SHORTFIN MAKO SHARK (*ISURUS OXYRHINCUS*) IN THE CATCH FROM THE VENEZUELAN PELAGIC LONGLINE FLEET IN THE CARIBBEAN SEA AND ADJACENT WATERS: PERIOD 1994-2011

Freddy Arocha[1], José Silva[1] and Luis A. Marcano[2]

SUMMARY

*Short fin mako shark (*Isurus oxyrhincus*) length composition, spatial and temporal sex ratio from the Venezuelan pelagic longline fishery is presented for the period 1994-2011. A total of 161 short fin mako sharks were caught and reported by trained observers aboard longline vessels (Pelagic Longline Observer Program) since 1994. Short fin mako were caught in 74 sets representing 1% of the longline observed sets and 6% of the total identified shark catch in the observed pelagic longline fishery. Pooled seasonal size information indicated that mean size for males ranged from 158.5 to 187.5 cm FL and for females ranged from 163.9 to 189.5 cm FL. Most of the short fin mako sharks were caught in the Caribbean Sea (79%). Spatial and seasonal sex ratio is mapped in 1x1 degree square by trimester with respect to bathymetry of the region. Overall sex ratio was dominated by females (56%) in the Caribbean Sea and was even on the Atlantic side. Seasonal sexual segregation in the Caribbean Sea resulted in an increasing gradient from October-December through to July-September where the proportion of females increased progressively from a low of 0.30 to 0.70.*

RÉSUMÉ

*La composition des tailles et le ratio spatio-temporel des sexes du requin-taupe bleu (*Isurus oxyrhincus*) provenant de la pêcherie palangrière pélagique du Venezuela sont présentés pour la période comprise entre 1994 et 2011. Au total, 161 requins-taupes bleus ont été capturés et déclarés par des observateurs formés embarqués à bord de palangriers depuis 1994 (Programme d'observateurs à bord de palangriers pélagiques). Les requins-taupes bleus ont été capturés dans 74 opérations, ce qui représentait 1% des opérations palangrières observées et 6% de la prise totale de requins identifiés dans la pêcherie palangrière pélagique observée. Les informations de taille saisonnières regroupées indiquaient que la taille moyenne des mâles oscillaient entre 158,5 et 187,5 cm FL et que les femelles mesuraient en moyenne entre 163,9 et 189,5 cm FL. La plupart des requins-taupes bleus ont été capturés dans la mer des Caraïbes (79%). Le sex-ratio spatio-temporel est décrit dans des carrés de 1ºx1º par trimestre par rapport à la bathymétrie de la région. Le sex-ratio global a été dominé par les femelles (56%) dans la mer des Caraïbes et même dans l'Atlantique. La ségrégation sexuelle saisonnière dans la mer des Caraïbes a donné lieu à un gradient croissant d'octobre-décembre à juillet-septembre, période pendant laquelle la proportion de femelles a augmenté progressivement de 0,30 à 0,70.*

RESUMEN

*Se presenta la composición por tallas y la proporción de sexos espacial y temporal del marrajo dientuso (*Isurus Oxyrhincus*) en la pesquería de palangre pelágico de Venezuela para el periodo 1994-2011. Desde 1994 un total de 161 marrajos dientusos ha sido capturados y comunicados por observadores formados embarcados en palangreros (programa de observadores de palangre pelágico). Los marrajos dientusos se capturaron en 74 operaciones, lo que representa el 1% de los calados de palangre observados y el 6% de la captura total de tiburones identificados en la pesquería de palangre pelágico observada. La información estacional reunida sobre tallas indicaba que la talla media de los machos oscilaba entre 158,5 y 187,5 cm FL y la de las hembras entre 163,9 y 189,5 cm FL. La mayoría de los marrajos dientusos se capturó en el Caribe (79%). La ratio de sexos espacial y temporal se muestra en mapas de cuadrículas de 1ºx1º y por trimestre con respecto a la batimetría de la región. La proporción de sexos global estaba dominada por las hembras (56%) en el Caribe e incluso en el Atlántico. La segregación sexual estacional en el Caribe produjo un gradiente ascendente*

[1] Instituto Oceanográfico de Venezuela, Universidad de Oriente, Cumaná-6101 Venezuela.
[2] Ministerio de Agricultura y Tierras, INIA-Sucre, Apartado 236, Cumaná, Sucre 6101 Venezuela.

desde octubre-diciembre hasta julio-septiembre, momento en el que la proporción de hembras aumentaba progresivamente desde un nivel bajo de 0,30 hasta 0,70.

KEYWORDS

Shortfin mako shark, Isurus oxyrhincus, Caribbean Sea, size distribution, sex ratio, spatial distribution

1. Introduction

Shortfin mako (*Isurus oxyrhincus*) is a poorly known species in Venezuelan waters. It is caught as bycatch in the pelagic longline fishery (industrial and artisanal) and the artisanal drift-gillnet fishery that targets billfish off the Venezuelan central coast. Observations made on landing sites by personnel of ICCAT's Enhanced Program for Billfish Research (EPBR) in Venezuela and reports of Captains to the same personnel noted that the landed catch from the pelagic longline fishery consists of the finned trunks (gutted and headed), and fins; where the trunk is sold in the local market and the fins are to be commercialized in the international market. In the artisanal drift-gillnet fishery, the fish is landed whole, gutted and finned on site, and sold to the local market. Earlier reports of shorkfin mako in the landed catch from the observed industrial pelagic longline fishery indicated that shortfin mako represented a small proportion (~7%) of the overall shark bycath (Arocha *et al*., 2002; Tavares and Arocha, 2008). Most of the information on shortfin mako in the Atlantic comes from fishing activities in temperate and subtropical waters where the species appears to be more vulnerable to the fishery; while in tropical waters like those of the Caribbean Sea and adjacent Atlantic, the information is more limited. The Venezuelan Pelagic Longline Observer Program (VPLOP) sponsored by ICCAT-EPBR have become a good source to track information of bycatch species (including other sharks) in the Caribbean Sea and adjacent Atlantic which have contributed to produce basic information for assessments and ERA of several shark species (Cortés et al., 2010). The present document reports, on the results obtained on length composition by sex, spatial and temporal sex ratio, and relative abundance of shortfin mako sharks from the Venezuelan Pelagic Longline (VPL) fishery for the period 1994-2011.

2. Methods

The data used in this document came from the database of the Venezuelan Pelagic Longline Observer Program (VPLOP) for the period 1994-2011. The VPLOP surveys on average ~11% of the Venezuela longline fleet trips (1994-2011). The data collected comprises a total of 5,396 record-sets from 1994 through 2011; of these sets, shortfin mako (SMA) was reported caught in 162 sets (3.0%). The Venezuelan Pelagic Longline fleet fishing grounds extends from northwest of Puerto Rico (22°N-68°W) to off the coast of northeastern Brazil (4°N-44°W), including the eastern Caribbean Sea.

Observations of shark length (FL, measured with metric-tape) were extracted by year and length, and by quarters (all years combined) and length. Lengths were sorted into 5-cm bins for the construction of histograms; annual mean lengths, and size range were estimated. The sex ratio data was calculated as the number of females divided by the sum of male and female. Due to the unbalanced number of samples in all years, the annual changes of seasonal pattern seemed unlikely. Instead, sex ratio data were summed over all years and shown as quarterly sum based on the proportion of females partitioned into four quarters for all years combined. The spatial sex segregation of shrotfin mako was based on the proportional capture location of male and female blue sharks in 1° squares mapped by quarter with respect to the bathymetry of the region. Seasonal catch rates (nominal CPUE) were calculated as number of shortfin mako caught per 1000 hooks, aggregated by quarters and displayed geographically into 1° squares.

3. Results and Discussion

A total of 161 shortfin mako sharks (SMA) were recorded by the VPLOP database during the reported time series, of which 68 SMA were measured and sexed as males and 88 SMA were measured and recorded as females. The pooled size distribution of male and female SMA does not show a uniform size distribution (**Figure 1**). The size distribution seem to be formed by 3 to 4 size groups based on the several modes observed, a first group seem to be made of small shark between 100-165 cm FL, the next group is made up of sharks between 165 and 200 cm FL, another group includes sharks between 200 and 230 cm FL. Finally, there is a group formed of the largest individuals caught throughout the time series and made of several sharks between 240 and 260 cm FL. Most of the males caught consisted of immature and/or juvenile sharks (<179 cm FL), based

on the maturity envelope defined by minimum length of first maturity and maximum length of median maturity reported by Stevens (2008; total length conversions to fork length were made using relationship given in Kohler *et al*., 1995). Although, there was also an important size group (205-230 cm FL) of mature males caught. The majority of the females were considered to be immature sharks, with the exception of two female sharks that fell within the defined maturity envelope.

The number of sampled SMA varied annually, the highest number of sampled SMA per year occurred between 1995 and 1998, thereafter the numbers caught dropped to single digit samples (<10), with the exception of 2003 when 12 SMA were sampled (**Table 1**). Of the total SMA samples, only 5 did not have sex information, all had length measurements. Annual mean size showed that SMAs caught by the VPL fleet consists of immature sharks, with some mature sharks caught occasionally as revealed by the annual size range.

Mean size of female SMA do not show a clear trend across seasons, mean size is around 165 cm FL with the exception of April-June when increases up to ~189 cm FL (**Figure 2**). In contrast, the males display an increasing trend in mean size observed from the beginning of the year (Jan-Mar) through to summer (Jul-Sep), remaining the same at the end of the year (Oct-Dec). The defined maturity envelope for males helps to infer that mature SMA males display a seasonal increasing trend in the area, commencing in spring (Apr-Jun) and is complete in the second half of the year, when the majority (75%) of the SMA males are mature (**Figure 2**). In the case of the females, the majority were immature shark across all seasons, with a few mature SMA at the beginning and the end of the year.

Sex ratio (as the proportion of females) was dominated by female SMA (0.56) in the entire fishing area where the VPL fleet operates (**Table 2**). However, knowing the sexual segregation displayed by SMA across seasons and areas, it was observed that for the overall fishing area an increasing seasonal trend in the sex ratio was present from October-December (0.35) through to July-September (0.71), resulting in a strong dominance of females during the warmer months of the year. Conversely, the sex ratio varied between fishing area, females dominated in the Caribbean Sea, and males dominated in the Atlantic side (Guyana-Amazon area) (**Table 2**). In the Caribbean Sea, similar to the overall fishing area, a seasonal increasing trend in the sex ratio favoring female SMA was present from October-December (0.33) through to July-September (0.72). In the Atlantic side, the very low number of specimens precludes any meaningful inferences regarding the seasonal sexual segregation.

The seasonal capture location of proportional numbers of male and female SMA in 1°square bins with respect to the bathymetry reflects the sexual segregation of the species in the fishing area (**Figure 3**). Moving progressively in time and beginning in October-December, a strong dominance of males is observed across the area, particularly in the Caribbean Sea where most of the catch of SMA takes place. As the season progresses (Jan-Mar), males continue to dominate but mostly because of an increase in SMA from the Atlantic side, but in the Caribbean Sea the number of females increases towards in the west. In April-June most of the SMAs were caught off the Venezuelan coasts and females dominated the western side, while males completely dominated the eastern side. Finally, by July-September, females dominated throughout the Caribbean fishing area, with several areas of complete male dominance.

Important relative abundance (#SMA/1000 hks) of SMA seem to be in three areas; one east of the northern portion of Brazil/French Guyana; a smaller one off Guyana and Surinam; and the last in the Caribbean Sea, close the Venezuelan central coasts and in the west, south of the Netherland Antilles (**Figure 4**). Important concentrations of SMA were also observed across the oceanic island chain off the Venezuelan coast where the continental shelf is very narrow and where most of the VPL fleet operates.

From the present results it can be inferred that SMA is not commonly caught by the VPL fleet, in particular over the last few years. In general, it can be also inferred that most of the SMA caught by the VPL fleet consist mostly of immature females, and a mixture of mature and immature males, which in general, has a specific spatial and temporal sexual segregation in the Caribbean Sea. However, there is information that in the coastal and off-shore artisanal Venezuelan fleets SMA is landed, along with LMA, but the amount of the landed catch remains unknown. Efforts are being made to estimate the species-specific landings of sharks by the Venezuela Artisanal Off-shore fleet, and a preliminary report is presented in SCRS working document SCRS/2012/040.

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Table 1. Annual number of shortfin mako samples recorded by sex, and estimated size metrics recorded by the Venezuelan Pelagic Longline Observer Program during the period 1994-2011.

	Males	**Females**	**Unk**	**Total**	**Mean size cm (FL)**	**Size range cm (FL)**
1994	3	5	-	8	170.3	73-244
1995	19	27	2	48	169.5	108-250
1996	8	13	-	21	166.0	129-210
1997	5	12	-	17	164.1	120-225
1998	5	10	1	16	157.7	123-200
1999	-	2	-	2	135.5	130-141
2000	-	2	-	2	166.0	143-189
2001	3	1	-	4	157.8	138-174
2002	2	2	1	5	168.9	112-220
2003	4	8	-	12	189.7	123-227
2004	5	1	-	6	178.0	157-201
2005	-	-	-	-	-	-
2006	3	1	-	4	226.3	215-240
2007	5	1	-	6	188.5	127-256
2008	-	1	-	1	218.0	-
2009	1	1	-	2	154.5	151-158
2010	5	1	1	7	168.4	126-220
2011	-	-	-	-	-	-
Total	68	88	5	161		

Table 2. Sex ratio as proportion of females by area and season for shortfin mako recorded by the Venezuelan Pelagic Longline Observer Program during the period 1994-2011. Quarterly number of samples, mean and size range for each sex by area.

Area	Proportion of females	Season	Proportion of females	*n*	Females mean size (FL cm)	Females size range (FL cm)	Males mean size (FL cm)	Males size range (FL cm)
Total area	0.56	Jan-Mar	0.52	62	164.6	123 – 256	158.5	123 – 227
		Apr-Jun	0.63	24	189.5	142 – 226	177.1	146 – 210
		Jul-Sep	0.71	46	163.9	108 – 222	187.5	120 – 240
		Oct-Dec	0.35	29	168.7	112 – 250	182.5	73 – 250
Caribbean Sea	0.59	Jan-Mar	0.57	35	160.5	123 – 256	165.8	123 – 227
		Apr-Jun	0.62	21	193.4	142 – 226	176.8	146 – 210
		Jul-Sep	0.72	30	165.1	108 – 222	190.6	120 – 240
		Oct-Dec	0.33	24	175.8	121 – 250	182.4	73 – 244
Guyana-Amazon (Atlantic Ocean)	0.48	Jan-Mar	0.46	26	171.6	134 – 218	150.7	127 – 185
		Apr-Jun	0.66	3	164.0	158 – 170	180.0	180
		Jul-Sep	0.50	2	126.0	126	151.0	151
		Oct-Dec	0.50	2	112.0	112	183.0	183

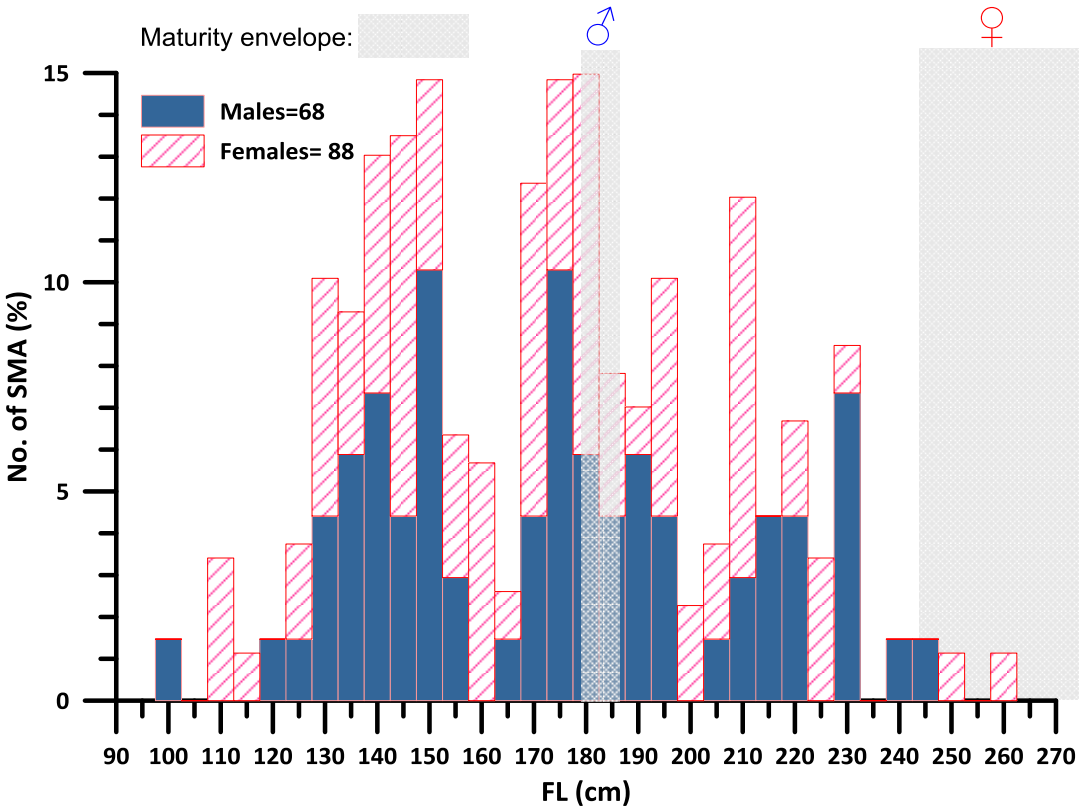

Figure 1. Overall size distribution of male and female shortfin mako in the Caribbean Sea and adjacent Atlantic during the period 1994-2011 as recorded by the Venezuelan Pelagic Longline Observer Program. Maturity envelope defined by minimum length of first maturity and maximum length of median maturity reported by Stevens (2008); total length conversions to fork length were made using relationship given in Kohler et al., 1995.

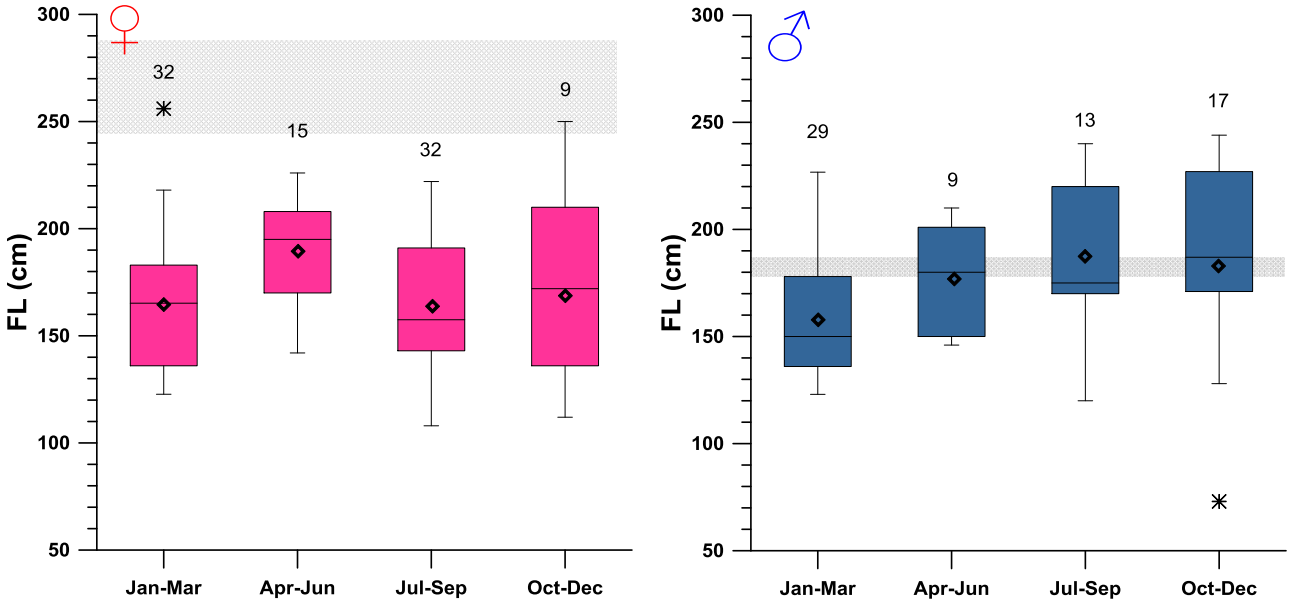

Figure 2. Seasonal size distribution of male (left) and female (right) shortfin makos in the Caribbean Sea and adjacent Atlantic, pooled over all years, for the period of 1994-2011. Maturity envelope (greyed band), defined by minimum length of first maturity and maximum length of median maturity reported by Stevens (2008); total length conversions to fork length were made using relationship given in Kohler et al., 1995.

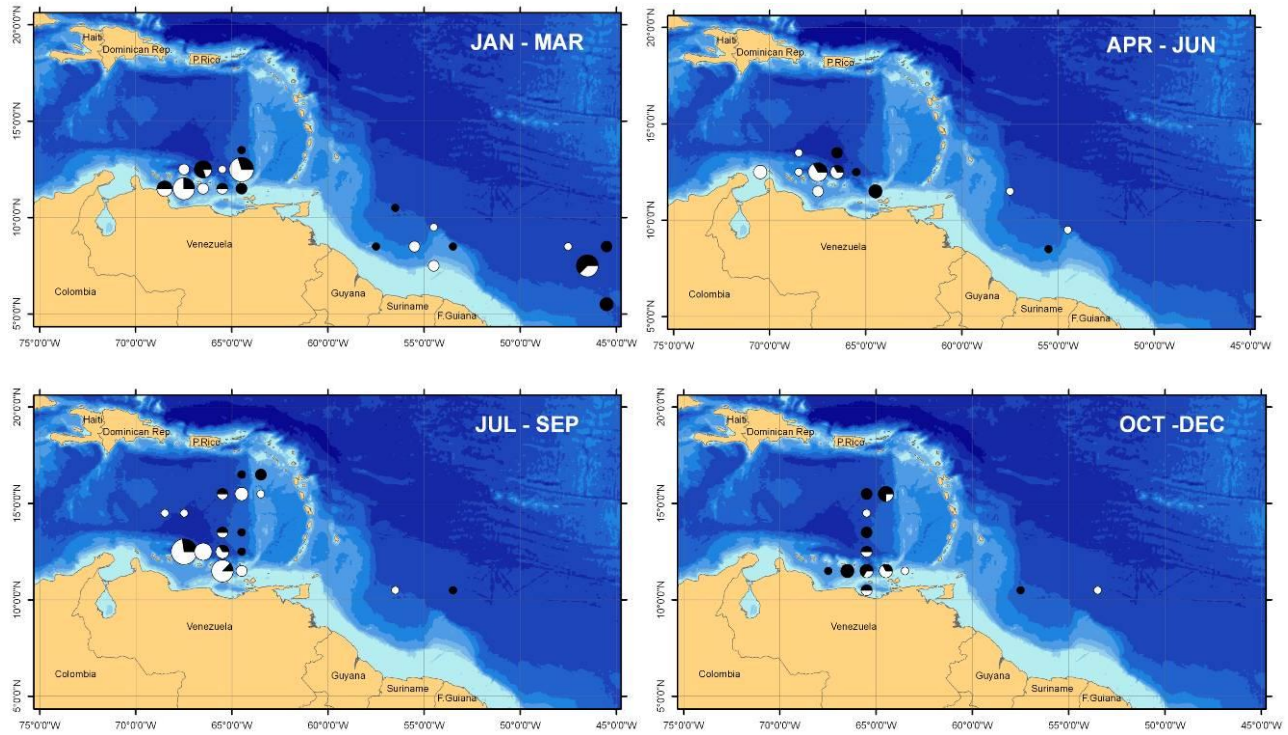

Figure 3. Seasonal capture location of proportional numbers of male (black, n=68) and female (white, n=88) shortfin mako sharks in 1°square bins with respect to the bathymetry of the fishing area. The size of the pie charts is proportional to the numbers of sharks caught.

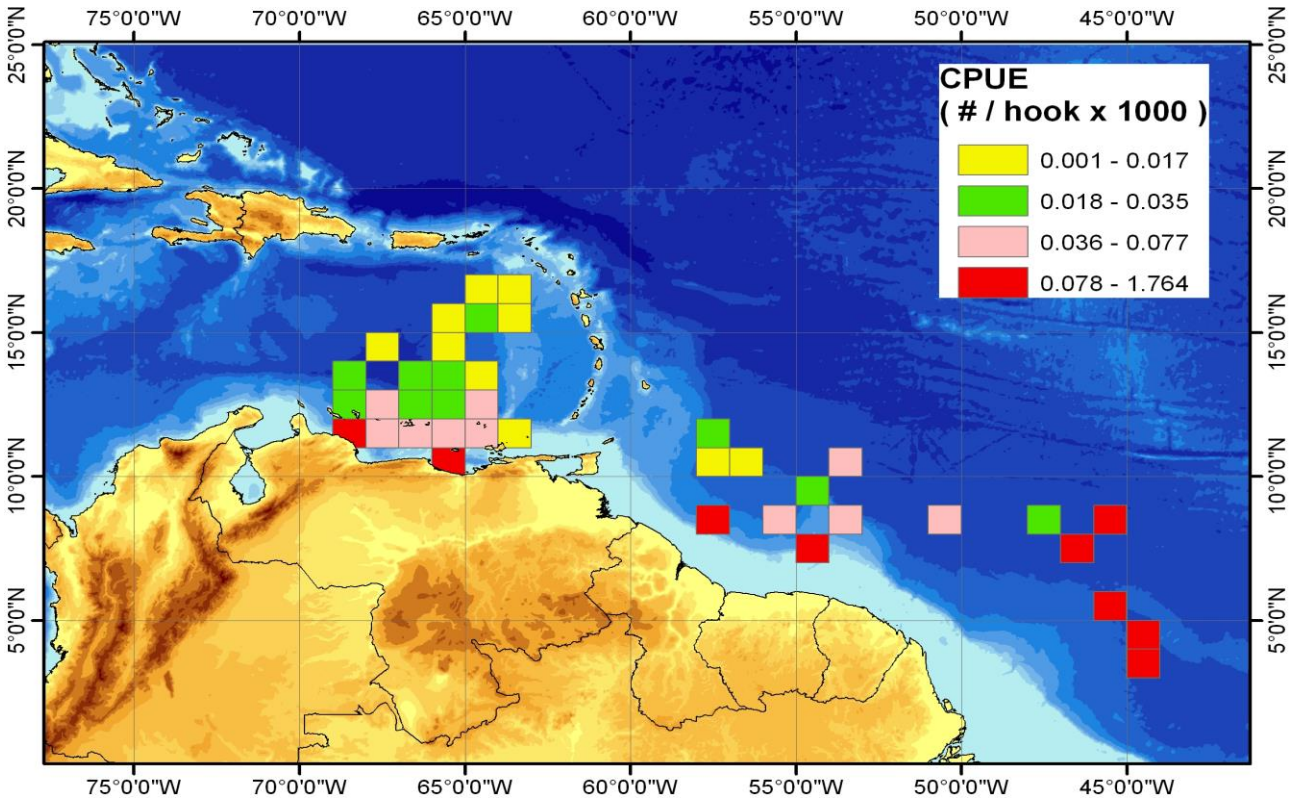

Figure 4. Relative abundance (#SMA/1000 hks) in 1°square bins during the period 1994-2011 as recorded by the Venezuelan Pelagic Longline Observer Program.