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Fishery and morphometric relationships of the banded guitarfish, *Zapteryx exasperata* (Elasmobranchii, Rhinobatidae), from the Gulf of California, Mexico

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Abstract. The banded guitarfish (*Zapteryx exasperata*) is a commercially-important species in the Northwest artisanal ray fishery of Mexico. However, very little information about its fisheries characteristics and catch abundance is available. Seasonal sampling was conducted between 1998─2000 and 2004─2005 in five fishery camps in the Gulf of California. *Z. exasperata* is a secondary resource in ground fisheries, and is caught using gill nets with mesh sizes between 15─20 cm from small fiberglass boats called "pangas," fishing between 4─54 m depth. Catches were composed of individuals between 41.3─90 cm TL with an average weight of 2.18 ± 1.13 kg. The sex ratio of the catches was 1:1. Females reached larger sizes and weights than males; therefore, the morphometric relationships were different between sexes. CPUE reached its highest values during spring (3.4 ind/trip), and was lowest during summer. CPUE was also higher in fishing sites with depths between 100─200 m (5.5 ind/trip). *Z. exasperata* fishery characteristics are similar to those reported for elasmobranchs in other regions of Mexico. In particular, the seasonality of the catches was similar to that reported for other ray species in the Gulf of California, with a peak during spring and summer.

Key words: Artisanal fisheries, CPUE, elasmobranch, catch composition

Resumen. Pesquería y relaciones morfométricas de el pez guitarra rayada, *Zapteryx exasperata* (Elasmobranchii, Rhinobatidae), en el Golfo de California, México. El pez guitarra rayada es una especie de importancia comercial en el noroeste de México, en donde es componente importante de las capturas de la pesquería artesanal de rayas, sin embargo no existe actualmente información sobre las características y abundancias de su pesquería en esta región del país. Se llevaron a cabo muestreos estacionales entre 1998─2000 y 2004─2005, en cinco campos pesqueros del Golfo de California. *Z. exasperata* es un recurso secundario en pesquerías de fondo, es capturada con redes de enmalle de 15 a 20 cm de abertura de malla, utilizando lanchas de fibra de vidrio denominadas "pangas" y a profundidades entre 4─54 m. Las capturas estuvieron compuestas por machos y hembras en una proporción 1:1 con LT entre 41.3 y 90 cm y con un peso promedio de 2.18 ± 1.13 kg. La talla y peso de las hembras fue mayor que en los machos por lo que las relaciones morfométricas fueron diferentes entre sexos. La CPUE presentó su mayor valor durante la primavera (3.4 inv/viaje) y el más bajo durante el verano, así mismo en los caladeros que presentaron profundidades entre los 100 y 200 m la CPUE fue la más alta (5.5 indv/viaje). Las características de la pesquería de *Z. exasperata* concuerda con la de la pesquería de elasmobranquios en otras regiones de México y la estacionalidad de las capturas en el golfo de California es similar a la de otras especies de rayas que se caracterizan por ser abundantes durante la primavera y el verano.

Palabras clave: Pesquería artesanal, CPUE, elasmobranquios, composición de las capturas

Introduction

The ray fishery in the Mexican Pacific was developed with the introduction of bottom gillnets in the Upper Gulf of California. Between 1990 and 2000, the ray landings from the Mexican Pacific coast showed a relatively stable trend with an average of 5,514 tons/year . The Gulf of California (GC) represented 93% of the Pacific coast total ray production during the same period (CONAPESCA 2002). The ray fishery extends throughout the Gulf of California, decreasing from north to south, and is largely represented by small-scale artisanal fishermen (Márquez-Farías 2002, Bizzarro *et al.* 2007, Bizzarro *et al.* 2009). Rays dominate artisanal chondrichthyans landed in Sonora, representing 63.4% of the total catch (Bizzarro *et al.* 2009). At least 18 ray species are caught in the GC, and the composition varies according to season, fishery area, and the nets employed for capture (Márquez-Farías & Blanco-Parra 2006, Bizzarro *et al.* 2009). The principal ray families captured in this fishery are: Rhinobatidae, Urolophidae and Mobulidae, representing more than 90% of the total rays captured in the GC (Márquez-Farías & Blanco-Parra 2006, Bizzarro *et al.* 2009).

Similar to sharks, batoids can also be extremely vulnerable to overfishing due to shared life history characteristics (late maturity, long life span, slow growth and low fecundity) that result in slow population growth (Stevens *et al.* 2000, Dulvy & Reynolds 2002). The most abundant ray family in the Gulf of California catches, the Rhinobatidae, accounts for 52% of the total number of individuals, with the main species consisting of *Rhinobatos productus*, *Rhinobatos glaucostigma* and *Zapteryx exasperata* (Márquez-Farías & Blanco-Parra 2006). Catches are seasonal, with 75% occurring from March to June, with a peak in April when gravid females migrate to shallower waters and become vulnerable to the bottom gillnets commonly used in the artisanal fishery (Villavicencio-Garayzar 1995, Márquez-Farías 2007). The limited distribution of most of the rhinobatid species, the lack of available biological information, and the exploitation by directed and undirected fisheries around the world all contribute to their risk of overexploitation.

The family Rhinobatidae represents one of the most ancient batoid lineages and contains approximately 42 species (Compagno 2005). The genus *Zapteryx* is comprised of three poorly-known species that are distributed only in the waters of the American continent. Two of the three species, *Z. exasperata* (Jordan & Gilbert 1880), and *Zapteryx xyster* (Jordan & Everman 1896), occur in the Eastern Pacific, and little is known of the distribution limits (Ebert 2003) and biology of these rays.

The banded guitarfish, *Z. exasperata*, is a bottom-living elasmobranch found on the Northeast Pacific coast from southern California (USA) to Mazatlán, including the Gulf of California, and inhabits rocky reefs from the intertidal zone to a depth of 69 m (Ebert 2003). The presence of this species south of Mazatlán (Gulf of California) is unknown due to possible misidentification with *Z. xyster*, a more tropically distributed species. *Zapteryx exasperata* is a commercially-important species in the northwest of Mexico, where it is one of the most important species caught in the artisanal ray fishery (Villavicencio-Garayzar 1995, Márquez-Farías & Blanco-Parra 2006), and is caught as bycatch by shrimp trawlers (Pérez-Mellado & Findley 1985). Despite the development of this fishery, there is no information available about its characteristics. Therefore, the aim of this study was to describe the basic characteristics of the *Z. exasperata* fishery, as well as their abundance and morphometric relationships, in the Gulf of California.

Materials and Methods

Seasonal surveys of artisanal fishing sites were conducted from March 1998 to May 2000, and from November 2004 to July 2005 at artisanal fishery landings in Sonora, along the northern Gulf of California (Fig. 1). During the first year, the aim of the surveys was to determine the location and activities of all active artisanal fishing sites. During 1999 and 2000, the primary elasmobranch fishing camps were visited to collect data on fishing effort, fishery targets, fishing operation, fishing location, gear type, catch composition and biological information.

Zapteryx exasperata individuals were sexed and total length (TL, to the nearest cm) and weight (W) (to the nearest 0.1 kg) were measured. Other morphological measurements were also taken: disc width (DW, linear distance across the widest portion of the disc), body length (BL, linear distance from the tip of the snout to the distal edge of the pelvic fin) and disc length (DL, linear distance from the tip of the snout to the distal edge of the pectoral fins). Sexual maturity was estimated in males by considering the degree of calcification and capacity of rotation of the claspers, and in females by macroscopic inspection of the ovaries and uterus (Blanco-Parra *et al.* in press). Juvenile (sexually immature organisms) and adult (sexually mature organisms) ontogenetic categories were assigned.

Fishing site locations were located on maps

using the fishermen's reports and were grouped in five zones based on the utilization of these sites by the fishermen from each fishing camp (Fig. 1). Zone one is the coast surrounding Tiburón Island, San Esteban Island and the Infiernillo channel; this zone includes nine fishing sites used by fishermen from Bahía de Kino. The second zone is the coast from Bahía de Kino to San Nicolas, which includes 15 fishing sites used by fishermen from Bahía de Kino, El Sahuimaro and El Choyudo. The third zone is the coast in front El Cardonal to el Sahuimaro, and includes five fishing sites used by fishermen from El Sahuimaro and El Choyudo. Zone four is the coast from Estero Tastiota to El Choyudo, and includes 12 fishing sites used by fishermen from El Choyudo. The fifth zone is the surrounding area from San Pedro Martir Island which is used by fishermen from Bahía de Kino.

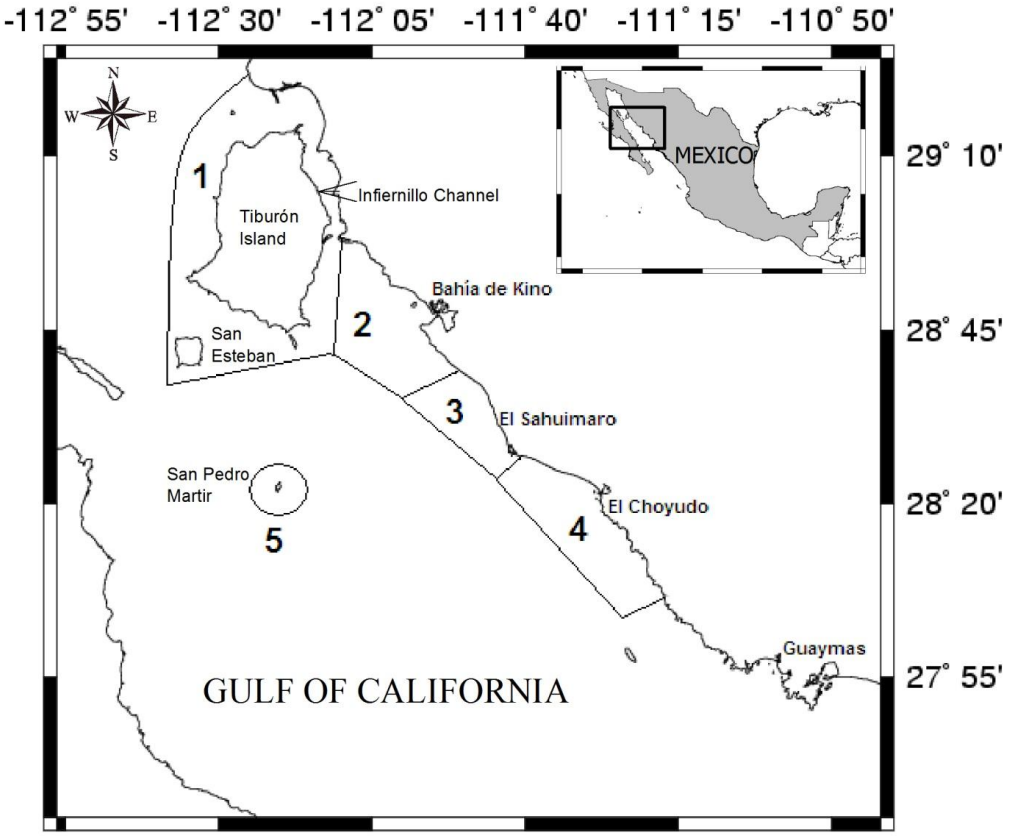

Figure 1. Study area showing de fishery camps sampled and the fishing areas into de Gulf of California

Catch per unit effort (CPUE), defined as number of individuals/vessel trip was determined for *Z. exasperata* from landings in each location.

Male and female size composition was tested for normality (Kolmogorov-Smirnov-Lilliefors test). Potential differences in mean size were then evaluated using parametric or non parametric statistics, as appropriate. Sex ratios were tested using a X^2 test with Yates correction for continuity (Zar 1996). The relationship between weight (W) and length (TL) was estimated for combined sexes and for males and females separately, adjusting the data to the following model:

$$W = a*TL^b$$

where *W* is the total weight (kg), *TL* is the total length (cm), and *a* and *b* are the fitting constants. In order to determine the type of growth shown by this species (isometric $b=3$ or alometric $b\neq3$), the t-Student test (one sample) was used (Zar 1996).

The relationships of DW, BL, DL to TL, were calculated using linear regression. Analysis of covariance (ANCOVA) was employed to determine potential differences between sexes in all relationships.

Results

Fishery description. *Zapteryx exasperata* is caught in a multispecific artisanal fishery in the northern Gulf of California using nylon bottomset gillnets (nylon diameter 0.4−0.55 mm) with mesh sizes between 9 to 33 cm (commonly 15−20 cm), and a length of 200 to 2400 m. Fiberglass boats regionally called "Panga", typically 6−9 m long,

with outboard engines of 115 HP, were used for the fishing operations. During winter, gillnets are typically soaked for 48 hours due to the low water temperature, but during summer a maximum period of 24 hours was employed. During winter months the main target species were flatfish, and *Z. exasperata* and other rays species were just secondary target species. However, during spring and summer months rays became the principal component of the catches (Fig. 2).

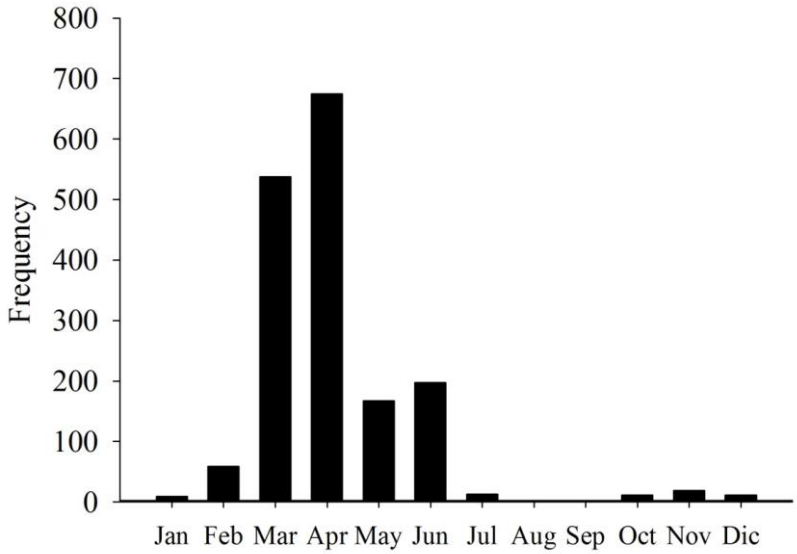

Figure 2. *Z. exasperata* catches distribution during 1998−1999 in the artisanal fishery from the Gulf of California.

The ray fishery in Sonora used 45 sites from Tiburon Island to Guaymas. The fishing depth usually ranged from 4 to 54 m. The fishermen that participate in this activity are local people. Some of them belong to fishery cooperatives, whereas others work by themselves only during the time that the shrimp fishery is closed. There are two kinds of fishing camps: permanent ones (Choyudo and Bahía de Kino) that comprise societies with well-organized infrastructure, and isolated camps with poor infrastructure, where fishermen move looking for better fishery areas. *Z. exasperata* is locally known with many names at each camp. Some of the common names include: *guitarrón*, *huesuda*, *bandolón*, and *chalaman*. This species is commercialized as fillets, and is sold under the name "payaso", and "cazón" mixed with other species of sharks and rays.

A total of 1688 individuals of *Z. exasperata* were caught in Sonora during the sampling period. Spring was the season where the catches were highest (65.52%.) and individuals were caught in waters between 9−22 m deep, whereas during winter and autumn, individuals where caught in deeper areas (54−92 m) and in lower amounts (5.13%). During August and September, no *Z. exasperata* were found in the catch.

Size composition and morphometric relationships. Banded guitarfish caught during the sampling period had a mean total length of 70.01 ± 9.91 cm (ranging from 41.3 to 93 cm) and a mean weight of 2.18 ± 1.13 kg (ranging from 0.3 to 6.97 kg). Size composition of the overall catch shows that the majority of the specimens ranged from 65 to 80 cm TL, with only females occupying size classes >85 cm (Fig. 3). Significant differences were found in the mean size and weight of females (73.46 ± 10.42 cm; ranging from 41.3 to 93 cm; mean weight 2.51 ± 1.13 kg) and males (66.06 ± 7.57 cm, ranging from 41.90 to 81.00; mean weight 1.49 ± 0.51 kg) [Kolmogorov-Smirnov; $p<0.001$]. The sex ratio was 1:1 (X^2 = 1.91, p = 0.16), and was constant throughout the sampling period.

The largest female was 82 cm TL and weighed 6.97 kg, whereas the largest male was 75 cm TL and weighed 4.33 kg. The model that provided the best fit for the W-TL relationship was, for females: $W_{(kg)} = 1\times10^{-6}TL^{3.4226}, r^2 = 0.97$; males $W_{(kg)} = 9\times10^{-6}TL^{2.8578}, r^2 = 0.95$ (Fig. 4), these relationships were significantly different between sexes (ANCOVA $p<0.01$). The slope (*b*) of the W-TL model differed from three for females and males (t-student, $p<0.01$).

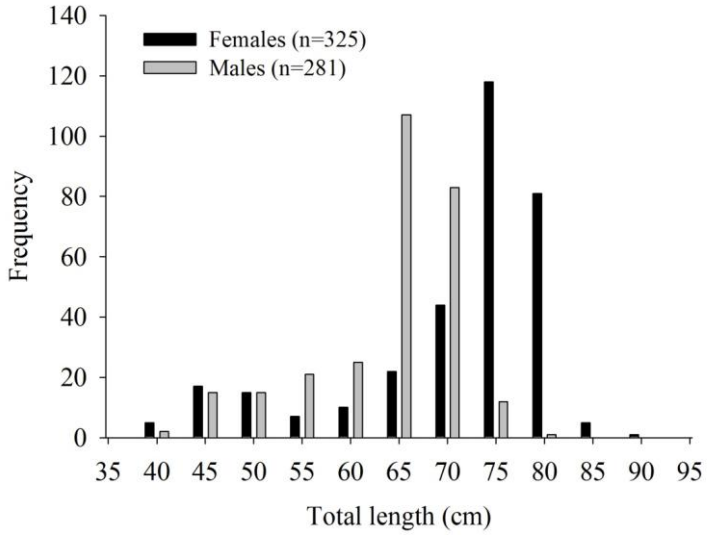

Figure 3. Size composition of *Z. exasperata* males and females sampled from the artisanal fishery landings in the Gulf of California

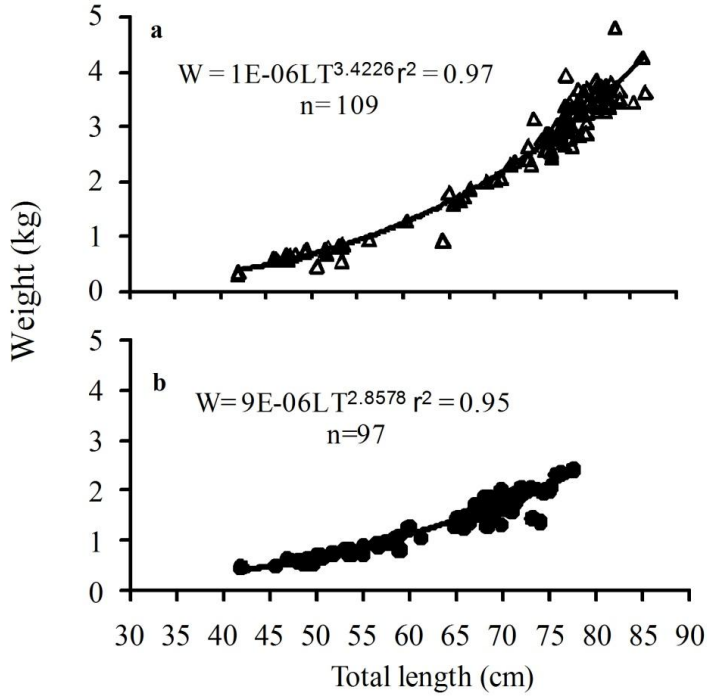

Figure 4. Weight-total length relationship for females (a) and males (b) of *Z. exasperata*

Sex-specific differences in all morphometric relationships were observed (ANCOVA, $p<0.01$) and were represented by the following linear equations:

Females

TL= 1.73BL+ 2.89 r^2= 0.95, (n=194);
TL= 2.41DL - 4.26, r^2 = 0.97 (n=164);
TL = 2.09DW - 3.04, r^2= 0.97, (n=199);

Males

TL= 1.87BL - 0.96, r^2= 0.97, (n=199);
TL = 2.67DL - 8.90, r^2 = 0.93, (n=170),
TL = 2.52AD - 12.02, r^2 = 0.9291, (n=199).

Catch per unit effort (CPUE). During the sampling period, 1688 individuals of *Z. exasperata* were registered in the catches. March and April were the months with the highest values (Table I). Spring was the season with the highest CPUE value (3.4), whereas winter showed the lowest value (1.0).

Table I. Individuals of *Z. exasperata* sampled in the catches of the artisanal fishery from the fishery camps sampled during 1998−1999.

	Choyudo	Kino	Sahuimaro	Tastiota	Lobos	Desemboque	TOTAL
January	1	8					9
February	38	21					59
March	167	226	116				538
April	455	206	8	6			675
May	91	76					167
June	168	29					197
July	11				2		13
October	2	2	1			6	11
November		19					19
TOTAL	933	587	125	6	2	6	1688

We did not register catches of *Z. exasperata* during August and September; however, in October the CPUE increased (1) until November (2.7) (Fig. 5).

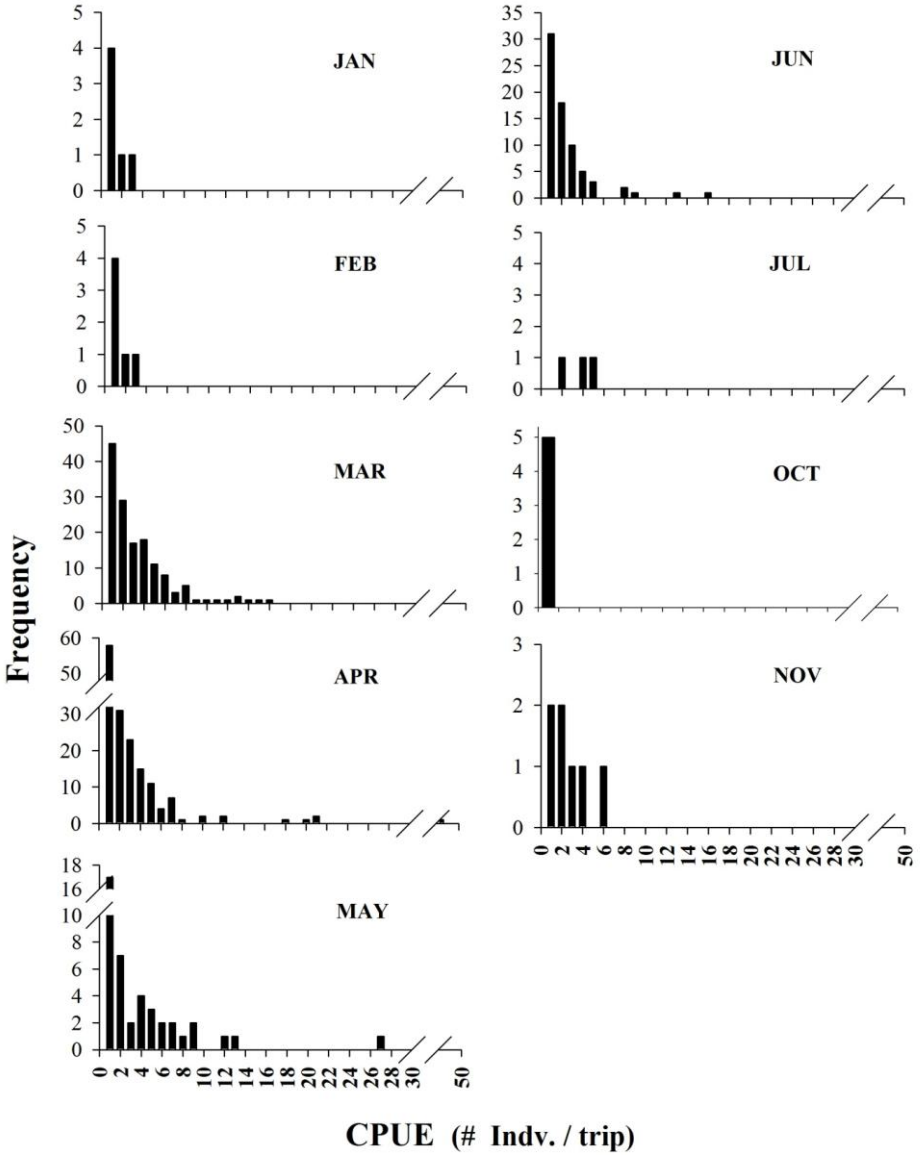

Figure 5. *Z. exasperata* CPUE per month in the Gulf of California.

The CPUE had similar values in all fishing zones, ranging from 2 (zone 5) to 3.5 (zone 3) (Fig. 6). El Sahuimaro was the fishing camp in which CPUE was highest (5.2), followed by El Choyudo (3.3). The mesh sizes with the highest CPUE values were 20, 21.5 and 33 cm, whereas the lowest value was for 9 cm mesh.

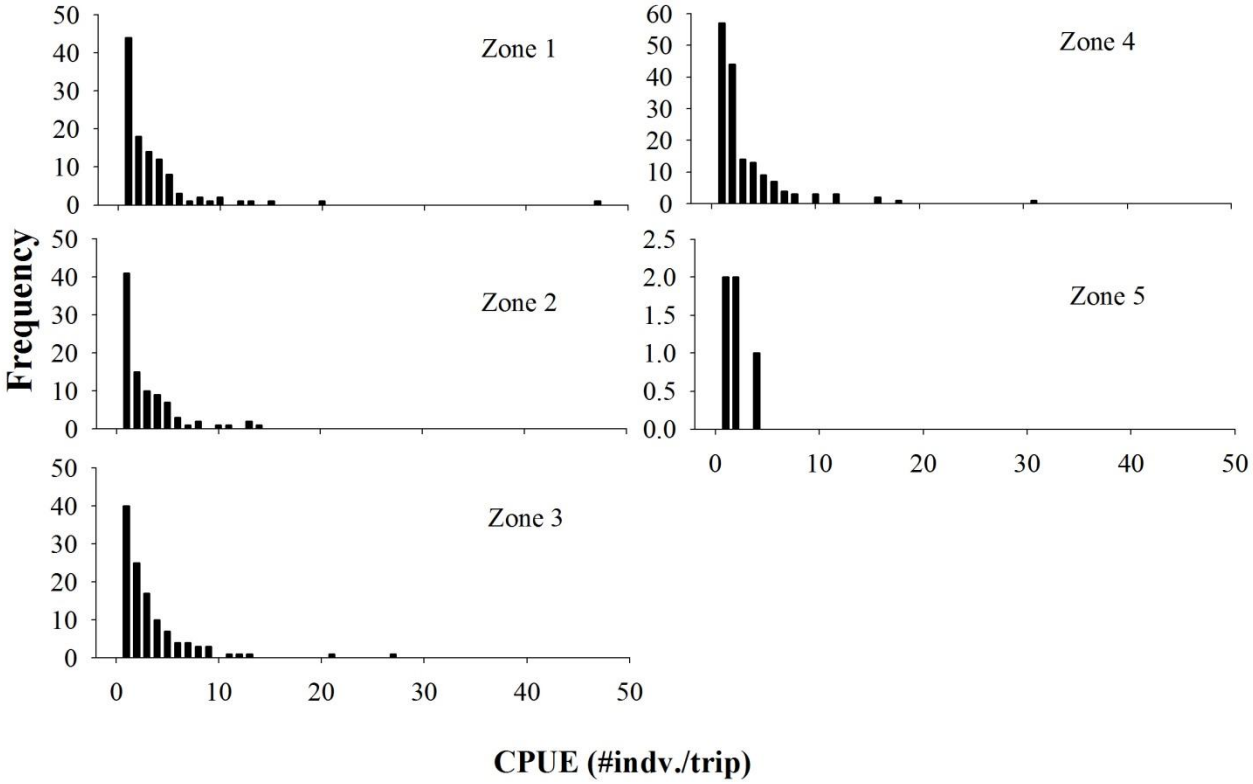

Figure 6. Z. exasperata CPUE per fishing zone in the Gulf of California.

Discussion

Most of the elasmobranch fishery in Mexico is a multiespecific artisanal activity (Castillo-Géniz 1992). In the Gulf of Mexico as well as in the Gulf of California this fishery depends on the seasonal abundance of elasmobranchs, as well as other resources such as teleosts and crustaceans (Castillo-Géniz *et al.* 1998, Márquez-Farías & Blanco-Parra 2006). In the Gulf of California the family Rhinobatidae is the most important component of the catches (Bizzarro *et al.* 2009). Our results confirm the importance of *Zapteryx exasperata* as target species in the artisanal elasmobranch fishery in the Gulf of California. The characteristics of the fishery remain similar to those described before in this region (Márquez-Farías 2002, Bizzarro *et al.* 2009). Villavicencio-Garayzar (1995) previously reported that *Z. exasperata* was caught only occasionally in the commercial fishery of rays in Bahía Almejas on the west coast of the Baja California Peninsula, in contrast to our results on the Sonora coast where this species was a common component in the catches. As in other regions of the Pacific coast of Mexico (Villavicencio-Garayzar 1995, Márquez-Farías & Blanco-Parra 2006), the *Z. exasperata* fishery in Sonora operates in coastal areas using small boats (pangas).

In the Gulf of California different gear types and set locations are used by the elasmobranch fishery (Bizzarro *et al.* 2009), and some ray species are caught with more than one gear type (Bizzarro *et al.* 2007). However, *Z. exasperata* was caught only with bottomset gillnets on the Sonora coast. These findings are consistent with previous reports on the west coast of the Baja California Peninsula, where this species was caught with bottomset gillnets (Villavicencio-Garayzar 1995).

Size-at-birth of *Z. exasperata* ranges between 15 and 22 cm TL, and the maximum reported size is 91 cm (Fisher *et al.* 1995). In the present study, landings of this species were composed of individuals in almost all its reported size range. Villavicencio-Garayzar (1995) report landings of individuals of *Z. exasperata* between 55.5 and 97 cm TL in the artisanal fishery from Bahía Almejas. Considering that in both areas

fishermen use similar fishing gear, the occurrence of smaller organisms in Sonora catches could be associated with nursery areas in this region.

Zapetryx exasperata is commonly segregated by sex, and males and females are only found together during mating seasons (Ebert 2003). On the western coast of Baja California Peninsula, landings were dominated by females (Villavicencio-Garayzar 1995). The presence of males and females in the same proportion in the landings of this study area provides evidence of the importance of the Sonora coast as a reproductive area for *Z. exasperata*. Recent studies confirmed the importance of the Sonora coast as a reproductive area for *Z. exasperata* (Blanco-Parra *et al.* in press) and other batoids such as the shovelnose guitarfish, *Rhinobatos productus* (Marquez-Farías 2007), and the golden cownose ray, *Rhinoptera steindachneri* (Bizzarro *et al.* 2007).

Sexual dimorphism in elasmobranchs can be seen in the teeth structures (Kajiura & Tricas 1996), head (Kajiura *et al.* 2005), or differences in length of both sexes (Bizzarro *et al.* 2007, Powter & Gladstone 2008). Female *Z. exasperata* were 11% bigger than males and all morphometric relationships were different by sex. Sexual dimorphism has been reported before for other rhinobatids, in which females were bigger than males (Capapé & Zaouali 1994, Villavicencio-Garayzar 1995, Ismen *et al.* 2007, Márquez-Farías 2007).

Differential growth by sex was observed for *Z. exasperata* based on the differences in the W-TL relationships found between sexes. In other rhinobatids, similar findings have been reported with females reaching larger weight and size than males (Ismen *et al.* 2007, Márquez-Farías 2007). Female *Z. exasperata* exhibit alometric growth with a value of b>3 (Wooton 1990), indicating a faster growth in weight than in size, probably as a result of the fast increase in weight during gestation period. Male *Z. exasperata* also had alometric growth, but with a value of b<3, indicating a faster increase in size. These differences have been reported in *Rhinobatos rhinobatos*, where males have isometric growth, and females had alometric growth (Ismen *et al.* 2007).

During spring and summer landings of the elasmobranch fisheries from the Gulf of California are dominated by ray species (Márquez-Farías & Blanco-Parra 2006, Bizzarro *et al.* 2007, Bizzarro *et al.* 2009). *Zapteryx exasperata* landings peaked during spring in the Sonora coast, whereas during late summer, autumn and winter, this species was rarely landed. Spring was also reported as the main season for *Z. exasperata* landings in Bahía Almejas (Villavicencio-Garayzar 1995). The low number of *Z. exasperata* individuals during summer could be associated with a migration of the species to deeper waters out of the fishing areas of the elasmobranch fishery. This behavior has been reported for other rays in the Gulf of California (Márquez-Farías & Blanco-Parra 2006).

The CPUE also showed seasonal changes, with high values during spring months (March, April and May). These results could be associated with the reproductive migration of males and females to shallower areas where they are vulnerable to bottom gillnets used in the artisanal fishery from Sonora. For *R. productus* from the Gulf of California, this kind of migration to and from shallow coastal areas during reproductive periods has been associated with changes in water temperature (Soto-Mardones *et al.* 1999, Márquez-Farías & Blanco-Parra 2006).

It has been reported that rocky reef is the most abundant habitat around Isla Tiburón and Infiernillo Channel, as well as the coast between El Sahuimaro and El Choyudo (Thomson *et al.* 2000). The CPUE values were very similar between zones; however in zones three (El Sahuimaro) and one (Isla tiburón and Infiernillo channel) they reached the highest values. These results could be explained by the preference of *Z. exasperata* for rocky reef habitats (Ebert 2003). Fishing sites with depths >100 m showed the highest CPUE values for *Z. exasperata.* These findings agree with previous reports for California, in which *Z. exasperata* was found commonly associated to areas with depths between 100 and 200 m (Allen *et al.* 2006).

A recent study on the reproductive biology of *Z. exasperata* from the Sonora coast has reported that the main reproductive season for this species takes place during spring and summer in the coastal areas (Blanco-Parra *et al.* in press). Therefore, our results showed that the reproductive portion of this population is directly affected by the artisanal elasmobranch fishery in the Gulf of California. Fishery regulations should thus be developed for the elasmobranch fishery from the Gulf of California in order to prevent the overexploitation of this and other ray species.

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References

Allen, L. G., Pondellla, D. J. & Horn, M. H. 2006. **Ecology of marine fishes: California and adjacent waters.** University of California, Berkeley, 660 p.

Bizzarro, J. J., Smith, W. D., Márquez-Farías, J. F. & Hueter, R. E. 2007. Artisanal fisheries and reproductive biology of the golden cownose ray, *Rhinoptera steindachneri* Everman and Jenkins, 1891, in the northern Mexican Pacific. **Fisheries Research,** 84: 137–146.

Bizzarro, J. J., Smith, W. D., Márquez-Farías, J. F., Tyminski, J. & Hueter, R. E. 2009. Temporal variation in the artisanal elasmobranch fishery of Sonora, México. **Fisheries Research,** 97: 103−117.

Blanco-Parra, M. P., Marquez-Farias, J. F. & Galván-Magaña, F. In press. Reproductive biology of the banded guitarfish, *Zapteryx exasperata*, from the Gulf of California, México. **Journal of the Marine Biological Association,** doi:10.1017/S0025315409990348.

Capapé, C. & Zaouali, J. 1994. Distribution and reproductive biology of the blackchin guitarfish, *Rhinobatos cemiculus* (Pisces, Rhinobatidae), in Tunisian waters (Central Mediterranean). **Australian journal of marine and freshwater research,** 45(4): 551–561.

Castillo-Géniz, J. L. 1992. **Diagnostico de la Pesquería de Tiburón de México.** INP Secretaría de Pesca. 76 p.

Castillo-Géniz, J. L., Márquez–Farías, J. F. Rodríguez De La Cruz, M. C., Cortés E. & Prado, A. C. D. 1998. The Mexican artisanal shark fishery in the Gulf of Mexico: towards a regulated fishery. **Marine and Freshwater Research,** 49: 611–620.

Compagno, L. J. V. 2005. Checklist of living chondrichthyes. Pp. 503-549. *In:* Hamlett, W. C. (Ed.) **Reproductive biology and phylogeny of chondrichthyes.** Science Publishers, Enfield, NH.

CONAPESCA. 2002. **Anuario estadístico de pesca 2002.** SAGARPA, México, D.F. 266 p.

Dulvy, N. K. & Reynolds, J. D. 2002. Predicting extinction vulnerability in skates. **Conservation Biology,** 16(2): 440–450.

Ebert, D. A. 2003. **Sharks, rays and chimaeras of California.** University of California, Los Angeles, 297 p.

Fisher, W., Krupp, F., Schneider, W., Sommer, C., Carpeter, K. & Niem, V. 1995. **Pacífico Centro-Oriental; Guía FAO para la identificación de especies para los fines de pesca.** FAO, Roma, pp. 648–685.

Ismen, A., Yigin, C. & Ismen, P. 2007. Age, growth, reproductive biology and feed of the common guitarfish (*Rhinobatos rhinobatos* Linnaeus, 1758) in Iskenderun Bay, the eastern Mediterranean Sea. **Fisheries Research,** 84(2): 263–269.

Kajiura, S. M., Forni, J. B., Summers, A. P., Tyminski, J. P. & Williams, A. T. 2005. Sexual dimorphism in elasmobranch fishes. **Integrative and Comparative Biology,** 45(6): 1023-1023.

Kajiura, S. M. & Tricas, T. C. 1996. Seasonal dynamics of dental sexual dimorphism in the Atlantic stingray *Dasyatis sabina*. **Journal of Experimental Biology,** 199(10): 2297-2306.

Márquez-Farías, J. F. 2002. The artisanal ray fishery in the Gulf of California: development, fisheries research and managment issues. **Shark News (IUCN Shark Specialist Group),** 14: 12–13.

Márquez-Farías, J. F. 2007. Reproductive biology of shovelnose guitarfish *Rhinobatos productus* from the eastern Gulf of California México. **Marine biology,** 151(4): 1445–1454.

Márquez-Farías, J. F. & Blanco-Parra, M. P. 2006. Rayas Pp. 303–319. *In:* Arreguin-Sánchez, F., Beléndez-Moreno, L., Méndez-Gómez-Humarán, I., Solana-Sansores, R. & Rangel-Dávalos, C. (Eds.). **Sustentabilidad y Pesca Responsable en México, Evaluación y Manejo.** Instituto Nacional de la Pesca, México.

Pérez-Mellado, J. & Findley, L. T. 1985. Evaluación de la ictiofauna acompañante del camarón capturado en las costas de Sonora y norte de

Sinaloa, México. Pp. 201–254. *In:* Yáñez-Arancibia, A. (Ed.) **Recursos pesqueros potenciales de México: la pesca acompañante del camarón.** Inst. Cienc. del Mar y Limnol., Inst. Nal. de Pesca., Mexico D.F.

Powter, D. M. & Gladstone, W. 2008. The reproductive biology and ecology of the Port Jackson shark *Heterodontus portusjacksoni* in the coastal waters of eastern Australia. **Journal of Fish Biology,** 72: 2615-2633.

Soto-Mardones, L., Marinone, S. G. & Parés-Sierra, A. 1999. Time and spatial variability of sea surface temperature in the Gulf of California. **Ciencias Marinas,** 25(1): 1–30.

Stevens, J. D., Bonfil, R., Dulvy, N. K. & Walker, P. A. 2000. The effects of fishing on sharks, rays, and chimaeras (chondrichthyans), and the implications for marine ecosystems. **ICES Journal of Marine Science,** 57: 476–494.

Thomson, D. A., Findley, L. T. & Kerstitch, A. N. 2000. **Reef fishes of the Sea of Cortez. The Rocky-Shore Fishes of the Gulf of California.** The University of Texas Press, Austin, 353 p.

Villavicencio-Garayzar, C. 1995. Biología reproductiva de la guitarra pinta, *Zapteryx exasperata* (Pisces: Rhinobatidae), en Bahía Almejas, Baja California Sur, México. **Ciencias Marinas,** 21(2): 141–153.

Wooton, R. 1990. **Ecology of teleost fishes.** Champman & Hall. New York.

Zar, J.H. 1996. **Biostatistical analysis.** Prentice Hall, Upper Saddle River, NJ. 944 p.

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