercial value in the market, as is the case in La Nueva Viga in Mexico City (Ballesteros-Hernández et al. 2019).



The Gymnuridae family is represented by four valid species in the Atlantic, including *Gymnura lessae*. The species *G. micrura* was previously believed to have a wide distribution, from the northern coasts of the USA to southern Brazil, and in the African continent from Senegal to South Africa. However, the morphological and taxonomic study concludes that the geographic distribution of *G. micrura* is restricted to the southwestern Atlantic, from northern Venezuela, including Trinidad and Tobago, to the state of Rio de Janeiro, Brazil. While in the north and central-western Atlantic, it is replaced by the species *G. lessae*, from southern Massachusetts and Buzzards Bay, USA, to the Gulf of Mexico (Yokota & Rodrigues de Carvalho 2017). This species is frequently captured in Mexican coastal waters of the Gulf (Zea-de la Cruz et al. 2016) and usually ventures into estuarine environments, such as the Celestún Lagoon (Vega-Cendejas 2004), the Términos lagoon, Campeche (Paz-Ríos et al. 2021), and in the Tamiahua, Tampamachoco and Ostión lagoons, in the state of Veracruz (Abarca-Arenas et al. 2016, Raz-Guzmán et al. 2018). However, it had not been recorded in Alvarado Lagoon, Veracruz (Chávez-López et al. 2009). The coastal lagoons have the function of serving as nursery for juveniles and gravid females of various fish groups (e.g. Centropomidae, Carangidae, Eleotridae). They generally have warm and shallow water, and they are protected by layers of vegetation such as algae and mangrove roots (Abarca-Arenas et al. 2016). Besides, many marine species, both juveniles and adults migrate to coastal lagoons in search of food (Raz-Guzmán et al. 2018). This is the explanation for the presence of *G. lessae* in Alvarado Lagoon, and it is the first record of this species in this lagoon system.

The species *Mobula hypostoma* has a wide distribution in the coasts of the Gulf of Mexico. The first record in the southwestern area corresponds to nine specimens captured in Las Barracas Beach, Alvarado, Veracruz (Del Moral-Flores et al. 2020). The environment where the specimen of this contribution was captured does not coincide with those of the marine-pelagic environment. It is an anomalous record and possibly this specimen was trapped in the lagoon after the strong storms, during the time known “nortes”, that passed through that locality days before its capture. The physicochemical parameters within the Alvarado Lagoon system are highly variable, during the northern season there is a salinity transition zone within the system, low depth and temperature predominate, turbidity is high and there is a decrease in transparency (Chávez-López et al. 2009).

Finally, this paper increases the numbers of records for elasmobranchs species to the southwestern region of the Gulf of Mexico, increasing the distribution range and knowledge about the chondrichthyo fauna of Mexico. In addition, the Fishing Management Plan for Sharks and Rays in the Gulf of Mexico and the Caribbean Sea was recently published, therefore, the reports of at least four species that are not found in this plan is important and is necessary to identify their relationship with artisanal fishing in order to know in the future the degree of susceptibility that their populations may have.

#### ACKNOWLEDGEMENTS

We thank the local fishermen, A. Campos Pérez, E. Campos Vicente, J. Arias Carmona and E. Herrera Palacios, for their help in field. This work was supported by UNAM-PAPIIT IA207820. We appreciate the support of SNI-CONACyT program. To the anonymous reviewers for their comments that helped improve this work.

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*Received: March 28, 2022; Accepted: September 8, 2022*

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