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SPATIAL AND TEMPORAL DISTRIBUTION PATTERNS OF SAILFISH (*ISTIOPHORUS ALBICANS*) IN THE CARIBBEAN SEA AND ADJACENT WATERS OF THE WESTERN CENTRAL ATLANTIC, FROM OBSERVER DATA OF THE VENEZUELAN FISHERIES

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SUMMARY

*Sailfish (*Istiophorus albicans*) is the most common of the istiophorids caught by the Venezuelan large pelagic fisheries over the past 25 years. The document analyzes the spatial and temporal distribution of sailfish caught by three different Venezuelan fisheries, namely, the industrial/tuna pelagic longline (1987-2013), the artisanal drift-gillnet (1991-2013), and the artisanal off-shore pelagic longline (2011-2014). A total of 102,402 sailfish records collected between 1987 and 2014 were analyzed. Sizes recorded ranged between 80 and 291 cm LJFL. The size data was separated into three distinct areas, Billfish hot-spot (10°45'N-67°00'W), Caribbean, Guyana-Amazon. In the Billfish hot-spot area size of females were higher than males, in the other areas mean size of males and females were relatively similar. The annual trend in sizes showed a decreasing trend in the last years of the series for males in the Billfish hot-spot and in the Caribbean areas. The monthly variability in the mean size of males and females was evident in all areas. Sex ratio varied between areas and months. The distribution patterns of sailfish in the fishing area presented in the document provide a better understanding of the species in the Caribbean Sea and adjacent areas of the western central Atlantic.*

RÉSUMÉ

*Le voilier (*Istiophorus albicans*) est l'espèce d'istiophoridés la plus fréquemment capturée par les pêcheries vénézuéliennes ciblant les grands pélagiques au cours des 25 dernières années. Le présent document analyse la distribution spatio-temporelle des voiliers capturés par trois différentes pêcheries vénézuéliennes, à savoir la pêcherie industrielle à la palangre pélagique ciblant les thonidés (1987-2013), la pêcherie artisanale de filet maillant (1991-2013) et la pêcherie artisanale côtière opérant à la palangre pélagique (2011-2014). Un total de 102.402 registres de voiliers recueillis entre 1987 et 2014 a été analysé. Les tailles enregistrées oscillaient entre 80 et 291 cm LJFL. Les données de taille ont été divisées en trois zones distinctes, le « point chaud » des istiophoridés (10°45'N-67°00'W), les Caraïbes et Guyana-Amazonie. Dans la zone de « point chaud » des istiophoridés, les femelles étaient plus grandes que les mâles alors que dans les autres zones la taille moyenne des mâles et des femelles était relativement similaire. La tendance annuelle des tailles présentait une tendance à la baisse au cours des dernières années de la série pour les mâles dans la zone de « point chaud » des istiophoridés et dans les Caraïbes. La variabilité mensuelle de la taille moyenne des mâles et des femelles était évidente dans toutes les zones. Le ratio des sexes variait d'une zone à l'autre et d'un mois à l'autre. Les modèles de distribution du voilier dans la zone de pêche présentée dans le document permettent de mieux comprendre l'espèce dans la mer des Caraïbes et les zones adjacentes de l'Atlantique centre-ouest.*

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RESUMEN

*El pez vela (*Istiophorus albicans*) es la especie más común de istiofórido capturada por las pesquerías venezolanas de grandes pelágicos en los últimos 25 años. El documento analiza la distribución espacial y temporal del pez vela capturado por tres pesquerías venezolanas diferentes, a saber, la pesquería industrial de palangre pelágico de túnidos (1987-2013), la pesquería artesanal con redes de enmalle a la deriva (1991-2013) y la pesquería costera artesanal de palangre pelágico (2011-2014). Se analizaron un total 102.402 registros de pez vela recogidos entre 1987 y 2014. Las tallas consignadas oscilaron entre 80 y 291 cm LJFL. Los datos de talla se desglosaron en tres zonas diferenciadas, la "zona álgida" de istiofóridos (10°45'N-67°00'W), la zona del Caribe y la zona de Guyana-Amazonas. En la "zona álgida" de istiofóridos las hembras fueron más grandes que los machos, en las otras zonas las tallas medias de machos y hembras fueron relativamente similares. La tendencia anual en las tallas mostró una tendencia decreciente en los últimos años de la serie para los machos en la "zona álgida" de istiofóridos y en la zona del Caribe. En todas las zonas se evidenció una variabilidad mensual en la talla media de machos y hembras. La proporción de sexos presentaba variaciones en función de las zonas y meses. Los patrones de distribución de pez vela en la zona de pesca presentada en el documento proporcionan una mejor comprensión de la especie en el mar Caribe y áreas adyacentes del Atlántico central-occidental.*

KEYWORDS

Sailfish, Spatial distribution, Size composition,
Sex ratios, Billfish hot-spot, Caribbean Sea, Venezuela

Introduction

Sailfish (*Istiophorus albicans*) have been an important component of the billfish landings in Venezuela coming from the large pelagic fisheries operating in the Caribbean Sea and adjacent waters of the North Atlantic (Arocha *et al*., 2015a). 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 billfishes in which sailfish represent about 29 % of the billfish species caught by the industrial/tuna pelagic longline fleet (Arocha et al., 2013). Sailfish are also an important part of the landings from the Venezuelan artisanal fisheries targeting large pelagic fishes, particularly billfishes, like the small drift-gillnet fishery operating from Playa Verde-La Guaira (Marcano *et al*., 2015) and the Venezuelan Artisanal Off-Shore (VAOS) pelagic longline fishery (Arocha *et al*., 2015b). 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 sailfish from the pelagic longline fishery consists of trunks (gutted and headed); where the trunk is entirely sold in the local market. In the artisanal drift-gillnet fishery, sailfish are landed whole then gutted and headed on site; while in the artisanal off-shore pelagic longline fishery, sailfish are landed headed and gutted. Sailfish from both artisanal fisheries are sold to the local market.

In recent time, stock assessments that attempt to reconstruct population biomass for marine species are based on age-structured models. However, such methods are difficult to be utilized in species that are problematic to age, such as tunas and billfish, all of which form the basis for very valuable fisheries. However, the size-composition of catches and its spatial and temporal patterns have been increasingly used in integrated statistical stock assessment models. In the last ICCAT billfish stock assessments (ICCAT, 2012, 2013), integrated statistical stock assessment models taking advantage of the fleet-area specific catch-at-size distributions were used to assess blue and white marlin populations in the Atlantic. Venezuela's sailfish landed catch is the third largest for the western Atlantic stock since 2000 and has the longest catch-rate time series. The EPBR has been collecting size related data in Venezuela since the early start of the ICCAT Billfish Program in 1987 from most of the Venezuela fisheries targeting large pelagic fishes; however, most of it comes from a fishery that fishes in one of the most recognized hot-spots for billfish in the Atlantic (La Guaira Bank) (Arocha *et al*., 2010). The main objective of the document is to contribute to the upcoming sailfish stock assessment by analyzing detailed catch-at-size information from the Venezuelan fleets that catch sailfish as by-catch and as target operating in the southwestern North Atlantic.

Materials and Methods

Data sources

Sailfish size-composition information was obtained from three monitored fisheries over different time periods: the Venezuelan industrial/tuna pelagic longline fishery that targets primarily tropical tunas, based out of Cumaná and Puerto La Cruz in northeastern Venezuela (1987-2013), the artisanal drift gillnet fishery based at Playa Verde (east of La Guaira, Billfish hot-spot) in the central coast of Venezuela which targets billfish (1991-2013), and the Venezuelan artisanal off-shore (VAOS) pelagic longline fishery based in Morro de Pto. Santo and JuanGriego in eastern Venezuela that targets primarily dolphinfish and billfishes (2011-2014).

The size data was collected from two different types of gear and different areas. For the analysis, the size data collected from the same gear (pelagic longline) were separated in two areas, the Caribbean Sea (CAR) and the Guyana-Amazon (GUY) area which represented the area of the Atlantic east of 61°W. The size data collected from drift-gillnet fishery came from the Billfish hot-spot, La Guaira Bank (PLYVRD) and was analyzed as a separate area.

Size by sex data was recorded by scientific observers and by trained captains (VAOS fishery) while aboard pelagic longline fishing vessels operating in the southwestern North Atlantic between 5°N and 25°N (west of 40°W), and by trained port samplers at the community of Playa Verde from artisanal drift-gillnet catches around the Billfish hot-spot of La Guaira Bank (10°45'N-67°00'W). The size measurement recorded was the lower-jaw-fork-length (LJFL) in cm, but in some cases when fish were dressed the recorded measurement was pectoral-fork-length (PFL) which was later converted to LJFL using ICCAT Manual's conversion equations. Sex determination was based on macroscopic characteristics of the reproductive organs; although the accuracy of sex identification for the smaller size fish (<130 cm LJFL) may be biased due to the subtle differences between sexual organs.

Data analysis

Size data were tested for normality with Kolmogorov-Smirnov normality test with the Lillifors correction (KSL test), and Welch's ANOVA was used to compare size distribution data when variances are heterogeneous. Sex ratios were calculated and compared with contingency tables and Likelihood ratio χ^2 tests. Sex ratios were also compared between months taking into account the three areas using Cochran-Mantel-Haenszel (CMH) χ^2 test. This test allows detecting seasonality of size-related effect in the sex ratios of each of the three areas analyzed. All statistical test were carried out using JMP v.11 (2014).

Results and Discussion

Spatial and temporal distribution of sailfish

The overall spatial distribution of the Venezuelan industrial/tuna pelagic longline fishing effort (in total number of hooks) observed by the Venezuelan observer programs (EPBR-VPLOP 1987-2011, and INSOPESCA-PNOB 2012-2013), which has an observer coverage of ~11%, 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 1a**). Most of the historical effort is localized in the Caribbean Sea, and more or less similar in the other areas. In contrast, the total relative abundance of sailfish (numbers of fish/hooks×1000) observed by the Venezuelan observer programs for the same period of time indicate that sailfish show the highest catch rates in the Guyana-Amazon area, off the big river deltas (Orinoco, Esequibo, and others in the area), and comparatively lower catch rates in the Caribbean area. But the highest catch rates in the Caribbean area were concentrated around Venezuela's off-shore islands and east of Grenada but are insignificant in the area off-north of the Antilles Island chain (**Figure 1b**). The VAOS pelagic longline fishery overlaps in fishing operations with the larger industrial/tuna pelagic longline fleet in the Caribbean Sea and the Guyana-Amazon areas (**Figure 1c**). It concentrates most of its effort in the Caribbean in the same areas as the industrial/tuna fleet, but in the Guyana-Amazon area it operates closer to shore than the industrial/tuna fleet. Similar to the industrial/tuna fleet, the catch rates of sailfish is highest in the same areas (**Figure 1d**) but in larger numbers due to the billfish target nature of the VAOS fleet (Arocha *et al*., 2015b).

The sailfish size data was spatially distributed into four size categories, immature fish (<150 cm LJFL), young mature fish (151-160 cm LJFL), mature fish (161-180 cm LJFL), large older fish (>180 cm LJFL) (**Figure 2**). Sailfish of all size categories were distributed throughout the fishing areas, no clear segregation pattern between size categories was observed. The highest densities observed were of young mature (151-160 cm LJFL) and mature (161-180 cm LJFL) sailfish in the southern Caribbean and SE of Trinidad, but only the young mature sailfish were closer to the coast in the GUY area.

Size distribution

A total of 102,402 sailfish were sampled and measured during the collection time period of the present document, but several fishes < 80 cm LJFL were excluded due to incomplete measurements because of shark bites, leaving a total of 102,399 sailfish records between 80 and 291 cm LJFL to be analyzed. The largest numbers of recorded sailfish were obtained from the port sampling in Playa Verde which were fished in the Billfish hot-spot area (10°42'N-67°00'W) representing a total of 92,581 sailfish, of which 45,085 were males (100-258 cm LJFL), 17,131 females (109-291 cm LJFL), and 30,367 were of unknown sex (101-278 cm LJFL). In the Guyana-Amazon area, a total of 5,913 sailfish size data were recorded of which 3,021 were males (80-194 cm LJFL), 2,218 females (85-257 cm LJFL), and 674 of unknown sex (97-193 cm LJFL). In the Caribbean area, the number of sampled sailfish recorded from the pelagic longline fishery were 3,905 specimens of which 1,854 were males (100-224 cm LJFL), 1,825 females (108-199 cm LJFL), and 226 of unknown sex (100-192 cm LJFL).

Size data was not normally distributed (KSL test, $D = 0.498$, $p < 0.0100$), and Welch's ANOVA test revealed that sailfish size data were significantly different between areas (Welch's test, $F = 333.7$, $df = 2$, $p < 0.0001$) and sexes (Welch's test, $F = 9095.7$, $df = 1$, $p < 0.0001$). A marked variability was observed in the size distributions between the areas. In the Billfish hot-spot, the size distributions for each sex (and unknown sex) were symmetrical and unimodal (**Figure 3**); in contrast, the size distributions from the Caribbean and Guyana-Amazon areas were negatively skewed. It appeared more evident in the Caribbean area likely due to the higher number of small sailfish in the females and unknown sex categories. In the Billfish hot-spot area (PLYVRD), mean sailfish sizes were noticeably large for females than for males (**Figure 4**), although mean female sizes were similar across all areas. The larger sailfish size distribution was observed for the males in the Caribbean area (CAR). The size distribution of females in the Caribbean area and that of males in the Guyana-Amazon area (GUY) shared a similar trend in which 2 density groups of sizes are observed, one around 160 cm LJFL and the other around 170 cm LJFL (**Figure 4**). It is possible that sailfish sizes in the areas could be affected by billfish-target (VAOS) *vs* billfish-non-target (industrial/tuna) pelagic longline fleets; sailfish mean sizes for males (158.3 cm LJFL) and females (162.6 cm LJFL) caught from VAOS fleet are smaller than sailfish mean sizes from the industrial/tuna fleet (168.1 cm LJFL for males and females), likely due to the difference in gear setting (depth) (Ortiz and Arocha, 2004; Arocha *et al*., 2015b).

The Welch's ANOVA test revealed that sailfish size data were significantly different between years (Welch's test, $F = 248.52$, $df = 27$, $p < 0.0001$), and when comparing years in each area (Welch's test, $p < 0.0001$ on all cases), particularly in the Caribbean and Guyana-Amazon areas. The annual trend in the size distributions of sailfish was relatively stable for fish caught in the area of the Billfish hot-spot (PLYVRD) during most of the time series. However, a smooth decreasing trend was more evident in males during the final years of the series (**Figure 5**). In the GUY-AMZ area a short period of lower sizes were present during the mid 1990s in both sexes, possibly due to low samples. However, a subtle decreasing trend was noticeable throughout the second half of the time series that becomes more evident in males for the final years of the series (**Figure 5**).

Seasonal trends in the sex specific size distributions of sailfish show minor variations between the areas. The Welch's ANOVA test revealed that sailfish size data were significantly different between months for all years combined (Welch's test, $F = 126.06$, $df = 11$, $p < 0.0001$), and when comparing months in each area (Welch's test, $p < 0.0001$ on all cases). In the billfish hot-spot (PLYVRD), there is a decreasing trend in male mean size towards the end of the year, while in females occurs during mid year (**Figure 6**). In the CAR and GUY-AMZ areas irregular changes in mean sizes are observed for both sexes, but a very subtle increasing trend towards the end of the year in mean size is noted for males in CAR.

Sex ratio

Overall sailfish with sex recorded resulted in 49,960 (70.24%) males and 21,174 (29.76%) females. There were significant differences in the overall sex ratios among the three areas (Likelihood Ratio: $\chi^2 = 1154.9$, $p < 0.0001$), and trimesters within each of the areas (**Table 1**). The proportion of males was high in the Billfish hot-spot area, less so in the Guyana-Amazon area (GUY). In contrast, the sex ratio was evenly distributed in the Caribbean area (CAR) (**Figure7a**).

There were also significant differences in sex ratios among months, even when compared conditionally within each of the different areas (CMH test: $\chi^2 = 966.57$, $df = 11$, $p < 0.0001$). In the CAR area during the beginning of the year, the trend in the proportion of males was similar (~0.70-0.75), but in the following months an increasing trend in the proportion of males was noted through November (**Figure 7b**). In contrast, in the GUY area sex ratio of females increased from July to November, but the overall sex ratio throughout the year was 49.61% for females and 50.39% for males (**Figure 7c**). In the Billfish hot-spot area, where males dominate throughout the year an increasing trend in the sex ratio for males was observed, from May to November (**Figure 7d**).

The spatial and temporal pattern of the proportion of females varied in the fishing areas (**Figure 8**). Sailfish was more common in the catches during the 2nd and 3rd trimesters (Apr-Jun, Jul-Sep), it diminished in Oct-Nov, and during Jan-Mar sailfish were at their lower numbers. In general, there was no clear sex ratio segregation pattern; during first half of the year sex ratio favored the males throughout the fishing areas, with few localized exceptions in both areas. In the 3rd trimester (Jul-Sep), the sex ratio increased to 1:1 in most of the fishing area, with some exceptions, close to the coast the Caribbean area the males continued to dominate the sex ratio, as well as in the outer edge of both fishing areas (Central Caribbean and off NE of French Guiana). During the last trimester, the proportion of females was greatly reduced except in central areas of the Caribbean Sea.

The analysis presented here provides a comprehensive study on sailfish catch at size distribution with data from three important fleets catching billfishes as directed catch and as bycatch in the southern Caribbean and adjacent waters of the western North Atlantic. The spatial and seasonal dynamics of sailfish indicated that there were significant differences in the length frequency distributions and sex ratios in the fishing areas examined.

It is important to note that the size data examined come from different fleets with different gears, target species, and operation modes, thus the size distribution is possibly affected by the area availability and fleet selectivity. Likewise, the observations recorded reflect in part the species spatial dynamics, but there is also influence of the sampling effort directed towards each fleet, as such it is possible that the size data reported may not represent the entire prevalence of sailfish throughout the fishing areas. Considering all these caveats, some characteristic features are evident from the data.

The relevance of the Billfish hot-spot (BHS) is evident from the high numbers of sailfish caught over the years, a little over 90% of the sailfish size data recorded from all fleets came from the BHS. The largest females in the catch at size were observed in the BHS, but a decreasing trend in the mean size of males was noticeable during the last few years of the time series in the BHS, and is of concern. The sex ratio favored the males, reaching more than 75% towards the last trimester of the year (Oct-Dec). The spatial and temporal dynamics in the catch at size in the BHS contrasts with that of the Caribbean and the Guyana-Amazon areas, although mean sizes for females are somewhat similar across areas, but not for males. It appears that larger males are more common in the Caribbean off shore waters where the sex ratio is around 1:1 throughout the year, and in the GUY area to some extent.

The sex ratio favoring the males in the BHS area may be related to spawning behavior of sailfish in the area. The combination of evidence of spawning (Ariza *et al*., 2015), and the characteristic *S*-shaped (*Spoon*-shaped) male sex ratio at size in the BHS (Arocha *et al*., 2010) can be considered a *courting* and *coupuling* behavior during the spawning process, similar to what has been characterized for swordfish in spawning areas (Neilson *at el*., 2013). This pattern has only been documented amply for swordfish, but it is possible that billfishes, and particularly sailfish, may display a similar pattern but in a more limited spatial dynamics due to the more "*coastal*" nature of sailfish. It is clear that one of the limiting factors to test this characteristic is the low catch-at-size samples throughout the area of the stock, efforts should be directed to increase the samples of sex specific catch-at-size.

References

Ariza, L. A., J.G. Núñez, M. Narváez, M. Medina, F. Arocha. 2015. Aspectos reproductivos del pez vela (*Istiophorus albicans*) en el Mar Caribe y aguas adyacentes del Océano Atlántico. Un análisis preliminar. ICCAT Coll. Vol. Sci. Pap. 71: 2217-2231.

Arocha, F., A. Larez, A. Pazos, X. Gutiérrez, L. A. Marcano, J. Silva. 2015a. Billfish catch in the Venezuelan Artsisanal Off-Shore Pelagic Longline Fishery: Past and Present (1986-2013). ICCAT Coll. Vol. Sci. Pap. 71:2203-2216.

Arocha, F., Pazos, A., Larez, A., Marcano J., Gutierrez, X. 2015b. 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. ICCAT Coll. Vol. Sci. Pap. 71:2316-2333.

Arocha, F., L.A. Marcano, J. Silva. 2013. Description of the Venezuelan pelagic longline observer program (VPLOP) sponsored by the ICCAT Enhanced Research Program for Billfish. ICCAT Coll. Vol. Sci. Pap., 69: 1333-1342.

Arocha, F. L.A. Marcano, J. Silva. 2010. Sex ratio at size for sailfish (*Istiophorus albicans*) from the Venezuelan fishery off the Caribbean Sea and adjacent areas. ICCAT, Coll. Vol. Sci. Pap., 65:1633-1640.

ICCAT. 2012. Report of the 2011 Blue Marlin Stock Assessment Meeting and White Marlin Data Preparatory Meeting (Madrid, Spain - April 25-29, 2011). ICCAT Coll. Vol. Sci. Pap., 68: 1273-1386.

ICCAT. 2013. Report of the 2012 White Marlin Stock Assessment Session (Madrid, Spain - May 21-25, 2012). ICCAT Coll. Vol. Sci. Pap., 69:1085-1183.

JMP® 11 Basic Analysis. 2014. Cary, NC: SAS Institute Inc.

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

Neilsen, J., F. Arocha, S. Calay, J. Mejuto, M. Ortiz, G. Scott, C. Smith, P. Travassos, G. Tserpes, I. Andrushchenko. 2013. The recovery of Atlantic swordfish: The comparative roles of regional fisheries management organization and species biology. Reviews in Fisheries Science, 21:59-97.

Ortiz, M., F. Arocha. 2004. Alternative error distribution models for standardization of catch rates of non-target species from pelagic longline fishery: billfish species in the Venezuelan tuna longline fishery. Fish. Res., 70:275-297.

Table 1. Sex ratio expressed as proportion of female *Istiophorus albicans*, and size metrics by fishing areas and seasons in Playa Verde (Billfish hot-spot, BHS), Caribbean Sea and Guyana-Amazon during 1987–2014.

Area	Proportion of females	Season	Proportion of females	n	Females mean size (FL cm)	Males mean size (FL cm)
Playa Verde (BHS)	0,15	January-March	0,20	7910	175,5±10,7	164,1±11,1
		April-June	0,16	24824	173,7±9,9	162,8±8,6
		July-September	0,15	26860	172,9±9,9	161,5±7,9
		October-December	0,12	17381	173,7±10	161,5±8,3
Caribbean Sea	0,44	January-March	0,42	743	159,1±14,1	157,3±12,6
		April-June	0,37	559	163,5±14,2	156,3±18,1
		July-September	0,49	608	161,8±11,9	162,5±13,5
		October-December	0,47	981	161,7±13,6	162,5±15,1
Guyana-Amazon	0,37	January-March	0,35	1457	164,1±12,4	159,3±12,4
		April-June	0,34	1047	167,9±11,6	162,1±12,1
		July-September	0,39	2365	166,6±11,4	163,2±12,7
		October-December	0,41	1047	164,3±12,5	162,1±12,4

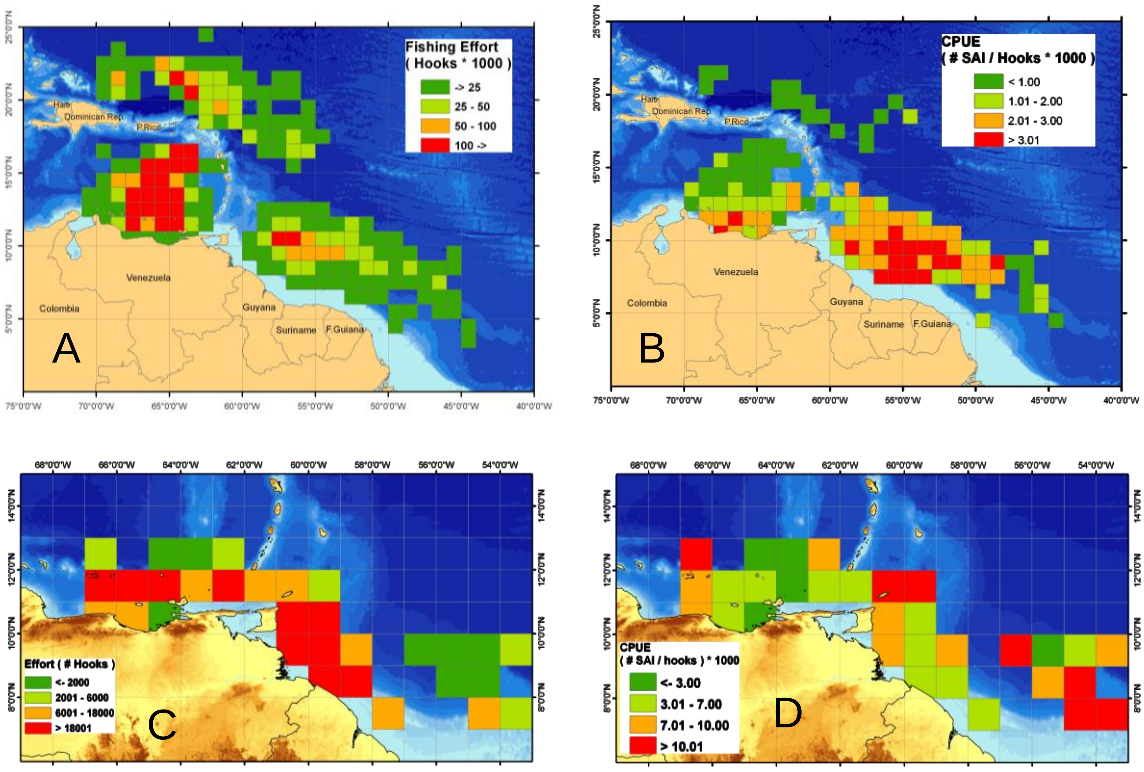

Figure 1. Total observed fishing effort (nos. of hooks) of the Venezuelan pelagic longline fleet (left), and nominal catch rates of sailfish (*Istiophorus albicans*) (right) from the observed sets of the Venezuelan pelagic longline (top) and the Venezuelan Artisanal Off Shore (bottom) fleets during 1987-2013 and 2011-2014, respectively.

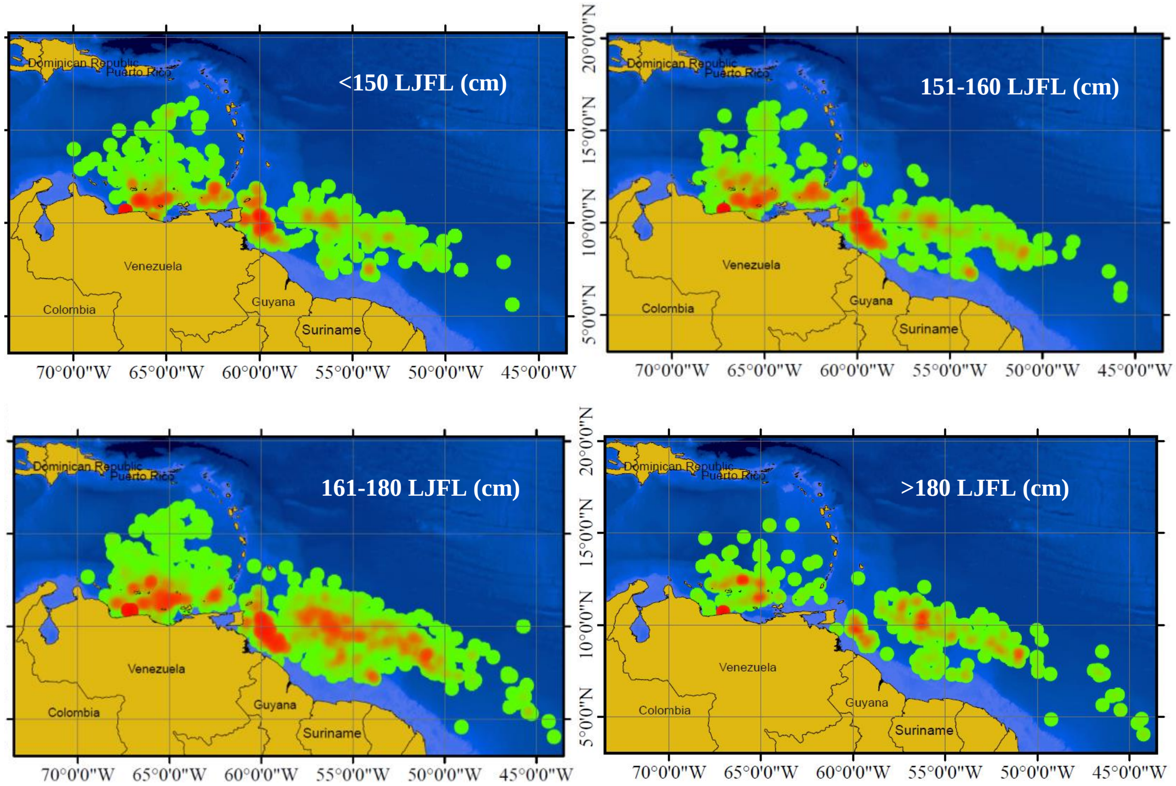

Figure 2. Location of sailfish (*Istiophorus albicans*) estimated kernel densities (Epanechnikov shape) by size class recorded by the 3 Venezuelan fleets analyzed during the period of 1987-2014. The brighter red color represents the highest density of fish in that size class.

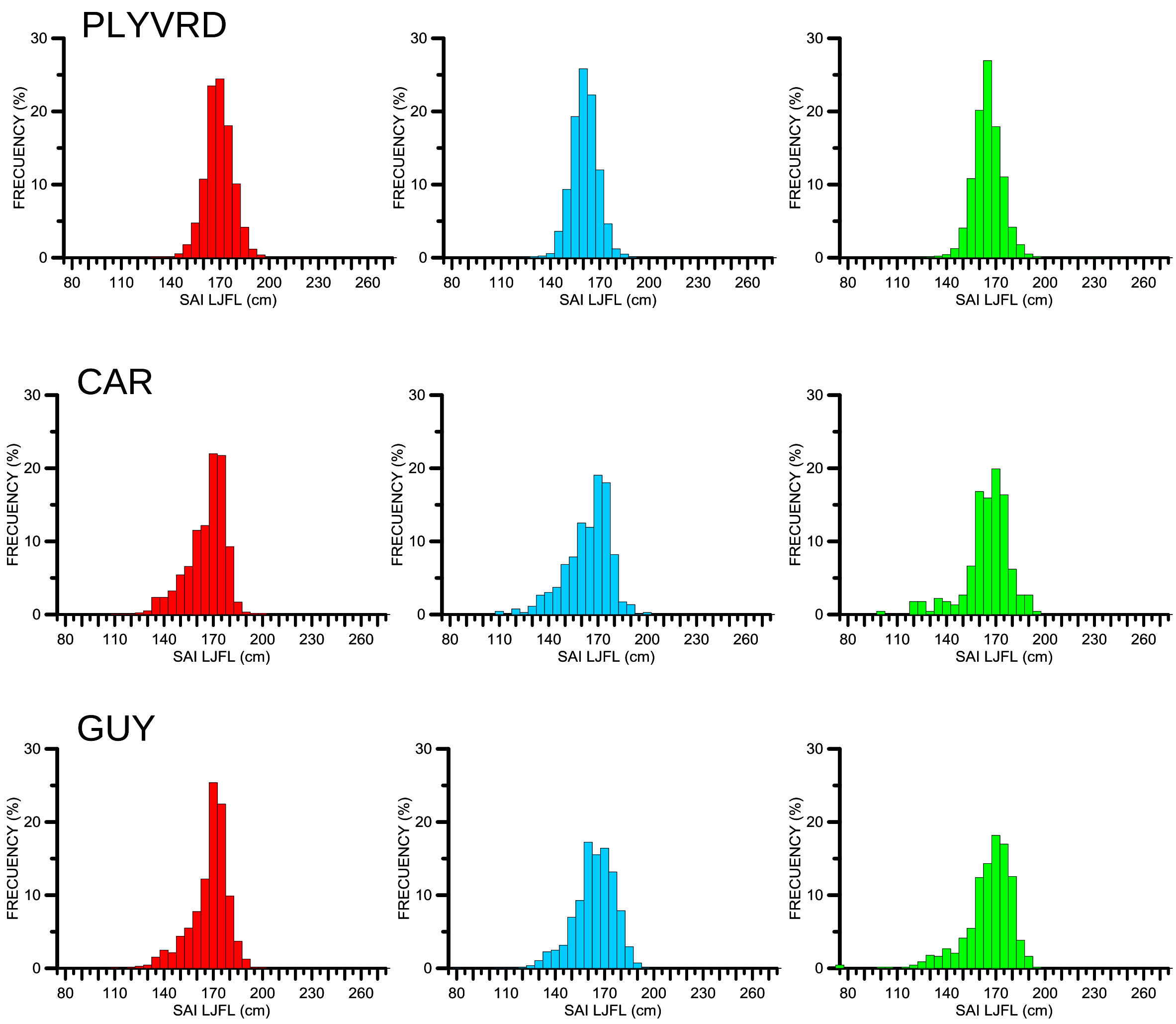

Figure 3. Size frequency distributions of female (red), male (blue), and unsexed (green) sailfish (*Istiophorus albicans*) caught in the Billfish Hot-spot off La Guaira (PLYVRD), the Caribbean Sea area (CAR), and the Guyana-Amazon area (GUY).

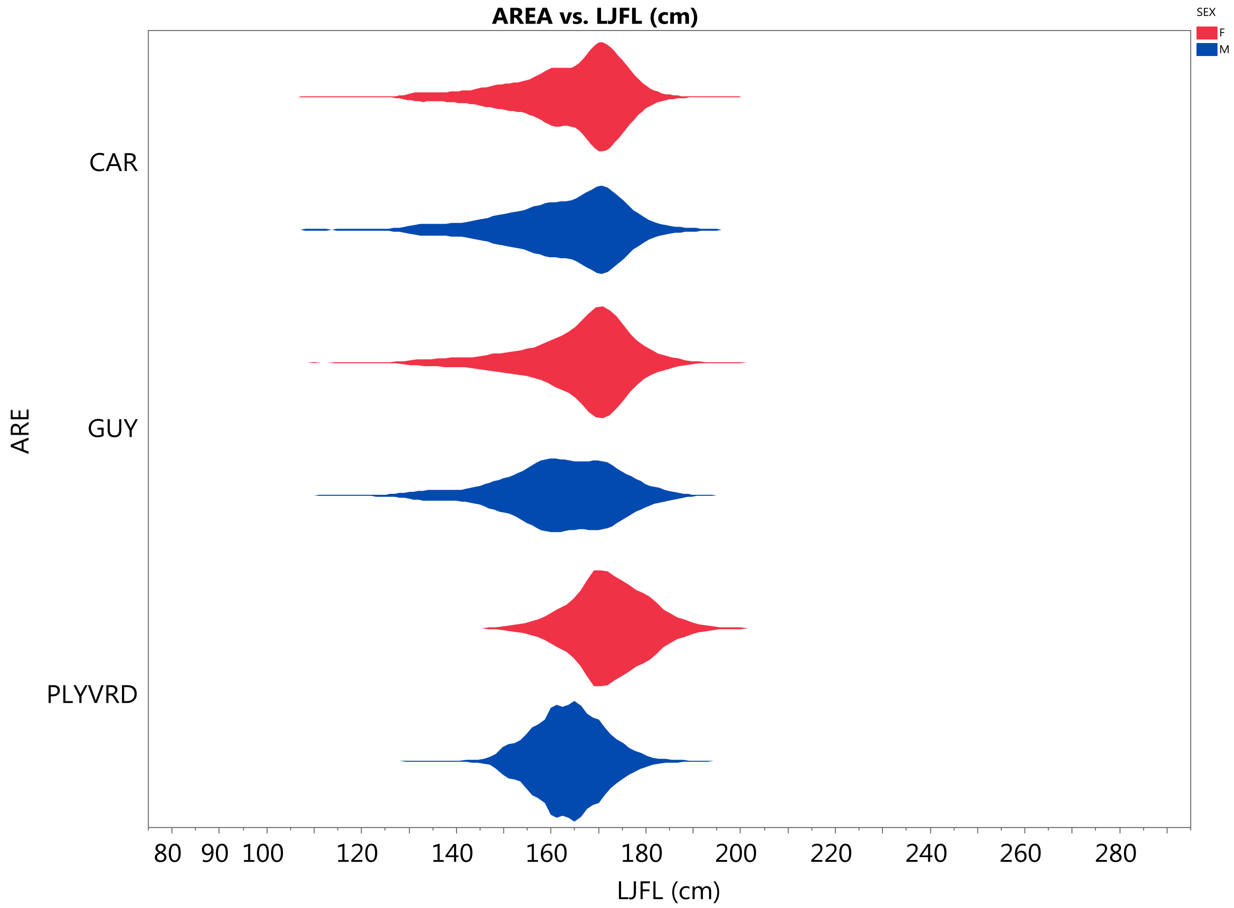

Figure 4. Size distribution (density plots) of male (blue) and female (red) sailfish (*Istiophorus albicans*) caught in the Billfish Hot-spot off La Guaira (PLYVRD), the Caribbean Sea area (CAR), and the Guyana-Amazon area (GUY) during the period of 1987-2014.

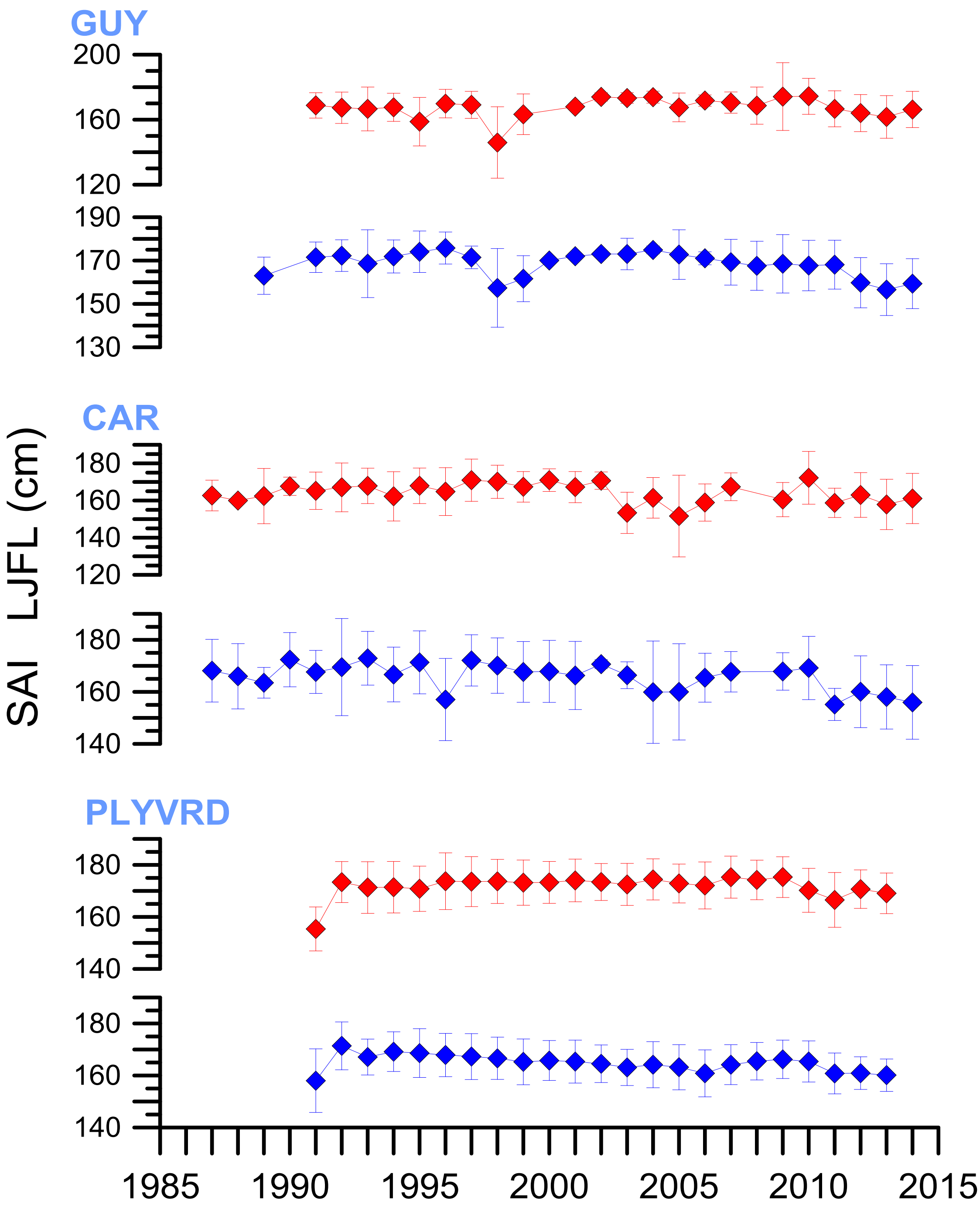

Figure 5. Annual mean sizes of male (blue) and female (red) sailfish (*Istiophorus albicans*) caught in the Billfish hot-spot off La Guaira (PLYVRD), the Caribbean Sea area (CAR), and the Guyana-Amazon area (GUY) during the period of 1987-2014. Error bars represent ±1 standard deviation.

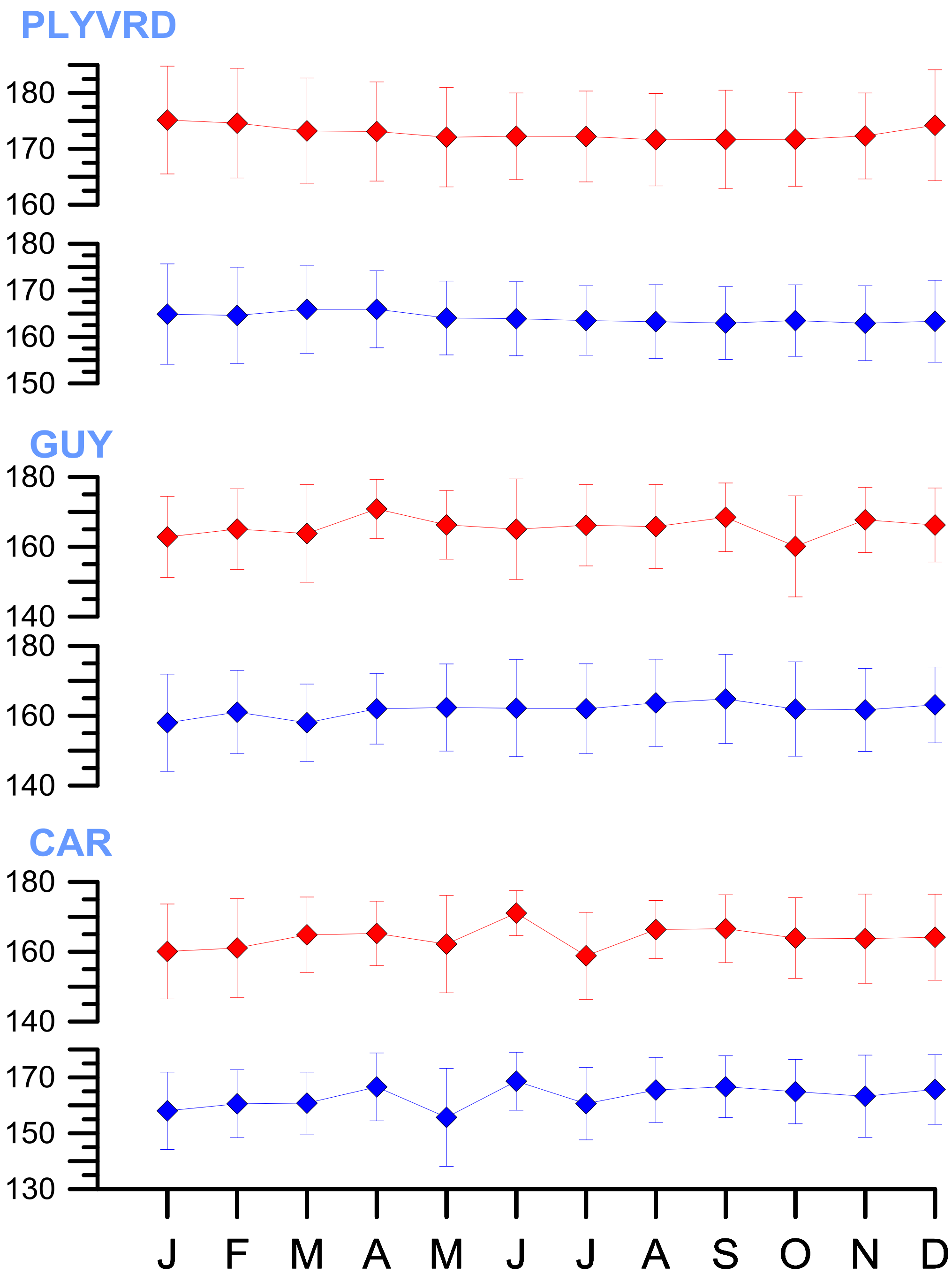

Figure 6. Seasonal (month) mean sizes of male (bleu) and female (red) sailfish (*Istiophorus albicans*) caught in the Billfish hot-spot off La Guaira (PLYVRD), the Caribbean Sea area (CAR), and the Guyana-Amazon area (GUY) during the period of 1987-2014. Error bars represent ±1 standard deviation.

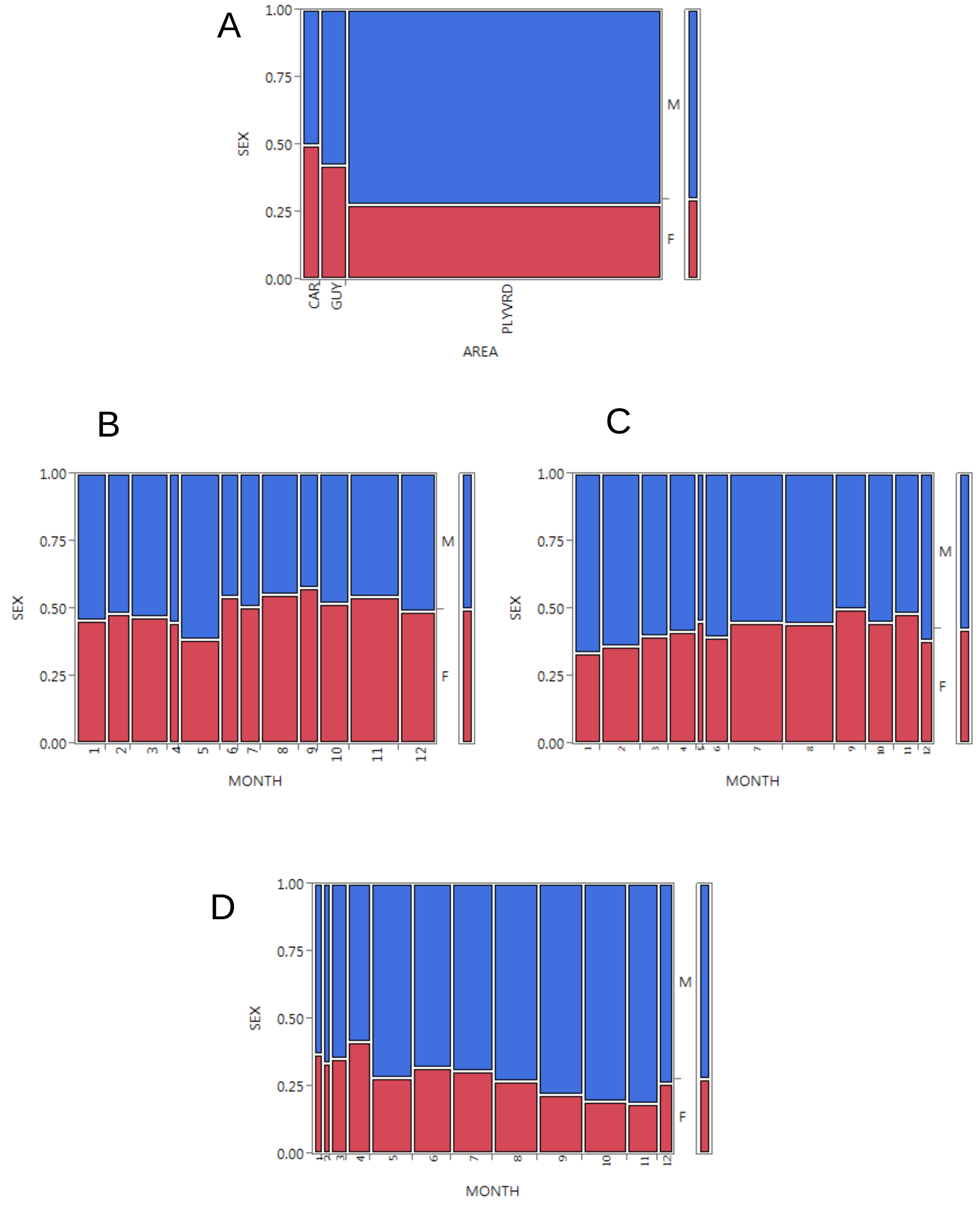

Figure 7. A) Overall sex ratio of male (blue) and female (red) sailfish (*Istiophorus albicans*) by areas during the period of 1987-2014; seasonal (months) sex ratio of male (blue) and female (red) sailfish (*Istiophorus albicans*) by areas: B) Caribbean Sea area (CAR), C) Guyana-Amazon area (GUY), D) Billfish hot-spot area (PLYVRD).

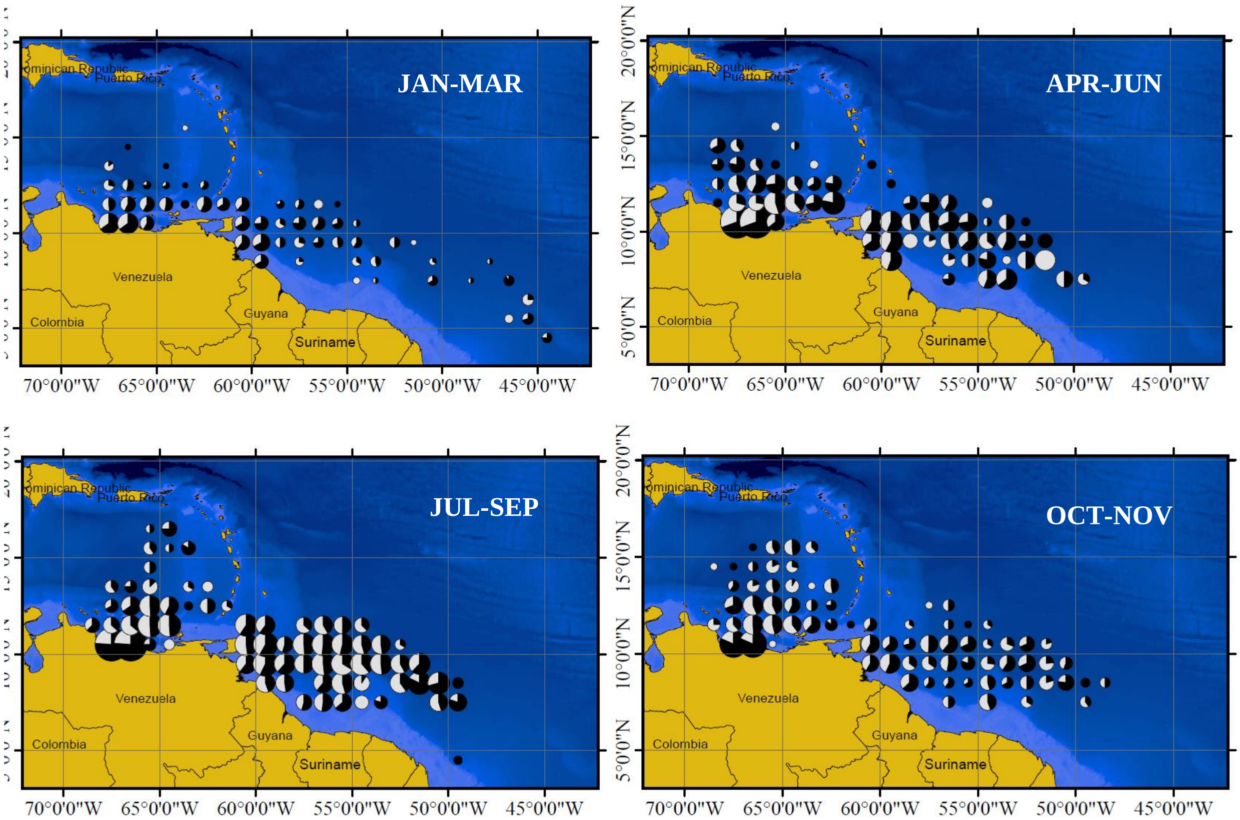

Figure 8. Overall and seasonal (trimester) capture location of proportional numbers of male (black) and female (white) sailfish (*Istiophorus albicans*) in 1◦ ×1◦ with respect to the bathymetry of the study area. The size of the pie charts is proportional to the numbers of sailfish caught during the period of 1987-2014.