Collect. Vol. Sci. Pap. ICCAT, 72(4): 1020-1032 (2016)

UPDATE ON THE VENEZUELAN CATCH AND SPATIAL-TEMPORAL DISTRIBUTION OF BLUE SHARK (*PRIONACE GLAUCA*) IN THE CARIBBEAN SEA AND ADJACENT WATERS OF THE NORTH ATLANTIC OCEAN.

Arocha F.[1], Narvaez M.[2], Silva J.[1], Gutierrez X.[2], Laurent C.[2], Marcano L.[3]

SUMMARY

Venezuelan blue shark catch estimates commenced to be recorded separately and reported to ICCAT in 2004, previously was recorded under the shark category (SHX). In this document statistical data from various sources, official statistics, publications, grey literature, expert opinion, and several ICCAT monitoring projects for data improvement in Venezuela were used to reconstruct the specific blue shark catch for the period of 1986-2013 caught by the industrial longline fishery and the artisanal drift-gillnet fishery for the period 1991-2013. Information on sex ratio at size of blue shark from the Venezuelan pelagic longline fishery and the artisanal drift-gillnet fishery is presented for the period 1994-2013. The document analyzes the spatial and temporal distribution of 1424 sharks (744 females and 654 males, and 26 sex unknown) from both fisheries.

RÉSUMÉ

Les estimations des prises de requin peau bleue du Venezuela ont commencé à être enregistrées et déclarées séparément à l'ICCAT en 2004. Auparavant, elles étaient consignées dans la catégorie des requins (SHK). Dans le présent document, les données statistiques issues de plusieurs sources (statistiques officielles, publications, littérature grise, opinion d'expert et plusieurs projets de suivi de l'ICCAT destinés à l'amélioration des données au Venezuela) ont été utilisées pour reconstruire la capture spécifique du requin peau bleue réalisée par la pêcherie palangrière industrielle entre 1986 et 2013 et la pêcherie artisanale utilisant le filet maillant entre 1991 et 2013. Des informations sur le ratio des sexes par taille du requin peau bleue provenant des pêcheries palangrières pélagiques et des pêcheries artisanales de filet maillant du Venezuela sont présentées pour la période comprise entre 1994 et 2013. Le document analyse la distribution spatio-temporelle de 1.424 requins (744 femelles et 654 mâles, et 26 spécimens de sexe indéterminé) issus des deux pêcheries.

RESUMEN

Las estimaciones de capturas de tintorera de Venezuela empezaron a consignarse de forma separada y a comunicarse a ICCAT en 2004, antes se consignaban en la categoría tiburones (SHK). En este documento se utilizaron datos estadísticos de varias fuentes, como estadísticas oficiales, publicaciones, documentación gris (no publicada oficialmente), opinión de expertos y varios proyectos de seguimiento de ICCAT para mejorar los datos en Venezuela, para reconstruir la captura de tintorera para el periodo 1986-2013 realizada por la pesquería de palangre industrial; y la pesquería de red de enmalle a la deriva artesanal para el periodo 1991-2013. Se presenta información sobre la ratio de sexos por talla de tintorera de la pesquería de palangre pelágico y de la pesquería artesanal de redes de enmalle a la deriva de Venezuela para el periodo 1994-2013. El documento analiza la distribución espacial y temporal de 1.424 ejemplares de tintorera (744 hembras y 654 machos, y 26 ejemplares de sexo desconocido) de ambas pesquerías.

KEYWORDS

Blue shark, catch, spatial distribution, Venezuela, Caribbean Sea, longline fishing

1. Introduction

Blue sharks (*Prionace glauca*) have been an important component of the shark landings in Venezuela coming from the large pelagic fisheries operating in the Caribbean Sea and adjacent waters of the North Atlantic (Arocha *et al*., 2002). In this part of the southwestern North Atlantic, Venezuelan fisheries targeting tropical tunas (*Thunnus albacares, T. obsesus*) and swordfish (*Xiphias gladius*) have had an important retention of sharks in which blue sharks represent about 35% of the shark species caught by the pelagic longline fleet (Tavares and Arocha, 2008). Blue sharks are also caught and landed by Venezuelan artisanal fisheries targeting large pelagics, like the small drift-gillnet fishery operating from Playa Verde-La Guaira (Marcano *et al*., 2014) and the Venezuelan Artisanal Off-Shore pelagic longline fishery (Arocha *et al*., 2014), both targeting billfishes. 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 of blue sharks 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 sharks are landed whole, gutted and finned on site; while in the artisanal pelagic longline fishery, blue sharks are landed headed and gutted with fins attached, and sharks from both fisheries are sold to the local market.

Venezuela has reported shark catch data to ICCAT as sharks unclassified since the late 1990's, and blue shark specific catch data since 2004 most of which came from the pelagic longline fishery. Recognizing the need to have better estimates of the blue shark catch in the Atlantic, an effort was made to reconstruct the blue shark catch data from Venezuela since 1986, when the data collection programs for large pelagics were initiated (Marcano *et al*., 2004). The blue shark catch data was reconstructed from various sources, official statistics, publications, grey literature, expert opinion, ICCAT's Enhanced Program for Billfish Research (EPBR) in Venezuela for the period of 1991-2013, and the Venezuela National Observer Program (INSOPESCA) for the period of 2012-2013.

In a recent study of blue shark demographics in the southwestern North Atlantic, Tavares *et al*. (2012) provided information contributing to understand and characterize the stock structure of blue shark in the area from information consisting of spatial and temporal data on size composition, sex ratios, among other characteristics. The present document offers an update on the temporal composition of size and the spatial and temporal distribution of the sex ratio of blue sharks caught by the Venezuelan large pelagic fisheries.

2. Material and methods

2.1 Data sources

Presently, the national agency responsible for collecting fishery statistical data in Venezuela is the Instituto Socialista de la Pesca y Acuicultura (INSOPESCA), while the official fisheries research conducted by the Instituto Nacional de Investigaciones Agropecuarias (INIA) contributes to provide catch estimates of species or taxonomic group from on-site sampling programs to enhance and correct INSOPESCA's fishery statistics. Over the years, sharks species have been included in the national statistics as *cazón tintorera (Galeocerdo cuvieri)*, *cazón viuda (Mustelus spp.)*, *cazón tiburón*, *cazón varios*, and rays. Blue shark catches are likely reported as *cazón tiburon* and/or *cazón varios*. Under this classification it would be complicated if not impossible to separate the shark catch that would include blue shark from the national statistics. In the study of Marcano *et al*. (2004), the shark catch data from the pelagic longline fishery reported for the first time was utilized to reconstruct the Venezuelan blue shark catch. Additional unclassified shark catch data from the pelagic longline fishery used in the reconstruction came from the Venezuelan National Report to ICCAT during 1999 and 2000 and from TASK I data of sharks unclassified for the period 2001-2003. The shark catch from the artisanal drift-gillnet fishery targeting billfishes off Playa Verde-La Guaira was included in the reconstruction of the Venezuelan blue shark catch from data collected by ICCAT's-EPBR in Venezuela since 1991. The shark catch from the Venezuelan Artisanal Off-Shore pelagic longline fishery was not included because a recent study indicated that the blue shark catch from that fishery was of low volume (Arocha *et al*., 2014), and would not impact the total catch of blue shark from Venezuela.

2.2 Disaggregation of the blue shark catch

The aggregated shark catch data from the Venezuelan large pelagic catch statistics was disaggregated to extract blue shark using species specific proportion in weight by year (1986-2013) obtained from a couple of sources; 1, ICCAT's EPBR at-sea sampling of the Venezuelan pelagic longline fishery; 2, ICCAT's EPBR port sampling of the artisanal drift-gillnet fishery from Playa Verde-La Guaira. In addition, ICCAT Task I data for the period 2004-2013 was used to estimate proportion of blue shark for 2002-2003.

2.3 Collection of samples and sex ratio

All blue shark specimens captured were sexed and the fork length (FL) and/or total length (TL) were measured to the nearest cm, TL were converted to FL using Kohler *et al*. (1995) length conversion factors. Considering that all specimens in the present study came from tropical waters of the western North Atlantic, the separation of immature sharks from mature specimens were the median sizes-at-maturity defined according to the ICCAT-Sharks Working Group report (Anon., 2015), for male mature sharks: ≥ 197.0 cm FL, and for female mature specimens: ≥ 182.1 cm FL.

Chi-square analyses were used to test for seasonal differences in the proportion of males and females in the fishing areas. Due to the unbalanced nature of the size specific sex data during some years, samples were pooled into a common year, thus seasonality was analyzed as trimesters. Additional, Chi-square analyses were then used to test for seasonal differences in the proportion of immature and mature blue sharks in each fishing area and 95% confidence intervals about proportions were calculated (Brown *et al*., 2001).

3. Results and discussion

3.1 Blue shark catch estimates

The reported shark unclassified catch and the estimated blue shark (*Prionace glauca*) from the Venezuelan large pelagic fisheries are shown in **Table 1**. The analysis of all the available statistical data on shark catches resulted in substitutions, corrections, and estimations when values were unlikely plausible knowing the source originating the value and the fleet operating during the time the value was recorded. The shark catch from the pelagic longline fishery was obtained from the study of Marcano *et al*. (2004), which came from fishing logbooks of pelagic longline vessels for the period of 1986-2000. However, the data for 1999-2000 was substituted with the shark catch data reported to ICCAT in the National Report from Venezuela which provided a higher and more realistic estimate of the shark catch for that period of time. The rest of the shark catch data used was from the one reported as Task I data. The shark catch from the artisanal drift-gillnet fishery from Playa Verde-La Guaira was obtained directly from daily recordings during the port sampling operations of the EPBR personnel for the period of 1991-2013.

The EPBR sampling programs in Venezuela started in 1991, it included the port sampling program at Playa Verde-La Guaira of the artisanal drift-gillnet fishery there, and the at-sea sampling program in the pelagic longline fishery which resulted in the VPLOP for the period of 1991-2011. Shark catches were recorded regularly on a daily basis along with the specific billfish and tuna catch from the artisanal drift-gillnet fishery. However, specific shark data, including catch in weight, was recorded by the VPLOP starting in 1994. It included specific catch data of the most important shark species (blue shark among them). The estimated proportions of blue shark with respect to the total shark catch is shown in **Table 2** for pelagic longline fishery catch data, and in **Table 3** for the artisanal drift-gillnet fishery. Given that the VPLOP started to record shark specific catch data in 1994, the estimated annual proportions of blue shark for the earlier period used was the mean of the annual blue shark proportions for the period of 1994-1999 recorded by the VPLOP. Considering that shark catch reported as Task I data to ICCAT started in 2001 and the specific blue shark data in 2004, the proportion of blue shark for 2002-2003 used was the mean of the annual proportion of blue shark for the period of 2001 and 2004-2013 (**Table 2**). In the artisanal drift-gillnet fishery, the specific blue shark catch is only available for 2011-2013, therefore, the mean value of the proportions was used for the earlier period (**Table 3**).

The total estimated blue shark catch (t) of the pelagic longline and artisanal drift-gillnet fishery for the period of 1986-2013 is shown in **Table 1**. The total blue shark catch show an uneven increasing trend that peaked in 2011 (**Figure 1**), with a high catch of ~117 t. It appears that high catches of blue shark appear for a period of 4 consecutive times and then drop to low levels. It is not clear if this is a commercial strategy of the pelagic longline fishery or a seasonal variation in the availability of blue shark in the fishing grounds. These new blue shark catches from Venezuela represents the most accurate catch estimate for the time series analyzed.

3.2 Spatial and temporal distribution of blue sharks

The overall spatial distribution of the Venezuelan pelagic longline fishing effort (in total number of hooks) observed by the VPLOP during the period of 1991-2013, which has an observer coverage of ~10%, covers three distinct areas, most of the entire eastern Caribbean Sea, the Guyanas-Amazon area southeast of Trinidad, and the northern part of the Antilles Island chain (**Figure 2a**). Most of the historical effort is localized in the Caribbean Sea, and more or less similar in the other two areas. In contrast, the total relative abundance of blue sharks (numbers of sharks/ hooks×1000) observed by the VPLOP for the same period of time indicate that blue shark show higher concentrations in the Caribbean Sea off the coast of Venezuela, and in the Guyanas-Amazon area along the shelf drop and off the big river deltas (Orinoco, Esequibo, and others in the area), but is insignificant in the area off north the Antilles Island chain (**Figure 2b**). The highest numbers of blue sharks were caught during the second quarter of the year (April-June), while the lowest numbers of individuals were during the fourth trimester (**Figure 3**). In addition, a higher number of blue sharks were found in the Caribbean Sea during all seasons. Therefore, most of the demographics of blue shark from the Venezuelan fisheries come from the two areas where the highest relative abundance was encountered.

3.3 Size distribution

In the study area, the overall blue shark size distribution appears to show evidence of bimodal distribution (**Figure 4**). Mean size of the 1424 caught blue sharks was 193.3 ± 38.9 cm FL with a size range from 50-355 cm FL. For the 744 females, the mean size was 195.9 ± 35.7 cm FL and for the 654 males it was 190.8 ± 42.2 cm FL. There were significant differences in size among years for females (K-W=91.62, p<0.001) and males (K-W=191.3, p<0.001). Also there were differences within months for all years combined in both sexes (K-W= 58.9, p<0.01, for females; K-W=34.6, p<0.001, for males). There was no apparent pattern in the size and number of blue shark caught by year for either sex; nevertheless, year to year variation is quite clear (**Figure 5**). However, during most of the annual time series the median of female blue shark was above the size-at-maturity; while the median in males was below their size-at-maturity (**Figure 5 A, B**). In terms of seasonal trends considering all years combined (**Figure 5 C, D**), the median of female blue shark was also above the size-at-maturity throughout the aggregated months; while in males was below with the exception of few months for which no seasonal trend was apparent.

3.4 Sex ratio

Female proportion estimated from all blue sharks was 0.53 which differ significantly from the 1:1 expected ratio (χ^2=5.79, p<0.05). Differences were also found in the Caribbean Sea area (female proportion 0.53; χ^2=4.15, p<0.05) and but not for the Guyana-Amazon area (female proportion 0.53; χ^2=1.65, p=0.199) (**Table 4**). Nevertheless, in terms of seasons, the sex ratio always departed from the expected 1:1 ratio during all trimesters in the Caribbean Sea (Jan-Mar: χ^2=10.2, p<0.05; Apr-Jun: χ^2=22.3, p<0.05; Jul-Sep: χ^2=6.4, p<0.05; Oct-Dec: χ^2=3.9, p<0.05), and in two trimesters in the Guyana-Amazon area (Jan-Mar: χ^2=15.1, p<0.05; Jul-Sep: χ^2=42.4, p<0.05). The proportion of females was favored only during the second and third trimester in the Caribbean area and during the third quarter of the year in Guyana-Amazon area. Spatial and temporal distribution of females and males changed through seasons (**Figure 6**). In the first trimester males dominated in the Guyana-Amazon area, and in the Caribbean Sea. In the second trimester there appears to be a dominance of the proportion of females towards the west in the Caribbean and towards the open ocean in the Guyana-Amazon area, but during the third trimester females dominated both areas. However, during the fourth trimester the proportion of females decreased with respect to the previous trimester in both areas, but still appeared higher than males.

The variation was also evident in terms of female proportions when we contrast both areas considering maturity sizes (**Figure 7**), immature females proportion (<182.1 cm FL) was higher in the Guyana-Amazon area during the last two quarters of the year; while it remained below 0.5 throughout the year in the Caribbean Sea. The proportion of mature females was well above 0.5 during greater par of the year (Apr-Dec) in both areas, it was only during the first trimester that the males dominated the sex ratio in both areas.

The analysis by size group showed that sex ratio differ from the expected 1:1 proportion only for individuals above size of maturity in the Caribbean (χ^2=65.3, p<0.05) and Guyana-Amazon (χ^2=17.0, p<0.05) (**Table 5**), as well as for the proportion of females below the size-at-maturity (CAR: χ^2=36.4, p<0.05; GUY-AMZ: χ^2=9.9, p<0.05). Nonetheless, when seasonality was taken into account for mature blue sharks (≥182.1 cm FL for females, ≥197.0 cm FL for males) sex ratio was significantly different in the Caribbean during April-June (χ^2=66.1, p<0.05), July-September (χ^2=25.11, p<0.05); while for the Guyana-Amazon area these differences were found across all trimesters (Jan-Mar: χ^2=9.19, p<0.05; Apr-Jun: χ^2=9.29, p<0.05; Jul-Sep: χ^2=46.55,

$p<0.05$; Oct-Dec: $\chi^2=4.21$, $p<0.05$). In contrast, for immature sharks (<182.1 cm FL for females, <197.0 cm FL for males) there were no differences in the Caribbean only during the third trimester ($\chi^2=3.44$, $p=0.064$), but in the Guyana-Amazon area differences were found during the first second ($\chi^2=5.89$, $p<0.05$) and second trimester ($\chi^2=13.77$, $p<0.05$), favoring males only in both geographical areas.

The pattern of sex ratio at size (**Figure 8**), the female proportion varied in both areas for matures sharks as well as for juveniles. In the Caribbean, there were a higher proportion of juvenile females, but in the Guyana-Amazon area this proportion got lower as the size increased. In this sense, there seems to be a mayor proportion of mature males for the Caribbean Sea in contrast to the Guyana-Amazon area.

The most noticeable changes observed in the present document with respect to the earlier study on blue shark in the area (Tavares *et al*., 2012), are the inclusion of the artisanal drift-gill net catch that increased the numbers of blue sharks in the Caribbean Sea, in particular during the first half of the year off the central coast of Venezuela. Other noticeable results are that most of the females are mature and most of the males are immature throughout the overall area across all years and during all the aggregated months. The spatial seasonal segregation of the sex ratio indicate that during the first trimester males dominate throughout the area; females dominate the overall area during the third trimester which remains similar to the earlier study (Tavares *et al*., 2012), although is more evident now. The rest of the trimesters show no clear pattern, although it appears during the second trimester the proportion of females' increases in the Caribbean Sea. Regardless of these contrasting differences the size-frequency distribution continues to show evidence of a bimodal distribution, and the seasonal sex ratio of mature blue sharks continue to favor the females during the last part of the year in both geographical areas. Part of the explanation for all of these changes can include the increase of the time series, increase of the number of samples, but it also include the change in the fishing operations due to the changing economic conditions in the country.

References

Anon. 2015. Report of the Inter-Sessional meeting of the sharks species group. Piriapolis, Uruguay, March 10 to 14, 2014, Madrid, Spain. Col. Vol. Sci. Pap. ICCAT, 71(6): 2458-2550.

Arocha F., Arocha O., Marcano L.A. 2002. Observed shark bycatch from the Venezuelan tuna and swordfish fishery from 1994 through 2000. Col. Vol. Sci. Pap. ICCAT, 54:1123-1131.

Arocha F., Pazos, A., Larez, A., Marcano J., Gutierrez X. 2015. Enhanced monitoring of large pelagic fishes caught by the Venezuela artisanal off-shore fleet targeting tuna and tuna-like species in the Caribbean Sea and adjacent northwestern Atlantic waters: Final analysis. Col. Vol. Sci. Pap. ICCAT, 71(5): 2316-2333.

Brown L.D., Cai T.T., DasGupta A. 2001. Interval estimation for a binomial proportion. Stat. Sci. 16, 101-133.

Kohler N., Casey J., Turner P. 1995. Length-weight relationships for 13 species of sharks from the western North Atlantic. Fish. Bull. 93, 412-418.

Marcano J.S., Lárez A., Gutiérrez X., Alió J.J., Salazar H., Márquez M. 2004. Captura incidental de agujas y otras especies por palangreros venezolanos en el Mar Caribe y Océano Atlántico occidental: Periodo 1986–2000. Ciencias Marinas, 30(1B): 201–217.

Marcano L.A., Arocha F., Alío J., Marcano I., Gutiérrez X. 2015. Actividades desarrolladas en el Programa de Investigacion Intensiva sobre Marlines en Venezuela. Período 2012-2013. Col. Vol. Sci. Pap. ICCAT, 71(5): 2302-2315.

Tavares R., Arocha F. 2008. Species diversity, relative abundance and length structure of oceanic sharks caught by the Venezuelan longline fishery in the Caribbean Sea and western-central Atlantic. Zootecnia Tropical, 26 (4):489-503.

Tavares R., Ortiz M., Arocha F. 2012. Population structure, distribution, and relative abundance of the blue shark (*Prionace glauca*) in the Caribbean Sea and adjacent waters of the North Atlantic. Fish. Res. 129-130:137-152.

Table 1. Venezuelan pelagic longline and artisanal drift-gillnet total shark unclassified catch for the period of 1986-2010, specific blue shark (*Prionace glauca*) catch reported from the pelagic longline and artisanal drift-gillnet, and total blue shark (*P. glauca*) estimated catch for the Venezuelan pelagic longline and artisanal drift-gillnet fisheries.

	Pelagic longline fishery				*Artisanal drift-gillnet fishery*		
Year	*SHK Unclass. (t)*	*BSH (t)*	*Source*	*BSH Total catch (t)*	*SHK Unclass. (k)*	*BSH (t)*	*BSH Total catch (t)*
1986	28,2	-	Marcano *et al*. (2004)	**11**	-	-	-
1987	39,3	-		**15**	-	-	-
1988	21,7	-		**8**	-	-	-
1989	22,9	-		**9**	-	-	-
1990	24,3	-		**9**	-	-	-
1991	16,9	-		**6**	9,7	-	**0,8**
1992	61,3	-		**23**	11,3	-	**0,9**
1993	60,2	-		**23**	2,3	-	**0,2**
1994	56,5	-		**17**	10,9	-	**0,8**
1995	46,3	-		**15**	9,1	-	**0,7**
1996	40,7	-		**4**	16,1	-	**1,3**
1997	65,3	-		**26**	16,1	-	**1,2**
1998	10,0	-	Ven National Report LL	**6**	21,3	-	**1,7**
1999	83	-		**47**	11,1	-	**0,9**
2000	106,3	-		**42**	19,2	-	**1,5**
2001	96,7	-		**46**	10,6	-	**0,8**
2002	37,3	-		**28**	13,2	-	**1,0**
2003	51	-		**38**	16,0	-	**1,2**
2004	-	8,5	ICCAT Task I LL	**9**	18,1	-	**1,4**
2005	-	26,1		**26**	20,8	-	**1,6**
2006	-	9,8		**10**	22,7	-	**1,8**
2007	-	17,5		**18**	22,3	-	**1,7**
2008	-	6,7		**7**	18,2	-	**1,4**
2009	-	71,4		**71**	17,7	-	**1,4**
2010	-	73,9		**74**	13,8	-	**1,1**
2011	-	116,4		**116**	-	0,68	**0,7**
2012	-	95,7		**96**	-	2,68	**2,7**
2013	-	50,6		**51**	-	0,96	**1,0**

Table 2. Proportion of blue shark (*Proinace glauca*) in the shark unclassified catch in weight of the Venezuelan pelagic longline recorded by ICCAT's EPBR Venezuelan Pelagic Longline Observer Program (VPLOP) and from ICCAT Task I data.
Note: † Represents mean value of the period 1994-1999. †† Represents mean value of the period 2001, 2004-2013.

Year	***prop.BSH_LL***	***Source***
1986-1993	0,376 †	VPLOP (mean)
1994	0,309	VPLOP
1995	0,321	VPLOP
1996	0,105	VPLOP
1997	0,399	VPLOP
1998	0,561	VPLOP
1999	0,561	VPLOP
2000	0,394	VPLOP
2001	0,479	VPLOP
2002-2003	0,750 ††	ICCAT/VPLOP (mean)
2004	0,766	ICCAT
2005	0,998	ICCAT
2006	0,605	ICCAT
2007	0,458	ICCAT
2008	0,711	ICCAT
2009	0,659	ICCAT
2010	0,681	ICCAT
2011	1,000	ICCAT
2012	1,000	ICCAT
2013	0,907	ICCAT

Table 3. Proportion of blue shark (*Prionace glauca*) in the shark unclassified catch in weight of the Venezuelan pelagic longline recorded by ICCAT's EPBR port sampling at Playa Verde-La Guaira.
Note: † Represents mean value of the period 2011-2013.

Year	*prop.BSH_SSFGN*	*Source*
1991-2010	0,077 †	EPBR-Vzla (mean)
2011	0,033	
2012	0,100	EPBR-Vzla
2013	0,099	

Table 4. Sex ratio expressed as proportion of female blue shark, *Prionace glauca*, and size metrics by fishing areas and seasons in the Caribbean Sea and adjacent waters of the Atlantic during 1994–2013.

Area	*Proportion of females*	*Season*	*Proportion of females*	*n*	*Females mean size (FL cm)*	*Males mean size (FL cm)*
Caribbean Sea	0,53	January-March	0.38	190	182.8 ± 40.6	190.6 ± 46.9
		April-June	0.62	380	193.5 ± 29	191.1 ± 40.1
		July-September	0.58	239	197.5 ± 40.2	183.1 ± 42.3
		October-December	0.42	148	216.1 ± 50.8	184.5 ± 52.7
Guyana-Amazon (Atlantic Ocean)	0,53	January-March	0.35	166	187.3 ± 37.8	205.4 ± 33.9
		April-June	0.48	119	195.1 ± 29.6	186.6 ± 31.5
		July-September	0.80	110	200.8 ± 26.4	187.5 ± 36.2
		October-December	0.61	46	198.6 ± 22.3	193.7 ± 32.6

Table 5. Sex ratio expressed as proportion of female blue shark, *Prionace glauca*, and size metrics by fishing area and separated into immature (<197 cm FL for males and <182.1 cm Fl for females) and mature (≥197 cm FL for males and ≥182.1 cm FL for females) size group collected in the Caribbean Sea and adjacent waters of the Atlantic during 1994–2013.

Area	Proportion of females non-mature BSH	n	Females mean size (FL cm)	Males mean size (FL cm)	Proportion of females mature BSH	n	Females mean size (FL cm)	Males mean size (FL cm)
Caribbean Sea	0.35	422	151.8 ± 22.4	157.7 ± 20.6	0.68	535	214.0 ± 26.5	235.3 ± 29.5
Guyana-Amazon	0.38	169	158.9 ± 23.3	170.4 ± 23.3	0.63	272	209.8 ± 18.5	224.6 ± 18.6

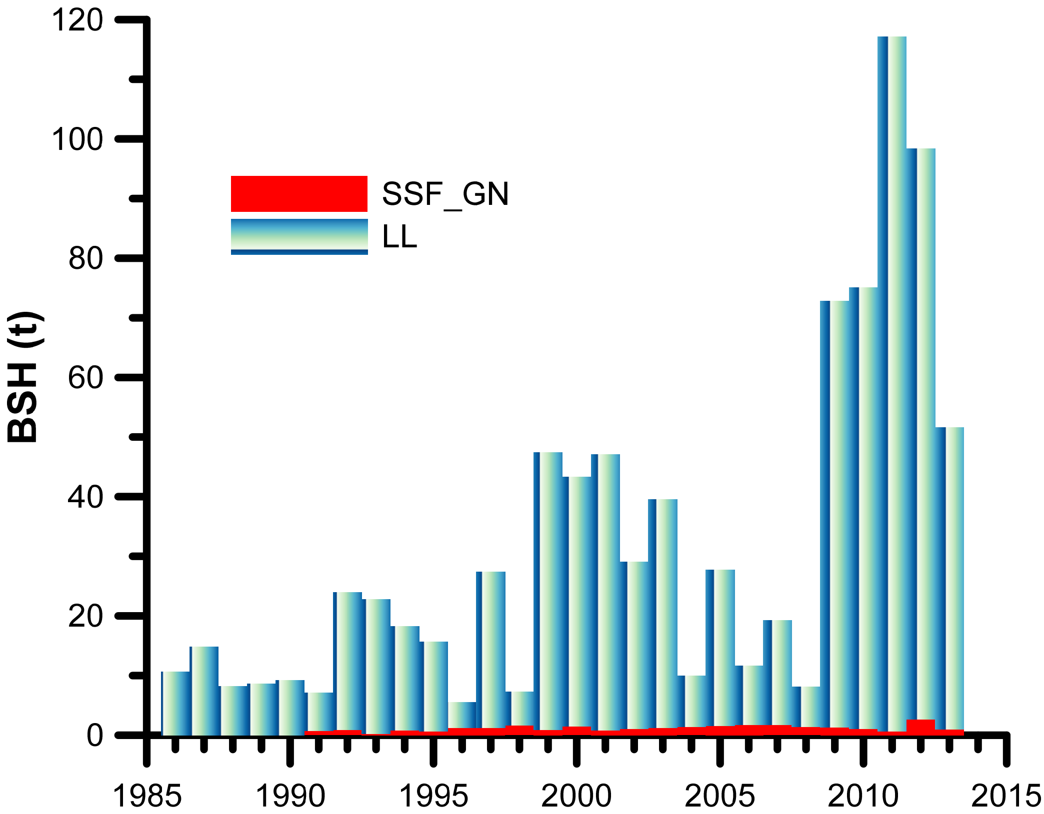

Figure 1. Estimated blue shark (*Prionace glauca*) catch from Venezuelan large pelagic fisheries.

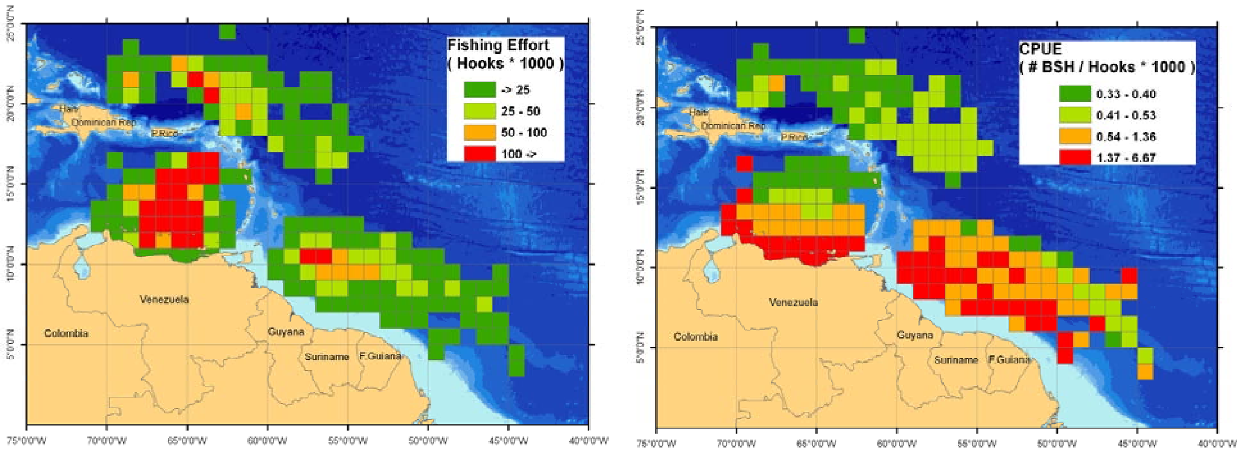

Figure 2. Total observed fishing effort (nos. of hooks) of the Venezuelan pelagic longline fleet (left), and nominal catch rates of blue sharks (*Prionace glauca*) from the observed sets of the Venezuelan pelagic longline fleet during 1994-2013.

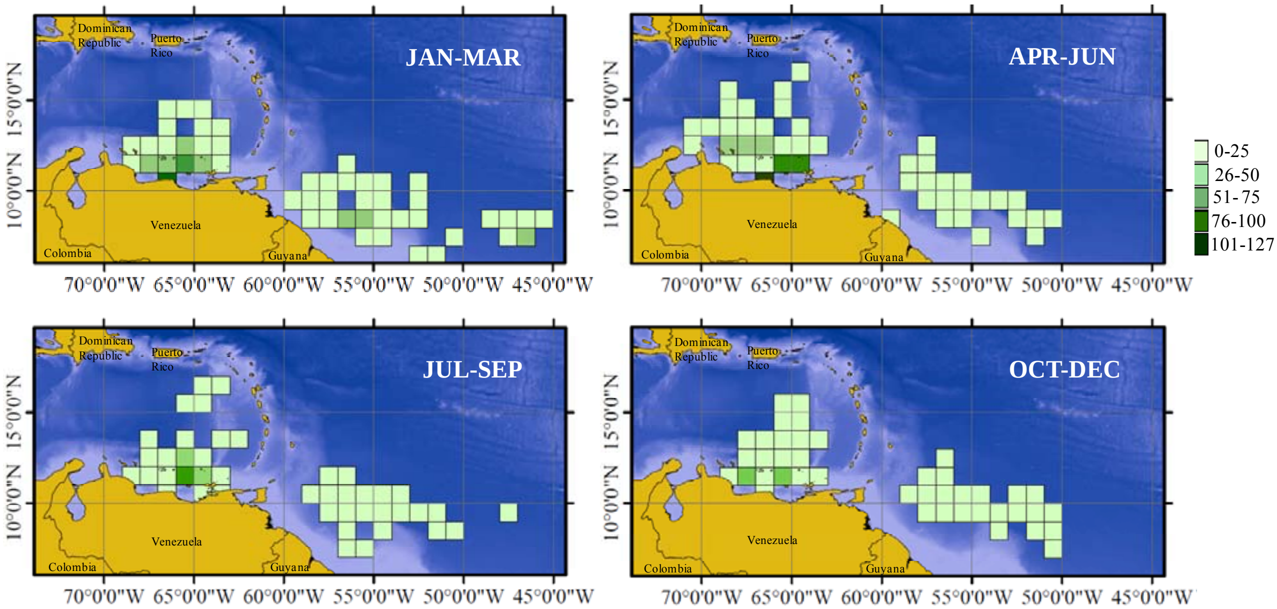

Figure 3. Seasonal spatial distribution of blue sharks (*Prionace glauca*) caught by the Venezuelan large pelagic fisheries during 1994-2013, from observed sets.

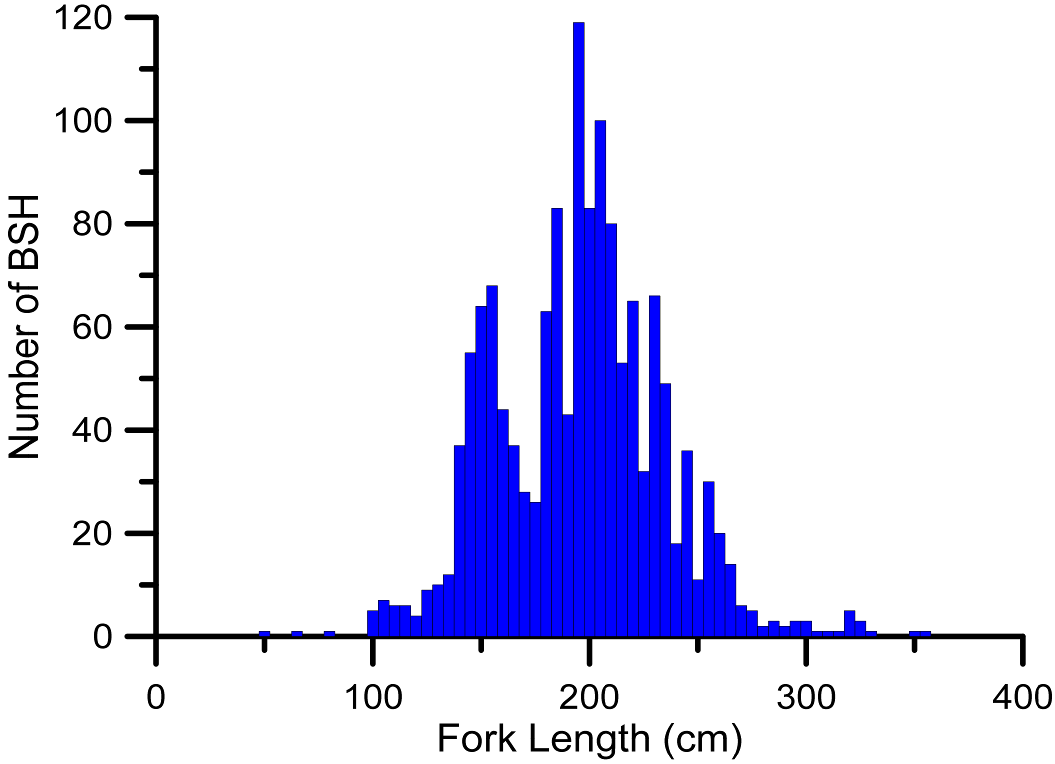

Figure 4. Size frequency distribution of blue shark, *Prionace glauca*, caught by the observed Venezuelan large pelagic fisheries in the Caribbean Sea and adjacent Atlantic waters during 1994-2013.

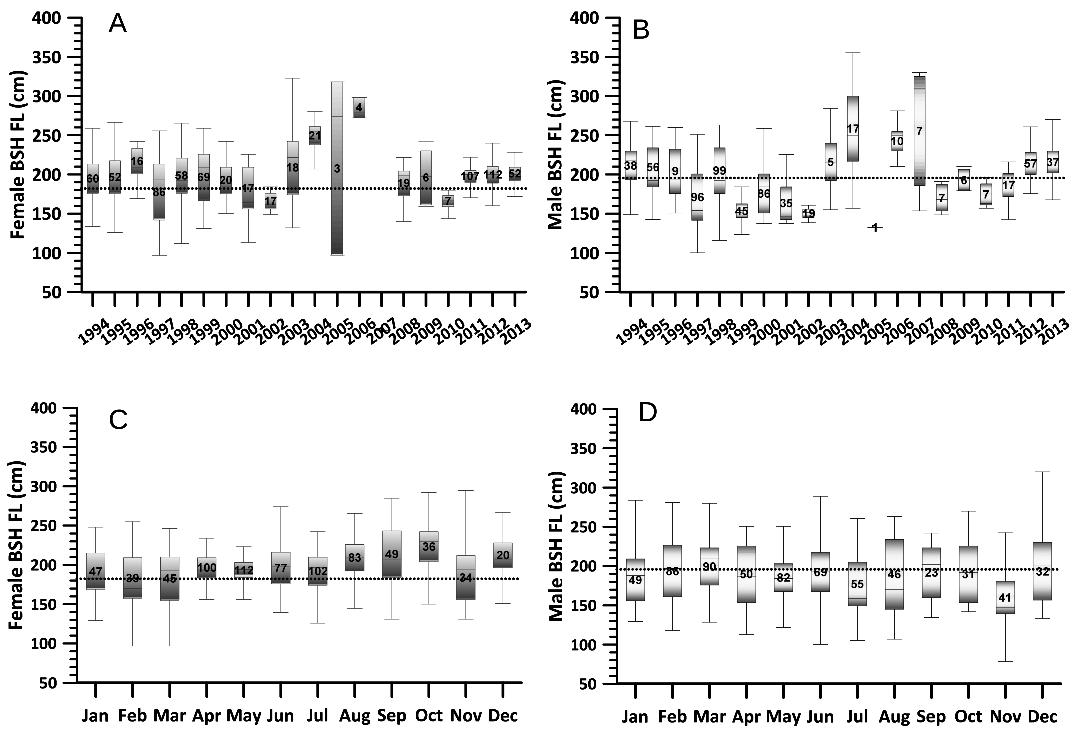

Figure 5. Annual and monthly time series for all years combined of female (A,C) and male (B,D) blue shark, *Prionace glauca*, fork length (FL) expressed as a median with the interquartile range (25% qt–75% qt) from individuals caught during the period of study. The dotted lines separate mature adult stages in males (197.0 cm FL) and in females (182.1 cm FL).

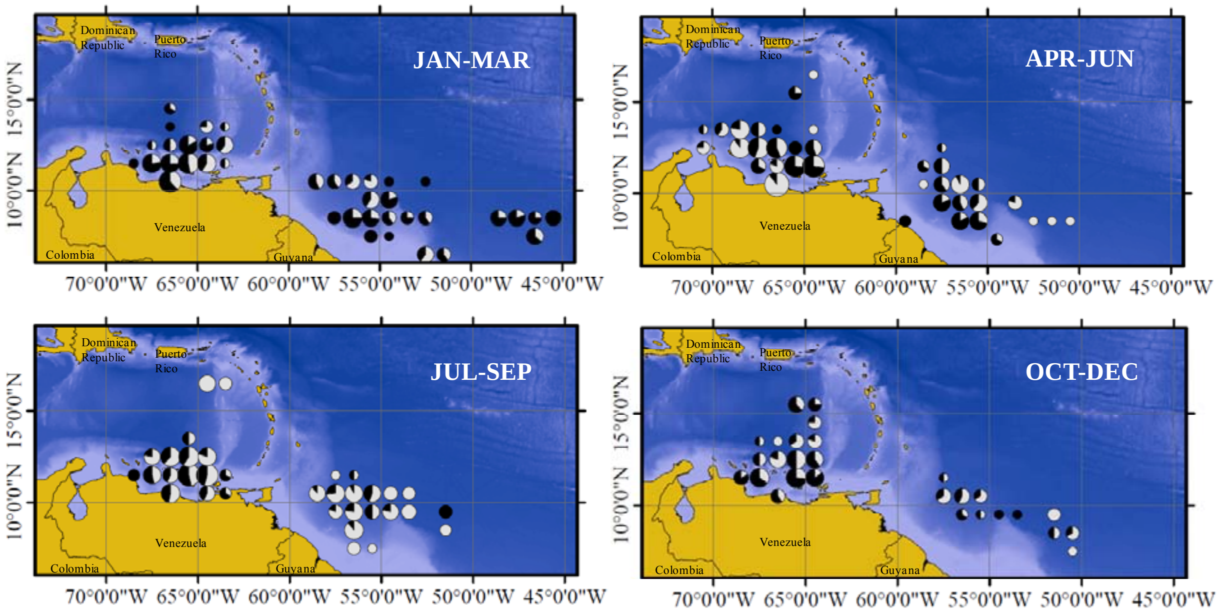

Figure 6. Capture location of proportional numbers of male (black) and female (white) blue sharks in 1◦ ×1◦ by trimester with respect to the bathymetry of the study area. The size of the pie charts is proportional to the numbers of blue sharks caught.

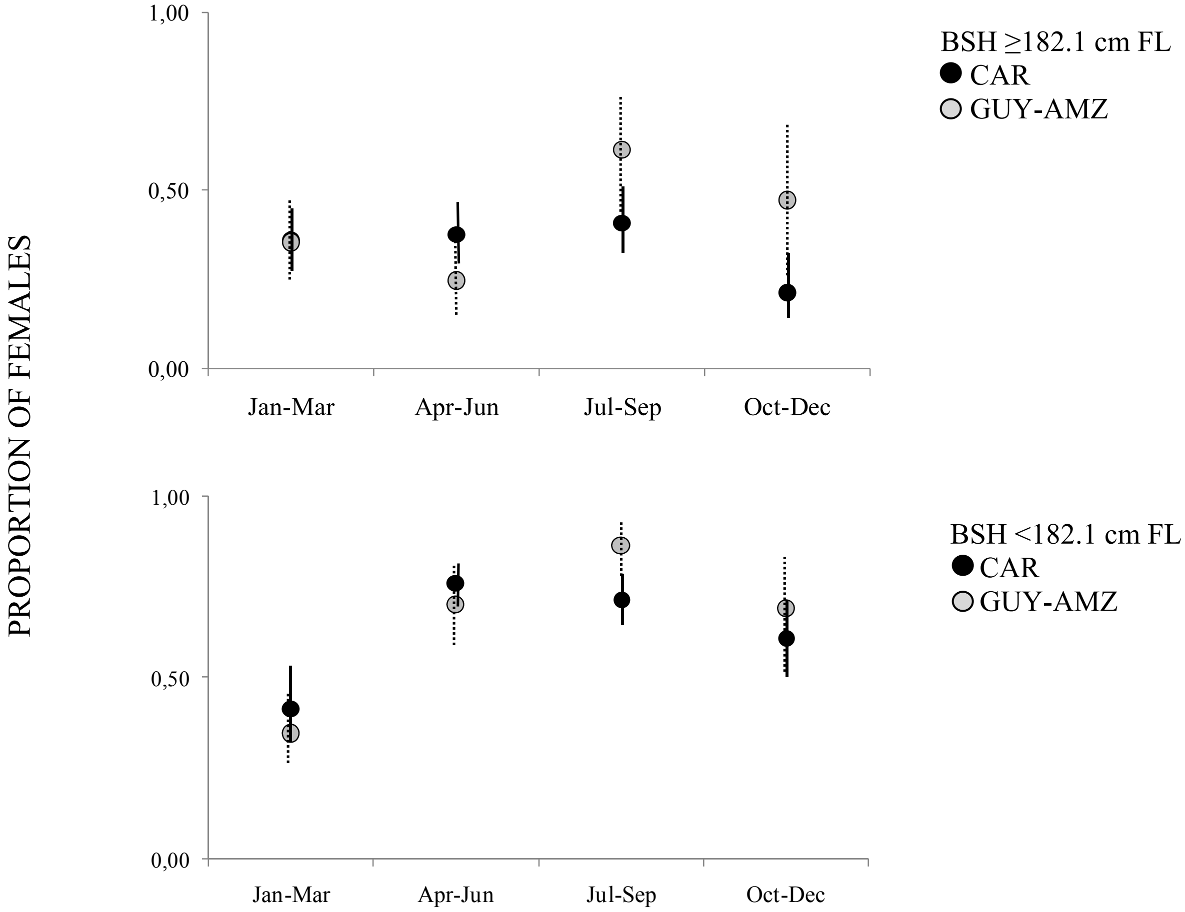

Figure 7. Seasonal sex ratio of blue shark, *Prionace glauca*, by size group (immature: <182.1 cm FL; mature: ≥182.1 cm FL) in the area of the Caribbean Sea (CAR) and the Guyana-Amazon area (GUY-AMZ). The vertical lines in each mean estimate represent 95% confidence intervals about proportions.

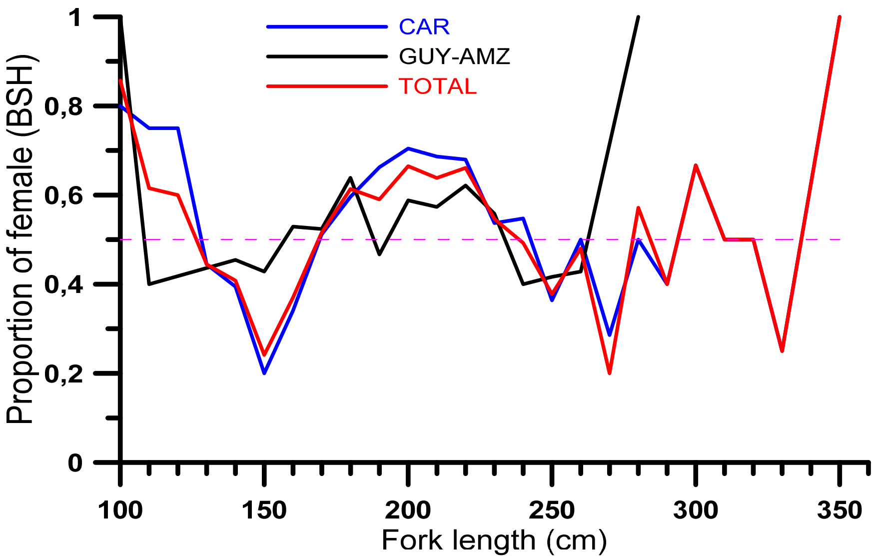

Figure 8. Sex ratio by fork length (FL) class as percentage of female blue shark in the Caribbean and adjacent areas for the whole study area (Total), the Caribbean area (CAR), and the Guyana-Amazon area (GUY-AMZ).