Notes on the Presence of Mustelus sinusmexicanus and Hexanchus nakamurai (Chondrichthyes: Elasmobranchii) in Mexican waters

Abstract

The taxonomy and distribution of 2 deep water sharks, Mustelus sinusmexicanus and Hexanchus nakamurai, is discussed here on the basis of 3 specimens from the Gulf of Mexico. Both species are distributed in the area; however, they are rarely found in ichthyological collections as they are seldom caught and due to the challenge of curating such large specimens. Thus, this is the first time that Gulf Smooth hound and Bigeye Sixgill shark specimens have been curated in a Mexican ichthyological collection, confirming its presence in México.

Keywords: New documented records; Hexanchidae; Triakidae; Mexican sharks; Mustelus sinusmexicanus; Hexanchus nakamurai

Introduction

Selachii comprise a taxon of particular interest for their unique biology, ecology, and behavior; but, intensive fisheries have been reduced dramatically their abundances [1]. Thus, it is imperative that we taxonomically verify any reports and curate samples of the specimens in the corresponding reference collections. In Mexico, Selachii or sharks are represented by 109 species, which in turn constitute 30% of the world’s species richness [2].

In this study, we present information regarding the taxonomic characteristics and distribution of Gulf Smooth hound (Triakidae) and Bigeye Sixgill sharks (Hexanchidae) based on the examination of three specimens from the Gulf of Mexico. While both species are distributed in the area, very few are included in reference collections [3,4] this is due to the rarity of capturing them and the difficulty of curating such large samples.

Material and Methods

Three specimens of the 2 species reported here were caught by the commercial fishery using bottom long lines near the Campeche Bank in Mexico. These specimens were deposited and cataloged in the ichthyology collection at El Colegio de la Frontera Sur (ECOSC). The specimens were identified following the relevant literature [2,5-11]. Additionally, biometrics were recorded for each specimen which follow to Ebert et al. [9] and Heemstra [10] with some modifications and additions based on the morphology of the organisms examined (Table 1). The nomenclature and taxonomic arrangement are after Page et al. [12].

Description

We identified a total of 2 genera corresponding to an equal number of families and orders, which were described as follows:

Taxonomy summary

Class: Chondrichthyes
Subclass: Elasmobranchii
Order: Carcharhiniformes
Family: Triakidae
Genus Mustelus Linck 1790

The genus Mustelus includes 27 species distributed in tropical, subtropical, and temperate climates of the world's oceans [5,7,8,9], representing 33.3% of the species in Mexican waters [2,13]. Mustelus sinusmexicanus Heemstra, 1997(Figure 1, Table 1).

a. Common name: Cazón del Golfo (Spa.), Gulf Smooth hound
b. Material examined: Two eviscerated, sexually mature specimens, 1 male (ECOSC 7471-1; 800 mm TL, 1,100 g) and 1 female (ECOSC 7471-2; 1,092 mm TL, 3,500 g). Both specimens were caught at 48.6 km north of the San Pedro Port, Centla, Tabasco, Mexico, near of the Campeche Canyon (18°38’36’’N and 98°28’07’’W) by a commercial fishing vessel using bottom longlines, on April 30, 2010.
c. Description: The Gulf Smoothhound specimens were identified based on a number features, including their long,
lean bodies that are flattened on the ventral side; a flattened head; a pointed, long rostrum (pre-oral length 6.2-7.2% TL); 5 pairs of gill slits, the fourth pair on the origin of the pectoral fins; large, oval eyes (2.6-3.2% TL); the internarial width (2.1-2.9% TL); a wide mouth (5.5% TL) with longer upper labial furrows (1.6-2% TL); a limited number of small teeth arranged in a mosaic of several rows; and the presence of tricuspid dermal denticles between the pectoral and pelvic fins. Biometric data for the specimens are presented in Table 1 most measurements were within the ranges indicated by Compagno [6] and Heemstra [10] for this species.

d. Distribution: This species of shark is considered endemic to the Gulf of Mexico, with a distribution that extends from Panama City, Florida, USA to the Campeche bay, Mexico [5,8,10]. Prior to this study, there have been no verified records of voucher specimens deposited in national reference collections; however, other researchers have previously discussed the species’ presence in Mexican waters [2].

**Table 1:** Morphometric data for *Mustelus sinusmexicanus* [MSM] and *Hexanchus nakamurai* [HN] form Mexican waters. Boldface measurements are expressed as percentages of total length.

| Biometrics (mm)       | MSM ECOSC 7471 | MSM ECOSC 7472 | HN ECOSC 7414 |
|-----------------------|----------------|----------------|--------------|
| Total length          | 800            | 1092           | 896          |
| Pre-caudal length     | 614.0 (76.7)   | 935.0 (85.6)   | 570.0 (65.6) |
| Pre-narinal length    | 32.0 (4.0)     | 52.0 (4.7)     | 13.0 (1.5)   |
| Pre-oral length       | 58.0 (7.2)     | 68.0 (6.2)     | 51.0 (5.8)   |
| Pre-orbital length    | 65.0 (8.1)     | 76.0 (6.9)     | 34.0 (3.8)   |
| Pre-spiracle length   | 40.0 (5.0)     | 55.0 (5.0)     | 96.0 (10.9)  |
| Pre-gill length       | 145.0 (18.1)   | 167.0 (15.3)   | 123.0 (14.0) |
| Pre-pectoral length   | 160.0 (20.0)   | 210.0 (19.2)   | 146.0 (16.6) |
| Pre-pelvic length     | 345.0 (43.1)   | 490.0 (44.8)   | 341.0 (38.9) |
| Snout-ventral length  | 382.0 (47.7)   | 475.0 (43.5)   | 366.0 (41.8) |
| Pre-dorsal length     | 200.0 (25.0)   | 307.0 (28.1)   | 420.0 (47.9) |
| Dorsal-caudal space   | 298.0 (37.2)   | 453.0 (41.5)   | 99.0 (11.3)  |
| Pre-anal length       | 525.0 (65.6)   | 705.0 (64.5)   | 468.0 (53.4) |
| Pectoral-pelvic space | 168.0 (21.0)   | 310.0 (28.3)   | 143.0 (16.3) |
| Pelvic-anal space     | 151.0 (18.9)   | 169.0 (15.5)   | 62.0 (7.1)   |
| Anal-caudal space     | 80.0 (10.0)    | 150.0 (13.7)   | 72.0 (8.2)   |
| Pelvic-caudal length  | 274.0 (34.2)   | 319.0 (29.2)   | 68.0 (7.7)   |
| Eye length            | 26.0 (3.2)     | 28.0 (2.6)     | 35.0 (3.9)   |
| Eye height            | 12.0 (1.5)     | 14.0 (1.3)     | 1.8 (0.16)   |
| Inter orbital length  | 58.0 (7.2)     | 73.0 (6.7)     | 72.0 (8.2)   |
| Nostril width         | 13.0 (1.6)     | 17.0 (1.5)     | 8.0 (0.9)    |
| Internarial width     | 17.0 (2.1)     | 32.0 (2.9)     | 36.0 (4.1)   |
| Anterior nasal fold   | 5.0 (0.6)      | 7.0 (0.6)      | 7.0 (0.8)    |
| Spiracle length       | 5.0 (0.6)      | 7.0 (0.6)      | 3.0 (0.3)    |
| Eye-spiracle length   | 7.0 (0.9)      | 8.0 (0.7)      | 37.0 (4.2)   |
| Mouth length          | 57.0 (7.1)     | 85.0 (7.8)     | 103.0 (11.7) |
| Mouth width           | 44.0 (5.5)     | 60.0 (5.5)     | 90.0 (10.3)  |
| Upper labial furrow   | 16.0 (2.0)     | 18.0 (1.6)     | 50.0 (5.7)   |
| Lower labial furrow   | 13.0 (1.6)     | 15.0 (1.4)     | 21.0 (2.4)   |
| First gill arch height| 25.0 (3.1)     | 41.0 (3.7)     | 85.0 (9.7)   |
### Notes on the Presence of Mustelus sinusmexicanus and Hexanchus nakamurai (Chondrichthyes: Elasmobranchii) in Mexican waters

| Measurement                          | Mean   | Standard Deviation | Minimum | Maximum |
|--------------------------------------|--------|--------------------|---------|---------|
| Second gill arch height              | 27.0   | 3.4                | 45.0    | 75.0    |
| Third gill arch height               | 25.0   | 3.1                | 37.0    | 63.0    |
| Fourth gill arch height              | 28.0   | 3.5                | 35.0    | 61.0    |
| Fifth gill arch height               | 17.0   | 2.1                | 22.0    | 58.0    |
| Sixth gill arch height               | -      | -                  | -       | 35.0    |
| Head height                          | 90.0   | 11.2               | 140.0   | 77.0    |
| Head width                           | 150.0  | 18.7               | 190.0   | 94.0    |
| Trunk height                         | 65.0   | 8.1                | 85.0    | 87.0    |
| Trunk width                          | 73.0   | 9.1                | 113.0   | 78.0    |
| Caudal peduncle height               | 22.0   | 2.7                | 30.0    | 37.0    |
| Caudal peduncle width                | 12.0   | 1.5                | 18.0    | 24.0    |
| Pectoral fin length                  | 72.0   | 9.0                | 159.0   | 105.0   |
| Anterior margin of pectoral fin      | 115.0  | 14.4               | 170.0   | 107.0   |
| Pectoral fin base length             | 35.0   | 4.4                | 47.0    | 44.0    |
| Pectoral fin height                  | 109.0  | 13.6               | 144.0   | 82.0    |
| Pectoral fin inner margin            | 60.0   | 7.5                | 75.0    | 49.0    |
| Posterior margin of pectoral fin     | 100.0  | 12.5               | 125.0   | 88.0    |
| Pelvic fin length                    | 74.0   | 9.2                | 103.0   | 81.0    |
| Anterior margin of pelvic fin        | 67.0   | 8.4                | 75.0    | 40.0    |
| Pelvic fin base length               | 48.0   | 6.0                | 50.0    | 56.0    |
| Pelvic fin height                    | 47.0   | 5.9                | 47.0    | 25.0    |
| Pelvic fin inner margin              | 40.0   | 5.0                | 55.0    | 23.0    |
| Posterior margin of pelvic fin       | 53.0   | 6.6                | 73.0    | 56.0    |
| Outer clasper length                 | 65.0   | 8.1                | -       | 27.0    |
| Inner clasper length                 | 78.0   | 9.7                | -       | 28.0    |
| Clasper base length                  | 10.0   | 1.2                | -       | 8.0     |
| First dorsal fin length              | 115.0  | 14.4               | 179.0   | 65.0    |
| Anterior margin of first dorsal fin  | 97.0   | 12.1               | 163.0   | 50.0    |
| First dorsal fin base length         | 87.0   | 10.8               | 130.0   | 49.0    |
| First dorsal fin height              | 64.0   | 8.0                | 103.0   | 26.0    |
| Inner margin of first dorsal fin     | 50.0   | 4.6                | 50.0    | 18.0    |
| Posterior margin of first dorsal fin | 90.0   | 8.2                | 149.0   | 45.0    |
| Second dorsal fin length             | 86.0   | 10.7               | 116.0   | -       |
| Anterior margin of second dorsal fin | 77.0   | 9.6                | 101.0   | -       |
| Second dorsal fin base length        | 56.0   | 7.0                | 85.0    | -       |
| Second dorsal fin height             | 49.0   | 6.1                | 64.0    | -       |
| Inner margin of second dorsal fin    | 33.0   | 4.1                | 73.0    | -       |
| Posterior margin of second dorsal fin| 64.0   | 8.0                | 78.0    | -       |
| Anal fin length                      | 56.0   | 7.0                | 80.0    | 53.0    |
| Anterior margin of anal fin          | 49.0   | 6.1                | 68.0    | 23.0    |
Notes on the Presence of Mustelus sinusmexicanus and Hexanchus nakamurai (Chondrichthyes: Elasmobranchii) in Mexican waters

| Measurement                                      | Male 1 | Male 2 | Male 3 |
|--------------------------------------------------|--------|--------|--------|
| Anal fin base length                             | 40.0 (5.0) | 51.0 (4.7) | 37.0 (4.2) |
| Anal fin height                                  | 25.0 (3.1) | 45.0 (4.1) | 14.0 (1.6) |
| Inner margin of anal fin                         | 20.0 (2.5) | 33.0 (3.0) | 13.0 (1.5) |
| Posterior margin of anal fin                     | 22.0 (2.7) | 47.0 (4.3) | 27.0 (3.1) |
| Dorsal margin of caudal fin                      | 422.0 (52.7) | 614.0 (56.2) | 282.0 (31.0) |
| Pre-ventral caudal fin margin                    | 73.0 (9.1) | 82.0 (7.5) | 63.0 (7.2) |
| Lower post-ventral caudal fin margin             | 27.0 (3.4) | 33.0 (3.0) | 34.0 (3.8) |
| Upper post-ventral caudal fin margin             | 77.0 (9.6) | 85.0 (7.8) | 160.0 (18.2) |
| Sub-terminal caudal fin margin                   | 27.0 (3.4) | 34.0 (3.1) | 44.0 (5.0) |
| Terminal caudal fin margin                       | 56.0 (7.0) | 67.0 (21.8) | 28.0 (3.2) |
| Terminal caudal lobe length                      | 172.0 (21.5) | 254.0 (23.3) | 64.0 (7.3) |
| Caudal fork length                               | 63.0 (7.9) | 65.0 (5.9) | 60.0 (6.8) |
| Distance between the origin of the first dorsal fin and the origin of the anal fin | 307.0 (38.4) | 486.0 (44.5) | 46.0 (5.2) |
| Distance between the origin of the first dorsal fin and the origin of the anal fin | 255.0 (31.9) | 380.0 (34.8) | 34.0 (3.9) |
| Distance between the origin of the second dorsal fin and the origin of the anal fin | 48.0 (6.0) | 90.0 (34.8) | - |
| Distance between the origin of the second dorsal fin and the insertion point of the anal fin | 25.0 (3.1) | 54.0 (8.2) | - |
| Caudal width space                               | 22.0 (2.7) | 28.0 (2.6) | 33.0 (3.7) |
| Caudal fork width                                | 22.0 (2.7) | 28.0 (2.6) | 33.0 (3.7) |
| Sex                                              | Mature male | Female | Immature male |
| Weight (g)                                       | 1,100 | 3,500 | 1,560 |
| Gastric contents                                 | Eviscerated | Eviscerated | Empty |

Figure 1: a) *Mustelus sinusmexicanus*, ECO-SC 7471-1 (male specimen, 800 mm TL, 1,100 g); and b) *Hexanchus nakamurai*, ECO-SC 7414 (male specimen, 896 mm TL, 1,560 g) from the Gulf of Campeche, Mexico.
Order: Hexanchiformes
Family: Hexanchidae
Genus Hexanchus Rafinesque 1810

The genus Hexanchus is represented by 2 species with a circumglobal distribution [5,7,8,9], in Mexico’s Atlantic and Pacific watersheds [2,14]. Hexanchus nakamurai Teng 1962 (Figure 1b; Table 1)

a. **Common name:** Cazón ojigrande de seis branquias (Spa); Bigeyed Sixgill Shark.

b. **Materials examined:** A sexually immature male specimen (ECOSC 7414; 896 mm TL, 1,560 g) was captured at a depth of 118.8 m by a commercial fishing boat using bottom longlines in the vicinity of Cayo Arcas (west of the Obispo Bank) near the Campeche Canyon (20°27’36”N and 92°12’39”W) and southwest of the Yucatan Peninsula, Mexico, on May 11, 2012.

c. **Description:** The H. nakamurai specimen was identified based on the presence of 6 pairs of gill slits, the first longer (8.5% TL) than the rest; a slim body; a flattened head with a long rostrum (41.8% TL), the head is pointed and narrow relative to the robust body and head of the related H. griseus Günther 1879[14]; relatively large eyes with a diameter 3.9% TL; a ventrally-located mouth; 5 large teeth in the mandible in a comb-like arrangement on each side of the symphysial tooth (located in the center of each mandible); an upper jaw with nine teeth on each side, with a knife-like anterior apex; a single dorsal fin located in the space between the posterior part of the pelvic fin and the origin of the anal fin; a long (11.3% TL) thin (2.7% TL) caudal peduncle; and a deep notch in the upper lobe of the caudal fin. The specimen’s biometrics are presented in Table 1; 68% are within the ranges reported by Ebert et al. [9] for the Sixgill Shark; the remaining 32% are within the range of variability in the specimens examined by those authors.

d. **Distribution:** The Sixgill Shark has a cosmopolitan distribution in the tropical and temperate oceans of the world (except the eastern Pacific). The species is distributed in the western Atlantic watershed from Florida to the West Indies, including the Gulf of Mexico and Caribbean Sea, to Venezuela and the Guianas, in the eastern Atlantic, from France to Morocco including the Mediterranean Sea; and in the southwest Indian Ocean, the Sea of Japan, Taiwan, and Australia. The species typically inhabits depths of 90-621 m, but is occasionally found on the surface or near the coast [5, 6, 7, 8, 9, 15]. On the Atlantic coast of Mexico, the species has been reported off the coast of Veracruz [2, 16, 17, 18], although national ichthyologic reference collections previously lacked curated examples.

e. **General comments:** This report of the Sixgill Shark, H. nakamurai Teng 1962 in Mexican waters is significant; the species’ taxonomy had been challenged by its apparent morphological similarity [19-22] with the Bigeye Sixgill Shark, H. vitulus Springer and Waller 1969; although they are genetically distinct [23,24,25]. Based on a taxonomic study of both species, Ebert et al. [9] determined that H. nakamurai should be recognized as a valid species that is widely distributed in the world’s oceans in accordance to the re-description and designation of a neotype for this species (NMMP 15835) supported by a specimen from Taiwan, as well as establishing H. vitulus as junior synonym [9]. The specimen reported here is the first to be deposited in a national ichthyological collection.

**Discussion**

Due to our limited knowledge of the biology and ecology of these species, they have been assigned a conservation status of “data deficient” [sic] in the IUCN Red List of Threatened Species [15,26]. Therefore, it is necessary to conduct basic studies of their population dynamics and other aspects of their basic biology in order to more accurately determine the current conservation status of their populations [5,11].

In recent years, there has been an increase in the number of studies reporting new species of sharks [13], including new records of their presence and extensions to their distribution in Mexican waters [1]. This situation highlights the fact that we have yet to fully explore the entirety of the country’s cartilaginous fish, making further studies focusing on these species imperative.

**Acknowledgement**

We thank the crew of the fishing boat, La Perla del Golfo, and the artisanal fishery based out of the port of San Pedro for capturing these specimens. This project was partially funded by Grant No. 120925 awarded jointly by El Consejo Nacional de Ciencia y Tecnología (CONACyT) and the Tabasco State Government. AFGA is grateful for funding from the SNI-CONACyT, and the EDI and COFAPA-IPN Programs. K Sullivan edited the English manuscript.

**References**

1. Ruiz-Campos G, Castro-Aguirre JL, Balart EE, Campos-Dávila L, Vélez-Márin R (2010) New specimens and records of chondrichthyan fishes (Vertebrata: Chondrichthyes) off the Mexican Pacific coast. Rev Mex Biodiv 81(2): 363-371.

2. Espinosa-Pérez H, Castro-Aguirre JL, Huidoob-Campos L (2004) IX. Catálogo sistemático de tiburones (Elasmobranchii: Selachimorpha). Listados Faunísticos de México. Instituto de Biología-Universidad Nacional Autónoma de México, Distrito Federal, México.

3. Froese R, Pauly D (2016) Fish Base.

4. Sánchez R, De Maddalena A (2003) Collection of the sharks of the Natural Museum in Prague- Part 1. Complete taxidernms and liquid preservations. J Nat Mus, Nat Hist Ser 172(1-4): 61-70.

5. Castro JI (2011) The sharks of North America. Oxford University Press, USA.

6. Compagno L (2002) Sharks. In: Carpenter K (Ed.), The living marine resources of the western central Atlantic. Introduction, mollusks, crustaceans, hagfishes, sharks, batoid fishes, and chimaerans. FAO Species Identification Guide for Fishery Purposes and American Society of Ichthyologists and Herpetologists, Special Publication 5, Rome 1: 357-600.

7. Ebert DA, Sthemann MFW (2013) Sharks, batoids and chimaerases of...
the North Atlantic. FAO Species Catalogue for Fishery Purposes 7, Rome.

8. Ebert DA, Fowler S, Compagno L (2013) Sharks of the world. Wild Nature Press, UK.

9. Ebert DA, White WT, Ho HC (2013) Redescription of Hexanchus nakamurai Teng 1962, (Chondrichthyes: Hexanchiformes: Hexanchidae), with designation of a neotype. Zootaxa 3752: 20-34.

10. Heemstra PC (1997) A review of the Smooth-hound sharks (genus Mustelus, family Triakidae) of the western Atlantic Ocean, with descriptions of two new species and new subspecies. Bull Mar Sci 60(3): 894-928.

11. Hurst R, Dando M (2010) Shark trust: an illustrated compendium of shark, skates, rays and chimaera. Chapter 1: The British Isles and Northeast Atlantic, Part 2: Sharks. Wild Nature Press, UK.

12. Page LM, Espinosa-Pérez H, Findley LT, Gilbert CR, Lea RN, et al. (2013) Common and scientific names of fishes from the United States, Canada and Mexico. American Fisheries Society.

13. Castro-Aguirre JL, Antuna-Mendiola A, González-Acosta AF, de la Cruz-Agüero J (2005) Una especie nueva del género Mustelus Linck, 1790 Chondrichthyes: Carcharhiniformes: Triakidae) de la costa suroccidental de Baja California Sur, México. Hidrobiológica 15: 123-130.

14. Castro-Aguirre JL, Antuna-Mendiola A, González-Acosta AF, de la Cruz-Agüero J (2003) Primer registro de Tiburón Cañabota Hexanchus grisaeus (Bonnaterre, 1788) (Chondrichthyes: Selachimorpha) en la costa occidental de Baja California Sur, México. Oceanidés 18: 39-41.

15. Ebert DA, Serena F, Mancusi C (2009) Hexanchus nakamurai. IUCN Red List of Threatened Species.

16. Applegate SP, Espinoza-Arubarrena L, Menchaca-López L B, Sotelo-Macías F (1979) Tiburones mexicanos. Secretaría de Educación Pública, Dirección General de Ciencia y Tecnología del Mar, México.

17. Applegate SP, Sotelo-Macías F, Espinoza-Arubarrena L (1993) An overview of Mexican shark fisheries, with suggestions for shark conservation in Mexico. US Nat Mar Fish Serv Tech Rep 115: 31-37.

18. Schadalach WL, Huidobro-Campos L, Espinosa-Pérez H (1997) Peces marinos. In: González-Soriano E., Dirzo R, Vogt RC (Eds.), Historia natural de los Tuxtlas (pp. 463-471). Instituto de Biología UNAM, Instituto de Ecología UNAM, CONABIO, México, DF.

19. Adnet S (2006) Biometric analysis of the teeth of fossil and recent hexanchid sharks and its taxonomic implications. Acta Paleontol Pol 51: 477-488.

20. McEachran JD, Fechhelm, JD (2005) Fishes of the Gulf of Mexico. Volume 1: Myxiniformes to Gasterosteiformes. University of Texas Press, USA.

21. Springer S, Waller RA (1969) Hexanchus vitulus, a new sixgill shark from the Bahamas. Bull Mar Sci 19(1): 159-174.

22. Taniuchi T, Tanikawa H (1991) Hexanchus nakamurai, a senior synonym of H. vitulus (Elasmobranchii), with notes on its occurrence in Japan. J Ichthyol 38: 57-60.

23. Naylor GJP, Cairns JN, Jensen K, Rosana KAM, White WT, Last PR (2012) A DNA sequence-based approach to the identification of shark and ray species and its implications for global elasmobranch diversity and parasitology. Bull Am Nat Hist Mus 367: 1-263.

24. Naylor GJP, Cairns JN, Jensen K, Rosana KAM, Straube N, Lakner C (2012) Elasmobranch phylogeny: a mitochondrial estimate based on 595 species. In: Carrier JC, Musick JA, Heithaus MR (Eds.), Biology of the sharks and their relatives CRC Press, USA pp. 3-69.

25. Tanaka K, Shiina T, Tomita T, Suzuki S, Hosomichi K et al. (2013) Evolutionary relations of Hexanchiformes deep-sea sharks elucidated by whole mitochondrial genome sequences. Biom Res Int 2013: 1-11.

26. http://www.iucnredlist.org/details/60206/0.