

**SPATIAL AND TEMPORAL SIZE/AGE DISTRIBUTION PATTERNS OF ALBACORE  
(*THUNNUS ALALUNGA*) IN THE CARIBBEAN SEA AND ADJACENT WATERS OF THE  
WESTERN CENTRAL ATLANTIC FROM OBSERVER DATA OF THE VENEZUELAN  
LONGLINE FISHERIES**

F. Arocha<sup>1\*</sup>, M. Ortiz<sup>2</sup>, E. Evaristo<sup>3</sup>, X. Gutierrez<sup>3</sup>, L. A. Marcano<sup>4</sup>

**SUMMARY**

*Albacore (Thunnus alalunga) is caught as by-catch of the tropical tuna catch of the Venezuelan large pelagic fisheries over the past 25 years. The document analyzes the spatial and temporal size distribution of northern albacore recorded by the ICCAT/EPBR sponsored Venezuelan Pelagic Longline Observer Program (1991-2011), and the National Observer Program on pelagic longline vessels (2012-2014). A total of 27,472 northern albacore records collected between 1991 and 2014 were analyzed. Sizes recorded ranged between 42 and 132 cm FL. The size data was separated into 3 distinct areas, Caribbean Sea, Guyana-Amazon, and SW Sargasso Sea. In the area of the SW Sargasso Sea, the size distribution was stable and narrower with average sizes of 105-110 cm FL; while in the Caribbean Sea and Guyana-Amazon a larger size variability and wider range in size was recorded. Temporal age-converted frequency distributions reflect that Venezuelan pelagic longline catches of albacore consists of ages 6 and larger. The composition and temporal variability of albacore catches varied over the time period, from large fish in the SW Sargasso Sea during 1995-2003, to medium to large fish in the Caribbean Sea and Guyana-Amazon area during the recent period (after 2007). The size distribution patterns of albacore in the area fished by the Venezuelan longline fleet provides a better understanding of the species in the Caribbean Sea and adjacent areas of the western central Atlantic.*

**RÉSUMÉ**

*Le germon (Thunnus alalunga) est capturé comme prise accessoire de la capture de thonidés tropicaux par les pêcheries vénézuéliennes ciblant les grands pélagiques au cours des 25 dernières années. Le présent document analyse la distribution spatiale et temporelle des tailles du germon du Nord consignées dans le cadre du programme vénézuélien d'observateurs palangriers pélagiques parrainé par ICCAT/EPBR (1991-2011) et du programme d'observateurs nationaux embarqués à bord de palangriers pélagiques (2012-2014). Un total de 27.472 registres de germon du Nord recueillis entre 1991 et 2014 a été analysé. Les tailles enregistrées oscillaient entre 42 et 132 cm LJFL. Les données de taille ont été divisées en trois zones distinctes, à savoir la mer des Caraïbes, Guyana-Amazone et Sud-Ouest de la mer des Sargasses. Au Sud-Ouest de la mer des Sargasses, la distribution des tailles était stable et plus étroite avec des tailles moyennes de 105-110 cm FL ; tandis que l'on a enregistré dans la mer des Caraïbes et en Guyana-Amazone une plus grande variabilité dans les tailles et une plus vaste gamme de tailles. Les distributions temporelles des fréquences converties en âge montrent que les prises des palangriers pélagiques vénézuéliens de germon sont composées de spécimens de six ans ou plus. La composition et la variabilité temporelle des prises de germon variaient au cours de la période temporelle, on trouvait des grands poissons au Sud-Ouest de la mer des Sargasses entre 1995 et 2003, des poissons de taille moyenne à grande dans la mer des Caraïbes et la zone Guyana-Amazone au cours de la période récente (après 2007). Les modèles de distribution des tailles du germon dans la zone de pêche de la flottille palangrière du Venezuela permettent de mieux comprendre l'espèce dans la mer des Caraïbes et les zones adjacentes de l'Atlantique centre-ouest.*

<sup>1</sup> Instituto Oceanográfico de Venezuela, Universidad de Oriente, Cumaná 6101 – Venezuela; Corresponding author: farocha@udo.edu.ve / farochap@gmail.com

<sup>2</sup> ICCAT Secretaría, Madrid, Spain

<sup>3</sup> INSOPESCA-Sucre, Cumaná 6101 – Venezuela

<sup>4</sup> Instituto Nacional de Investigaciones Agrícolas, Cumaná 6101 – Venezuela

## RESUMEN

*El atún blanco (Thunnus alalunga) se captura de forma fortuita en la captura de túnidos tropicales de las pesquerías de grandes pelágicos de Venezuela que capturan atún en los últimos 25 años. El documento analiza la distribución espacial y temporal de tallas del atún blanco del norte consignadas por los programas de observadores de palangre pelágico de Venezuela (1991-2011) auspiciado por el ICCAT/EPBR y el Programa nacional de observadores en palangreros pelágicos (2012-2014). Se analizaron un total 27.472 registros de ejemplares de atún blanco del norte recogidos entre 1991 y 2014. Las tallas consignadas oscilaron entre 42 y 132 cm LJFL. Los datos de talla se desglosaron en tres zonas diferentes: mar Caribe, zona guyano-amazónica y suroeste del mar de los Sargazos. En el mar de los Sargazos suroccidental, la distribución de tallas era estable y más estrecha, con tallas medias de 105-110 cm FL, mientras que en el mar Caribe y la zona guyano-amazónica se consignó una mayor variabilidad en las tallas y un rango más amplio de tallas. Las distribuciones temporales de frecuencias de edad convertidas reflejan que las capturas de palangre pelágico venezolano de atún blanco estaban compuestas por edades 6 y superiores. La composición y variabilidad temporal de las capturas de atún blanco presentaron diferencias durante el periodo, desde peces mayores en el mar de los Sargazos suroccidental durante 1995-2003, a peces más jóvenes en el mar Caribe y la zona de guyano-amazónica durante el periodo reciente (después de 2007). Los patrones de distribución de talla en la zona explotada por la flota de palangre de Venezuela proporcionan una mejor comprensión de la especie en el mar Caribe y áreas adyacentes del Atlántico central occidental.*

## KEYWORDS

*Albacore, size, spatial-temporal distribution, Venezuela, Caribbean Sea, Longline fishing*

## Introduction

Albacore (*Thunnus alalunga*) is considered to be a by-catch of the Venezuelan tuna fishery, which is mostly dedicated to target yellowfin tuna and skipjack. Average albacore catches from Venezuela represents 0.9% of the total northern albacore catch for the period of 1982-2014 (ICCAT, 2015). Since the beginning of the Venezuelan tuna surface fishery (PS and BB) in 1982, half (49.9%) of the albacore catch come from the purse seine fishery; while 44.7% is caught by the longline fishery during the same time period, and the rest is caught by the baitboat fishery. However, albacore tuna has been caught and landed by the longline fishery as part of the by-catch of the tropical tuna fishery since 1960s. In recent years, since 2009, the albacore catch from the longline fishery has increased substantially; while the catch from the surface fishery has remained relatively low (ICCAT 2015). The sudden increase has resulted in substantial discards in the most recent year and is likely to continue. The aim of the present document is to contribute to the understanding of the demographics of the albacore caught by the Venezuelan longline fleet.

## Material and Methods

### *Data sources*

The data used in this study came from the database of the ICCAT sponsored EPBR Venezuelan Pelagic Longline Observer Program (VPLOP) for the period 1991-2011 and from INSOPESCA's National Observer Program (PNOV) for the period 2012-2014 (Gassman et al., 2014). Arocha and Marcano (2001) described the main features of the fleet, and Marcano *et al.* (2007) reviewed the available catch and effort data from the Venezuelan Pelagic Longline fishery covered by the observer program. The VPLOP surveyed on average 10,9% of the Venezuela longline fleet trips during the period of 1991-2011 (Arocha et al., 2013), and the PNOV about 5% for the period of 2012-2014. Of the 6,901 sets observed, albacore was reported caught in 3,636 sets (52.69 %).

### *Collection of samples*

The Venezuelan Pelagic Longline fleet fishing grounds extends from northwest of Puerto Rico (22°N-68°W) to off the coast of north-eastern Brazil (4°N-44°W), including the eastern Caribbean Sea. Since 1991, trained scientific observers have recorded detailed information on gear characteristics, fishing operations as well morphometric and biological information from all tuna species caught by the Venezuelan longline pelagic vessels (Arocha and Marciano, 1999). All albacore specimens captured were measured to the fork length (FL) and to the nearest cm. Sex information was not recorded due to the priority of the billfish program.

### *Estimation of catch-at-age*

The size frequency distributions per year-quarter were converted to age distributions, using the same algorithm as in the last assessment of northern albacore (ICCAT 2010, Restrepo et al., 2010); which consisted in an iterative procedure using a prior length-at-age key and size frequency distribution to estimate an age distribution following the Kimura-Chikuni algorithm (Kimura & Chikuni 1987). The size frequencies were restricted to those that had more than 50 fish sampled per year-quarter. The size frequency samples were aged up to age 15+, including a size range from 40 to 150 cm FL using the same algorithm settings as in the last ALB\_north SA. For presentation purposes, ages were restricted to the 10+ age group.

## **Results and Discussion**

A total of 27,472 albacore were sampled from the Venezuelan pelagic longline fleet recorded by scientific observers of both programs from 1991 to 2014. The distribution of albacore samples by year, revealed a substantial increase in albacore sampling beginning in 1995 that remained relatively high (> ~1000 fish/yr) through to 2003, with the exception of 1999 and 2001. However, in recent years, the number of sampled fish increased again close to and more than 1000 fish/yr (**Figure 1**).

Albacore sampling covered all months, but 67.7% of the samples were caught during the months of May, June and July; while the spatial distribution of albacore recorded revealed that the majority of the samples (66.8%) were taken from area 3, which is the area SW of the Sargasso Sea (**Figure 1**). Much of it can be explained by the annual distribution of observed nominal catch rates over the fishing area of the Venezuelan pelagic longline fleet (**Figure 2**). The highest catch rates occurred from 1995 through 2003 in the area SW of the Sargasso Sea with the exception of the very low catch rates observed in 1999 and 2001. After 2004, the highest albacore catch rates were observed in the Guyana-Amazon area; while it disappeared from the SW Sargasso Sea. Although, in part, the spatial shift in albacore sampling can be attributed to observer placement/coverage, it is also attributed to the shift in area of operations of the fleet. The important fishing effort (#hooks) observed during the spring and early summer from the mid 1990s to 2003 disappeared almost completely; while the fishing effort, after 2003, increased in The Caribbean Sea and the Guyana-Amazon area (Arocha et al., 2016).

Observers and interviews with Captain and crews indicated that the shift in fleet operations were attributed to a shift in targeting from albacore in the SW Sargasso Sea to tropical tunas in the Caribbean, and an increase of operations in the Guyana-Amazon area.

Overall albacore size was between 95 and 125 cm FL throughout the fishing areas (**Figure 3**); although there were some catches of smaller size fish between 55 and 90 cm, particularly from the Caribbean Sea (Area 1). But as indicated before, sampling was sparse in 1991 – 1994; thereafter, size sampling came primarily from the SW Sargasso Sea (Area 3), from where albacore displayed a rather stable and narrow size distribution from 1995 to 2003 (except 1999, due to no observer coverage in that area) with fish on average of 105 -110 cm FL (**Figure 4**). In contrast, albacore caught in the Caribbean Sea (Area 1) and in the Guyana-Amazon (Area 2) showed more variation in its size distribution and a wider range of sizes. During 1995 through 2003, albacore from areas 1 and 2 ranged in size from 90 cm to 130 cm FL, with larger fish caught in Area 1 compared to Area 2. After 2003 due to shift in operations of the fleet samples from Area 3 stopped. Thereafter, most of the albacore sampled came from Areas 1 and 2, where a clear declining trend in the size distribution from 2008 to 2011 is observed in the Guyana-Amazon area (Area 2) dropping from an average of 115 cm to 100 cm FL (**Figure 5**). But in 1994 and in 2006, albacore sampled average sizes were among the lowest (<85 cm FL) in both areas (areas 1 and 2), particularly for 2006 in which most of the samples were <75 cm FL (**Figure 5**).

There is also an indication of seasonality in albacore catches between areas (**Figure 6**). The small albacore (<90 cm FL) caught in the Caribbean Sea (Area 1) and in the Guyana-Amazon area (Area 2) occurred between January and March (Figure 4); while most of the albacore caught in the SW Sargasso Sea (Area 3) which is >95 cm FL, was caught during the months of fishing operations in that area (Feb-Aug).

The resulting mean lengths at age by quarter and sigma used to generate the age distributions using the Kimura and Chikuni algorithm are presented in **Table 1**. The resulting overall age distribution of albacore caught by the Venezuelan pelagic longline fleet indicated that the albacore catch consists primarily of ages 6 and larger, and in which age 10 represents the plus group (10+) (**Figure 7 a**). The annual trend of the albacore age composition showed that during the period of 1995-2003, the catch was dominated by ages 6 to 10+ (**Figure 7 b**); but thereafter, particularly from 2007 to 2014, catches of albacore consisted of ages 5 to 8. However, in 2006, a year in which most of the sampled albacore were small fish, it consisted of age 2 fish.

The annual proportion of the age distribution of the albacore catch caught by Venezuelan pelagic longline fleet for the period of 1995-2014, showed that from 1995 to 1998 the age composition consisted primarily of ages 6, 7, 8, 9 and 10+ (**Figure 8**). Then from 1999 to 2005, the proportion of older fish 8, 9, 10+ increased, particularly for the 10+ age group that remained high through 2008, with the exception of 2006 during which most of the sampled catch was of young fish (Ages 2-3). After 2008, ages 5,6 and 7 dominated the catch.

The seasonal component of the annual catch at age showed that catches of ages 6-10+ occurred primarily during the 2<sup>nd</sup> and 3<sup>rd</sup> quarters of the year for the period between 1995 and 2003 (**Figure 9**). Then, from 2007 to 2014, albacore catch-at-age was somewhat evenly distributed throughout the years for ages 5-8, albeit in the recent years of the series in which the albacore catch in the 4<sup>th</sup> quarter increased, compared to the other quarters of the year.

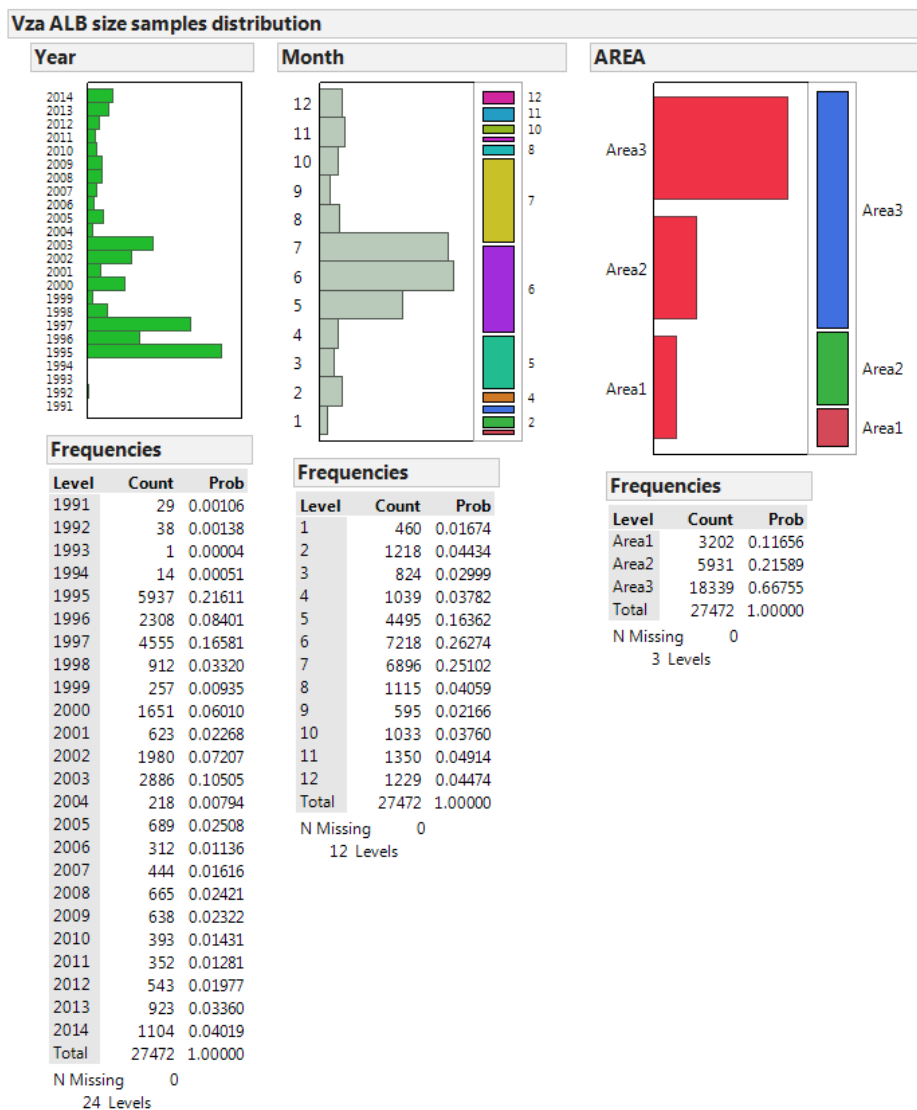
In summary, size and age composition show significant trends in the Venezuelan pelagic longline fleet operation, both in area distribution and seasonal operations. The size and age composition of catches from the SW Sargasso Sea (Area 3) consisted of predominantly large size fish (> 95 cm FL) and older (6+) age groups that were the target of several vessels of the fleet that was active during the 1995-2003 period, as was reported by Arocha and Marcano (2004) in an earlier analysis. It was determined that the vessels targeting albacore in that period shifted operations to the Caribbean Sea to target tropical tunas, and continue to do so. After 2003, the composition and seasonality of albacore catches changed, due to the shift in fishing effort primarily in Area 1 and more recently to Area 2, with catches of medium and large albacore, but operating more evenly throughout the year.

## References

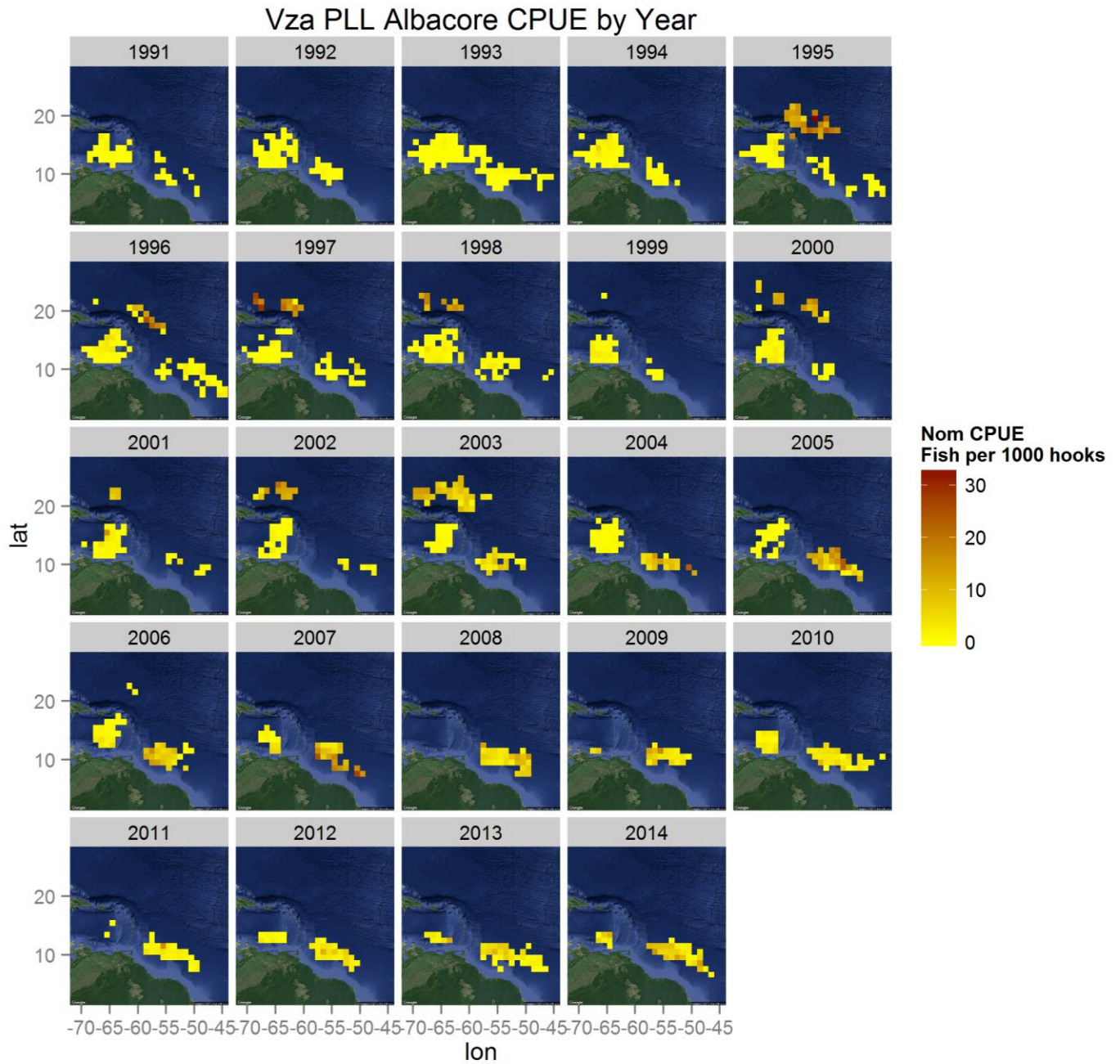
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**Table 1.** Albacore mean size at age and variance of size distribution used in the ageing algorithm (Kimura & Chikuni 1987) to estimate catch-at-age of fish caught by the Venezuela Pelagic longline fleet during 1991-2014.

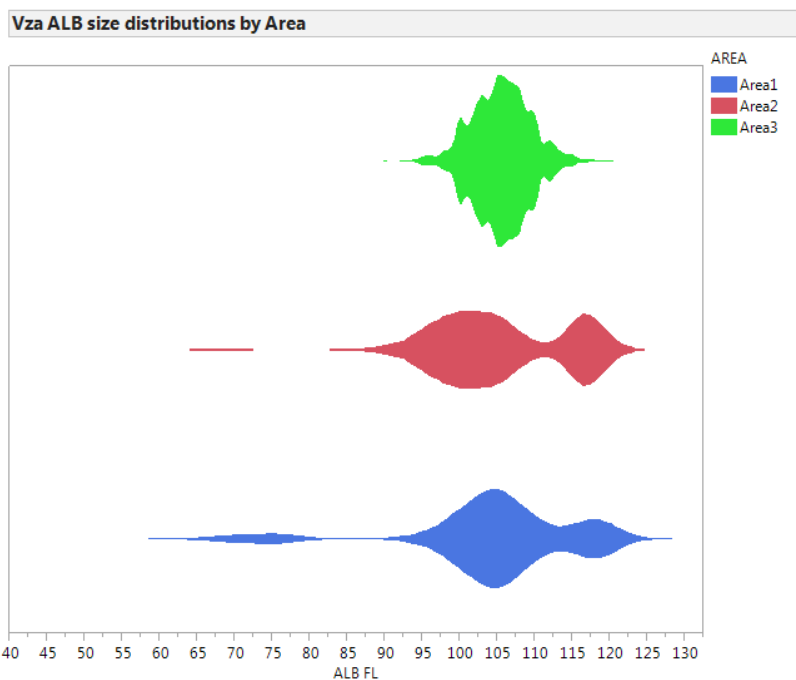
	age:	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Quarter 1	mean	44.46	59.75	72.06	81.96	89.93	96.35	101.52	105.68	109.03	111.72	113.89	115.63	117.04	118.17	119.08	119.81
	sigma	2.73	3.05	3.31	3.54	3.73	3.89	4.03	4.14	4.24	4.32	4.39	4.45	4.5	4.54	4.58	4.61
Quarter 2	mean	30.61	48.6	63.08	74.74	84.12	91.67	97.75	102.65	106.58	109.75	112.31	114.36	116.01	117.35	118.42	119.28
	sigma	2.73	3.05	3.31	3.54	3.73	3.89	4.03	4.14	4.24	4.32	4.39	4.45	4.5	4.54	4.58	4.61
Quarter 3	mean	35.48	52.52	66.24	77.28	86.16	93.32	99.08	103.71	107.44	110.45	112.86	114.81	116.37	117.64	118.65	119.47
	sigma	2.73	3.05	3.31	3.54	3.73	3.89	4.03	4.14	4.24	4.32	4.39	4.45	4.5	4.54	4.58	4.61
Quarter 4	mean	40.09	56.23	69.22	79.68	88.1	94.88	100.33	104.72	108.26	111.1	113.39	115.23	116.72	117.91	118.87	119.64
	sigma	2.73	3.05	3.31	3.54	3.73	3.89	4.03	4.14	4.24	4.32	4.39	4.45	4.5	4.54	4.58	4.61



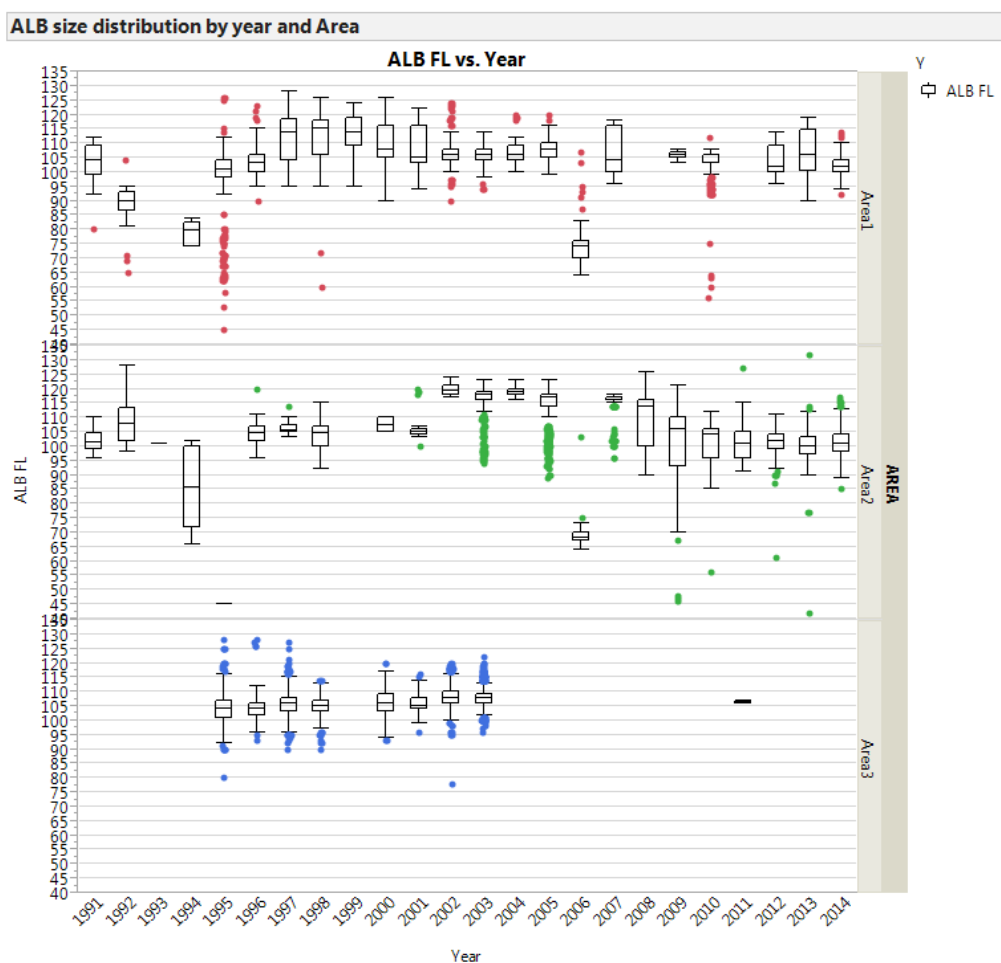
**Figure 1.** Frequency distributions of albacore size sampling from the Venezuelan Pelagic Longline fleet between 1991 and 2014.



**Figure 2.** Spatial ( $1^{\circ} \times 1^{\circ}$ ) and annual distribution of albacore nominal catch rates (numbers of fish/1000 hks) from the Venezuelan Pelagic Longline fleet between 1991 and 2014.

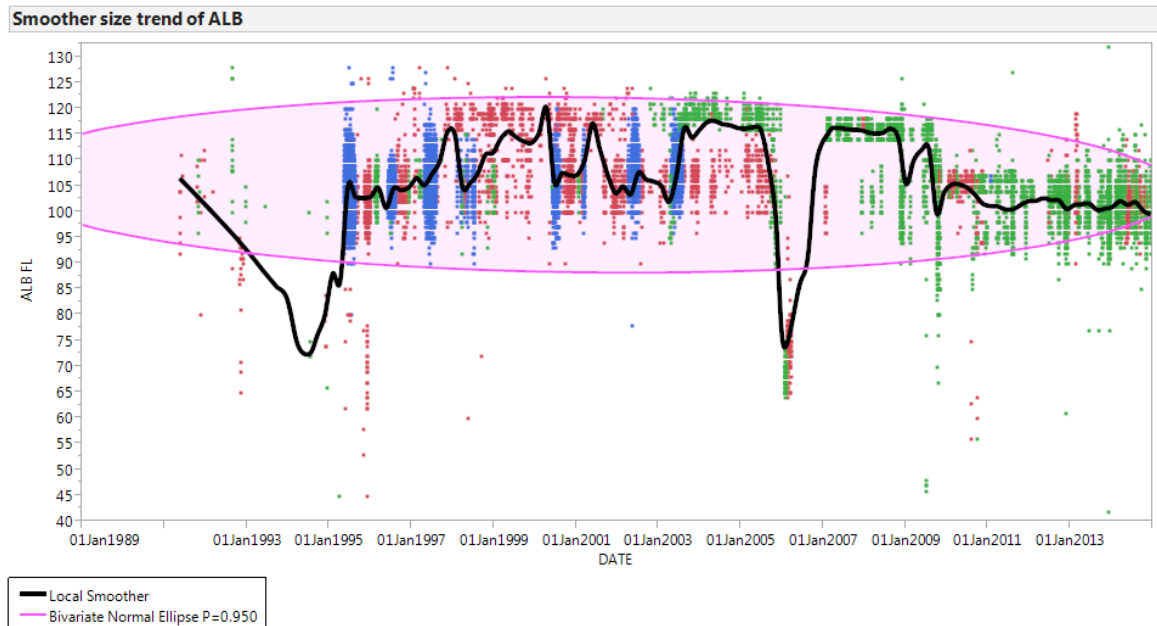


**Figure 3.** Albacore size density distributions by geographical area for all years. Area 1: Caribbean Sea; Area 2: Guyana-Amazon; Area 3: SW Sargasso Sea.

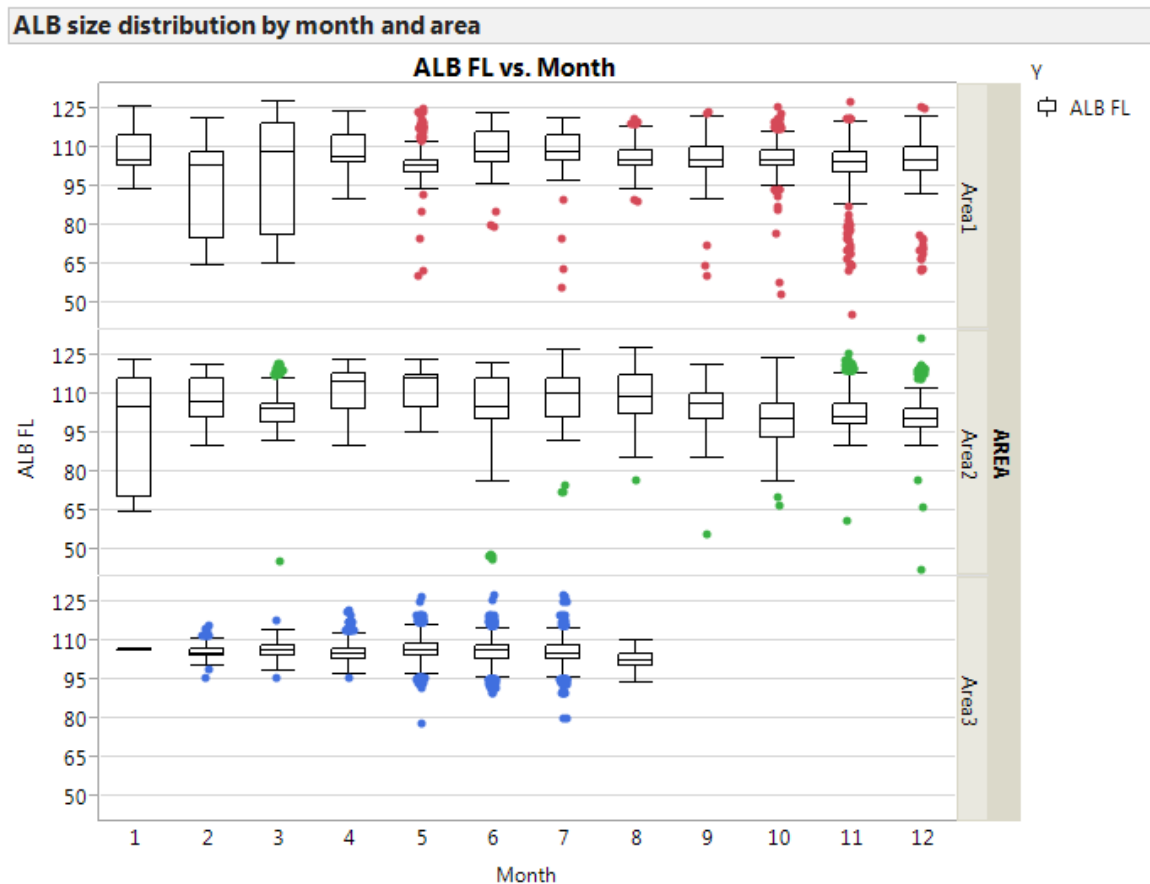


**Figure 4.** Annual size distribution (box plots) of albacore sampled from the Venezuelan Pelagic Longline fleet by geographical areas (Area 1: Caribbean Sea; Area 2: Guyana-Amazon; Area 3: SW Sargasso Sea)

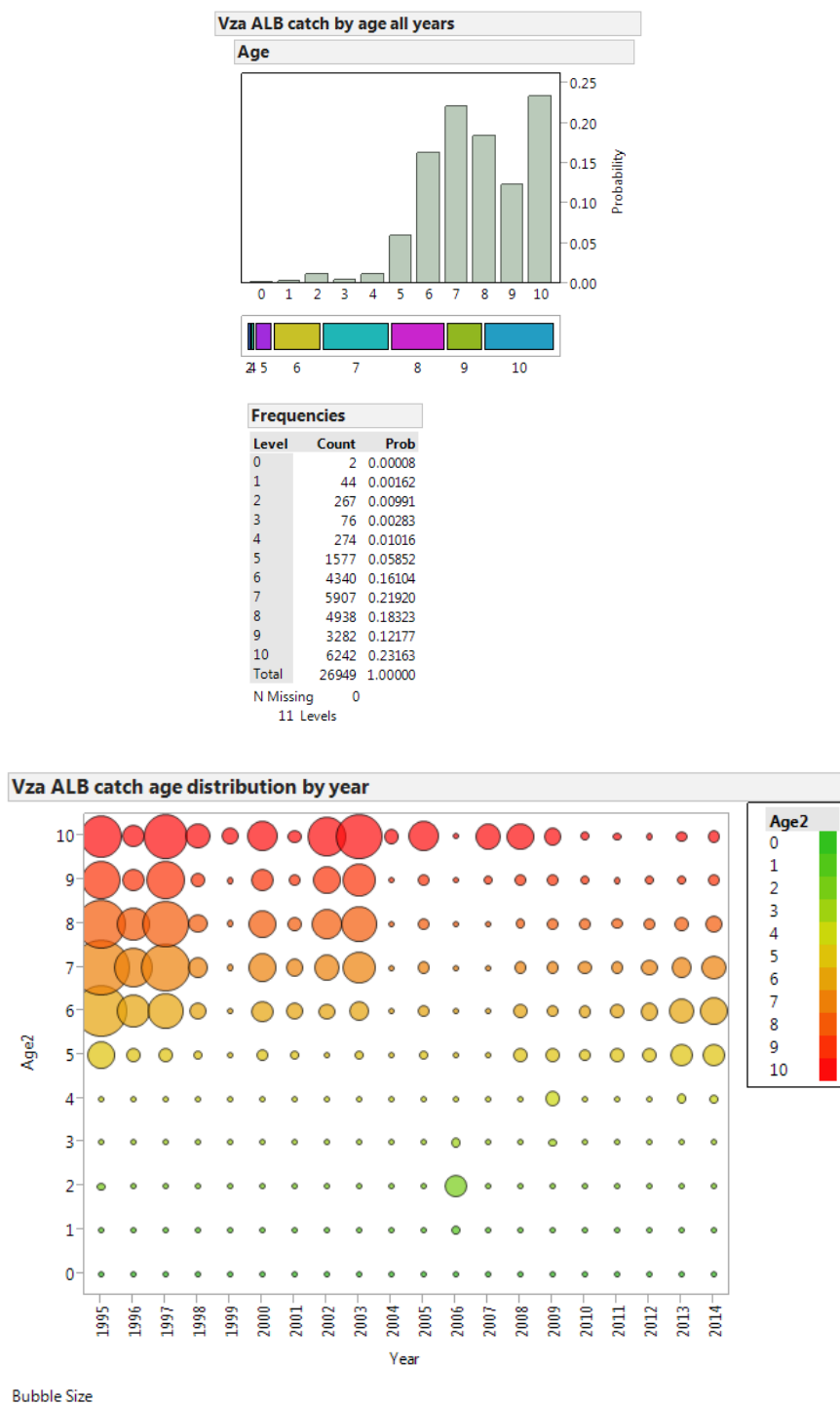




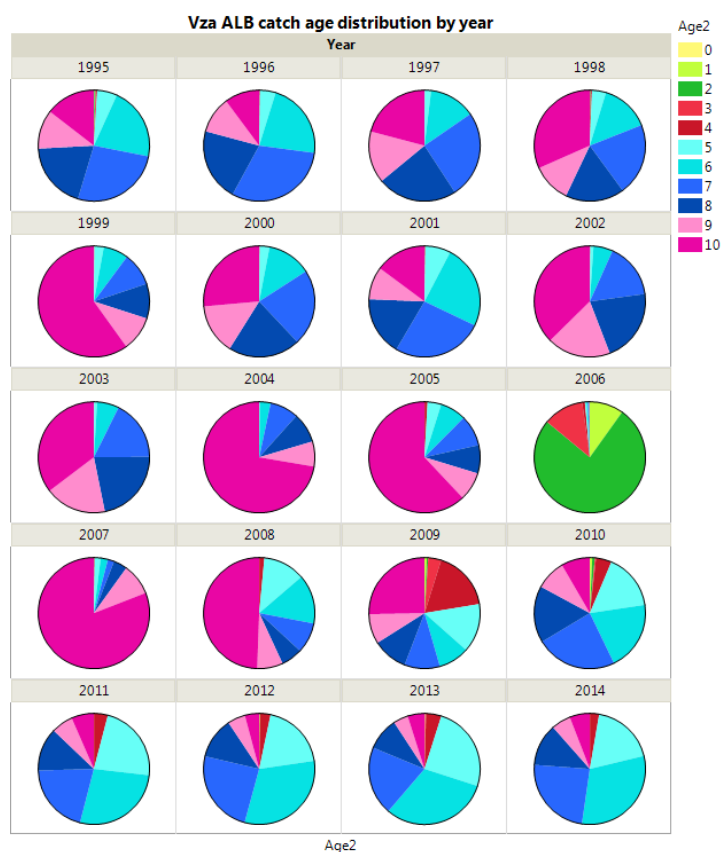
**Figure 5.** Time series of mean size of albacore caught by the Venezuelan Pelagic Longline fleet. Colors represent the geographical areas of the samples: red, Caribbean Sea; green, Guyana-Amazon; blue, SW Sargasso Sea, and the shaded ellipse represents the 95% bivariate confidence bounds.



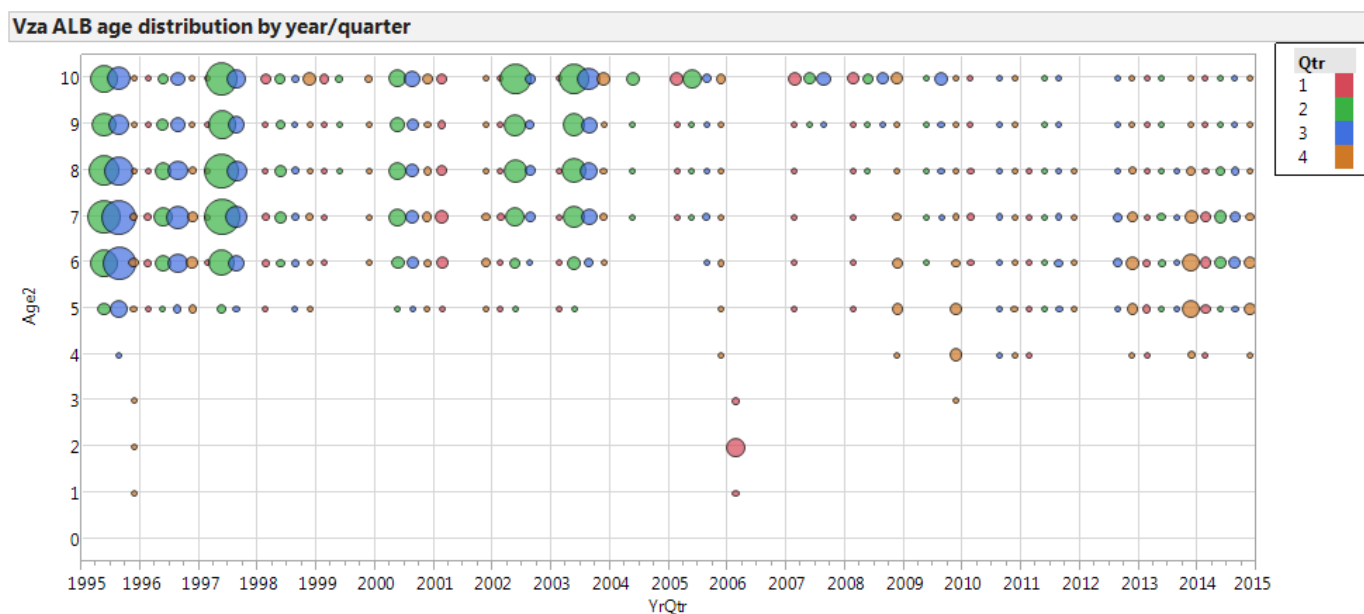
**Figure 6.** Monthly albacore size distribution (box plots) by area (Area 1: Caribbean Sea; Area 2: Guyana-Amazon; Area 3: SW Sargasso Sea).



**Figure 7. a)** Overall age distribution albacore samples from the Venezuelan Pelagic Longline fleet; **b)** Annual albacore age distribution. Bubble size is proportional to the number of fish per age year class; age 10 represents a plus group.



**Figure 8.** Annual proportional distribution for albacore catch-at-age from the Venezuelan pelagic longline fleet during the period of 1995-2014.



**Figure 9.** Catch-at-age distribution of albacore from the Venezuelan Pelagic Longline fleet by year-quarter, bubbles show only ages with 5 or more fish per strata.