Arquivos de Ciências do Mar

WEIGHT X LENGTH RELATIONSHIP AND LENGTH CONVERSION OF YELLOWFIN TUNA, Thunnus albacares, FROM FISHERIES ASSOCIATED WITH AN OFFSHORE BUOY IN THE WESTERN EQUATORIAL ATLANTIC[1]

Relação peso x comprimento e conversão do comprimento da albacora-laje, *Thunnus albacares*, em pescarias associadas a uma bóia oceânica no Atlântico Oeste Equatorial

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ABSTRACT

This paper presents the estimate of the weight-length relationship for the Thunnus albacares *fishery associated with an offshore buoy in the Equatorial Atlantic, as well as the length conversion to access the actual population structure that is being exploited. Data were obtained from May, 2010 to April, 2011 in the landings at the fishing pier of Areia Branca, Northeast Brazil, and on board during a research cruise in February, 2011. We sampled a total of 348 individuals of* T. albacares *but the estimates of the length conversion equation data were derived from 174 individuals and to the weight x length relationship data from 201 individuals. By linear regression analysis the following conversion formula of pectoral fin-fork length on fork length data was obtained: FL = 6.0522 + 1.2445 PFFL. The relationship between log-length and log-weight data is represented by the regression ln DWT= -10.711+ 2.9347 ln FL, whose potential equation is WT = 0.0000223 x* $FL^{2.935}$.

***Key words**: yellowfin tuna,* Thunnus albacares*, morphometry, fish aggregation device.*

RESUMO

Este trabalho apresenta a estimativa da relação peso x comprimento de Thunnus albacares *associadas a bóias oceânicas no Atlântico Oeste Equatorial, bem como a conversão de comprimento para se ter acesso a real estrutura populacional que vem sendo explotada. Os dados foram obtidos no período de maio/2010 a abril/2011 nos desembarques no cais pesqueiro de Areia Branca-RN e em um embarque realizado em fevereiro/2011. Foram amostrados 348 indivíduos de* T. albacares*, sendo utilizados para a estimativa da conversão de comprimento os dados de 174 indivíduos e para a estimativa da relação peso x comprimento os dados de 201 indivíduos. Através da análise de regressão linear chegou-se à fórmula de conversão de comprimento da nadadeira peitoral a forquilha para comprimento furcal: FL = 6,0522 + 1,2445 PFFL. A relação entre os dados log-transformados de comprimento e peso é representada pela regressão ln WT = -10,711 + 2,9347 ln FL, cuja equação potencial é WT = 0,0000223 .* $FL^{2,935}$

***Palavras-chaves**: albacora-laje,* Thunnus albacares*, morfometria, atrator artificial.*

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INTRODUCTION

The collapse of the *Panulirus* lobster stocks in Brazil is mainly due to the excessive practice of predatory and illegal fisheries, so that the fishery sector in Areia Branca county, Northeast Brazil, has searched for alternatives to the activity, among which stands out the small-scale tuna fishery associated with an ocean buoy anchored in Atlantic Ocean as part of the PIRATA Project (Pilot Research Moored Array in the Tropical Atlantic) which has acted as a fish aggregation device, known worldwide by its acronym FAD. In Brazil, the practice of installing floating artificial attractors aiming at the concentration of pelagic fish has been conducted mainly in Southern and Southeastern regions, besides conducting fisheries near oil drilling platforms, which also act as aggregators (Lima *et al.* 2000; Santos & Andrade, 2004). However, studies about the population structure of exploited species in this type of fishing are still incipient.

Weight x length relationships are among the most common tools used in studies of population dynamics and are important for determining the weight corresponding to a given length (Davis, 1991; Gaertner, *et al.* 1992; Asano-Filho *et al.*, 2004; Froese, 2006). The yellowfin tuna, *Thunnus albacares*, stocks have been systematically studied in the Atlantic Ocean, with a number of research articles on morphometric relationships, with emphasis on the Eastern Atlantic where there is an outstanding performance by the bait boat, purse seine and longline fleets (Lenarz, 1971; Caveriviére, 1976; Choo, 1976). It is worth noting other studies on the weight x length relationships of *T. albacares*, which were carried out by Davis (1991) in the North Atlantic and by Gaertner *et al.* (1992) from the catches of the Venezuelan fleet operating in the Southern Caribbean Sea, as well as Scida *et al.* (2001) in the Western North Atlantic. In addition, we also highlight the work of Zhu *et al.* (2010) comparing the weight x length relationships of *T. albacares* in the Indian, Pacific and Atlantic Oceans.

Most estimates of the weight x length relationships and length conversions of *T. albacares* in the Atlantic Ocean were derived from the catches of fish schools by pelagic longline. Lessa *et al.* (1993) conducted a biometric study on board Brazilian vessels operating in the Southwestern Equatorial Atlantic. Asano-Filho *et al.* (2004) dealt with tunas caught in experimental cruises in the oceanic zone of Northern Brazil. Frota *et al.* (2004) described the weight x length relationships of 85 fish species in the central coast of Brazil which included *T. albacares*. Costa *et al.* (2005) used data from the fleet based in Santos operating in Southwestern Atlantic. Oliveira *et al.* (2005) presented the weight x length relationships as well as length conversion equations of tunas caught by national and leasehold fleets in Western Tropical Atlantic.

For several reasons, among which increase of hold capacity and fish quality are worth mentioning, commercial and recreational tuna fisheries the catch landings are composed of beheaded fish (Choo, 1976; Scida *et al.* 2001). Round weight is the wet weight of whole fish, typical of most of the landings from surface hook-type gears, due to the large number of small individuals captured; on the other hand, in longline fisheries, small tuna are kept intact while the larger individuals have their fins, gills and gut removed, being called "GG" and billfishes are "dressed", with its head, fins and viscera removed (Miyake *et al.*, 2010).

In the case of the fleet based in Areia Branca county, *T. albacares* is landed in two ways: the small fish are classified as "GG" and the others weighing over 15 kg as "dressed", having their head removed as part of the processing on board (Figure 1). This practice makes it difficult to have access to real fork length frequency distribution, which is the standard

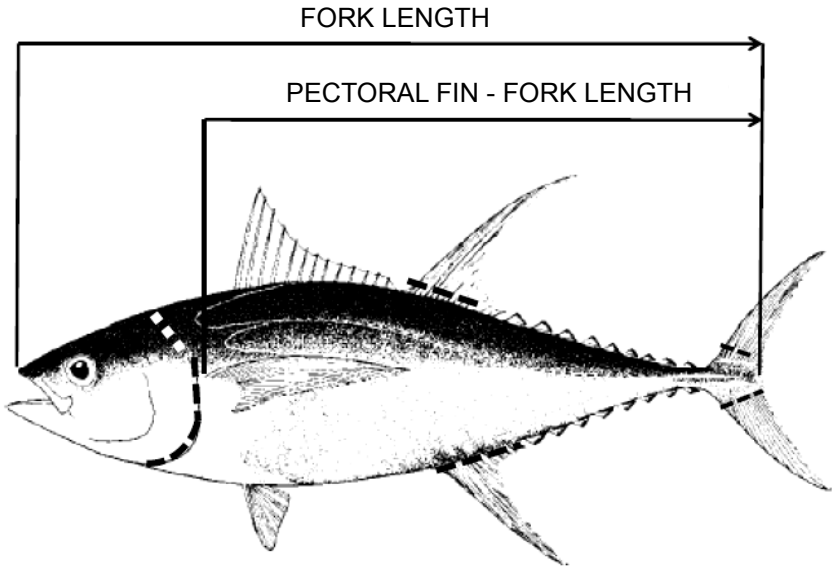

Figure 1 – Illustrative drawing of the yellowfin tuna, *Thunnus albacares*, with the pattern of measurements and the cut-off parts for dressed fishes (adapted from Collette & Nauen, 1983).

measure used in databases of the major management bodies, justifying this study on length conversion.

Thus, this paper aims to provide estimates of the weight x length relationship of *T. albacares* associated to an offshore buoy anchored in the Western Equatorial Atlantic as well as the length conversion to access the actual population structure that is being exploited by that type of fishery.

MATERIAL AND METHODS

The main buoy used in this monitored fishery is located at the position 00°N and 35°W, 323 nautical miles distant from fishing pier at Areia Branca. The fishing craft used is a motorboat with 13 meters in overall length and power engines of about 110 HP. The fishery makes use of a variety of gears that comprises handline, rod-and-line using natural or artificial baits, and trolling with artificial baits.

Data were obtained from May, 2010 to April, 2011 during the landings in the fishing piers and on board during a cruise in February, 2011. The fishes were weighed to the nearest 10 g using a digital scale with a capacity of 30 kg and for measurements of the fork length (FL) and pectoral fin fork length (PFFL) (Figure 1) a 180 cm caliper with accuracy to the nearest 1 cm was used, following the recommendations set out in the ICCAT Manual (2009). To convert the length of the pectoral fin-fork length to fork length, a linear regression equation following the model FL = a + b PFFL was derived and the weight x length relationship was estimated by the formula $WT = A.FL^b$, by fitting log-transformed data to a linear regression model ln WT = ln A + b ln FL for the determination of the parameters a (= ln A, wherefrom $A = e^a$), and the slope, b, which was used for assessing the occurrence of significant difference in relation to its parameter value, b = 3, by means of the Student's t-test ($p < 0.05$).

RESULTS

A total of 348 individuals of yellowfin tuna were landed, with minimum, average and maximum fork length values of 44.0 cm, 78.0 cm and 172.0 cm, respectively. Samples with 174 individuals and 201 individuals were used for estimating the fork length conversion and for deriving the weight x length relationship. The length conversion formula of the pectoral fin fork length to fork length was: FL = 6.0522 + 1.2445 PFFL, with coefficient of determination $R^2 = 0.995$ (Figure 2). By converting the data length, the frequency distribution by fork length classes showing the population structure of *T. albacores* associated with the buoy in the Western Equatorial Atlantic that is caught by the fleet based in Areia Branca (Figura 3).

The weight x length relationship was represented by the potential equation WT = 0.0000223 x

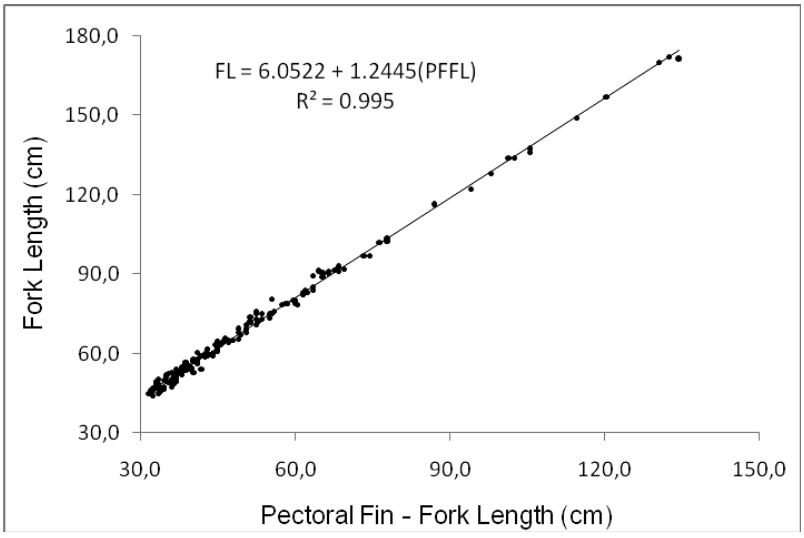

Figure 2 – Linear regression of fork length (FL) on pectoral fin fork length (PFFL) of the yellowfin tuna, *Thunnus albacares*, caught in the Western Equatorial Atlantic.

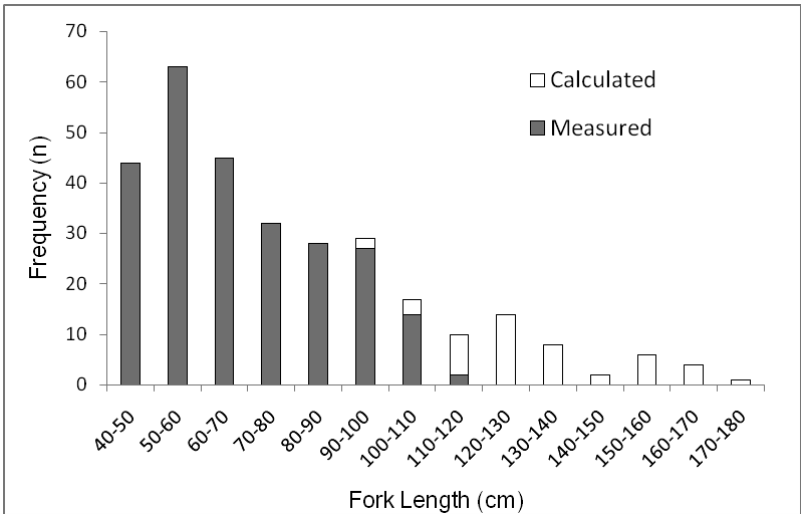

Figure 3 – Fork length frequency distribution of the yellowfin tuna, *Thunnus albacares*, caught in the Western Equatorial Atlantic.

$FL^{2.935}$ (R^2 = 0,999) whose log-transformed version is ln WT = -10.71 + 2.9347 ln FL (r = 0.9977; p < 0.01) (Table I; Figure 4). The *b*-value was statistically different from b=3, indicating a slight tendency to negative allometric growth.

DISCUSSION

The length conversion provides access to the actual length distribution of *T. albacores* exploited by fisheries associated with a fish aggregation device in the Western Equatorial Atlantic. As shown in Figure 3, it can be clearly seen that from the range of 90-100 cm FL class there have begun to emerge in the landings individuals with the head removed, creating the need for conversion to fork length.

Scida *et al.* (2001) report the existence of a conversion equation to estimate the fork length (FL) from the pectoral fin fork length for the bluefin tuna, *Thunnus thynnus*, which is already incorporated as a

Table I - Summary of weight x length relationships of the yellowfin tuna, *Thunnus albacares* in the Atlantic Ocean. WTR - round weight; WTGG - gilled and gutted weight; WTD - dressed weight; Fork length - FL; OCKL – operculum-caudal keel length.

Relationship	Parameters		n	Length range	Authors	Area
	a	b				
WT_{GG}/FL	0.0000223	2.935	201	44-113	Present	Western Equatorial Atlantic
WT_{D}/FL	0.00001659	2.9691	299	83-173	Zhu *et al.* (2010)	Tropical Atlantic
WT_{D}/OCKL	0.0002	2.7859	1870	63-211	Oliveira *et al.* (2005)	Western Tropical Atlantic
WT_{GG} /FL	0.00002	2.932	-	40-190	Costa *et al.* (2005)	Southwestern Atlantic
WT_{R} /FL	0.0002	2.44	407	65-190	Asano-Filho *et al.* (2004)	Western Tropical Atlantic
WT_{R} /FL	0.0147	3.013	71	82-136	Frota *et al.* (2004)	Southwestern Atlantic
WT_{GG} /FL	0.00001293	3.048	234	90-168	Lessa *et al.* (1993)	Southwestern Equatorial Atlantic
WT_{GG} /FL	0.0000661	2.7148	495	40-130	Gaertner *et al.* (1992)	Wester Atlantic South Caribean
WT_{D} /FL	0.0000043	2.3	288	88-164	Davis (1991)	Western North Atlantic
WT_{R} /FL	0.004278	3.3432	79	104-163	Choo (1976)	Eastern Atlantic
WT_{GG} /FL	0.0000218	2.9698	3689	40-170	Lenarz (1971)	Eastern Tropical Atlantic

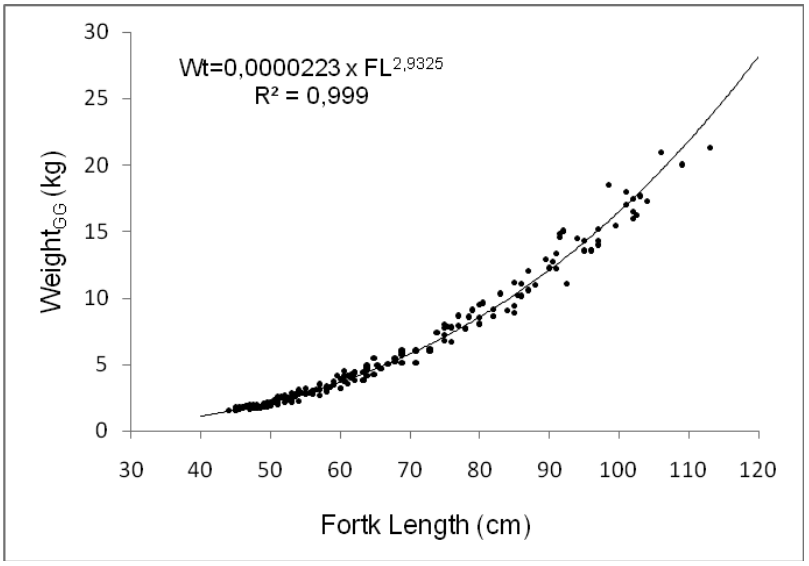

Figure 4 – Weight x length relationship of the yellowfin tuna, *Thunnus albacares*, caught in the Western Equatorial Atlantic.

regulatory measure. However for other species such as *T. albacores* and *T. obesus* which also have the minimum size regulated, there is no conversion equation being used. Oliveira *et al.* (2005) chose to use the relationship between the length of the operculum to the caudal keel on total and fork lengths to estimate the equations of length conversions. Already, Caverivière (1976) established the conversion between the pre-dorsal length and fork length, justifying the fact that the fish suffer various kinds of deformations during processing and storage on board causing bias in the sampling process during the landings.

The concentration of smaller specimens in estimating the weight x length relationship (Figure 4) is accounted by the differential treatment of bigger specimens, with the removal of the head still on board, making it difficult to obtain data on their total weight. Accordingly, the use of larger-sized fish could give slightly different results (Gaertner *et al.*, 1992). In Table I, which presents results of the various studies on weight x length relationship, with the a and b parameters, sample size and length range of *T. albacores* in the Atlantic, we can see that there is great variation in sampled length range, probably depending on the type of fishing gear, a fact that may bring about significant differences in the estimated parameters. Froese (2006) recommends there to be an effort in studies of weight x length relationship for sampling randomly-distributed individuals along the whole size range so as to reduce the chance of bias in the estimation of the regression parameters.

The various ways how the values of weight and length are obtained should be underscored, especially as regards the form and type of measuring gadgets used, such as tapes and calipers, also allowing for lack of information on sampling procedures to that end. Moreover, according to market needs where the individuals of *T. albacores* are landed, one can use various forms of weight. For instance, the thawing a 40 kg "GG" yellowfin tuna will result in a loss of 2-3 kg (Ward & Ramirez, 1992).

Most of the weight x length relationships of *T. albacores* found to date suggest that there is no significant difference between sexes (Lessa *et al.*, 1993; ICCAT, 2009), but. Costa *et al.* (2005) observed differences between sexes in individuals caught by the longline fleet operating in the Southwest Atlantic. Ward & Ramirez (1992), reviewing the weight x length relationship, suggested that such factors as fishing area, season and fishing gear should be taken into account.

Finally, the slight tendency of the negative allometric growth due the statistical difference between the *b*-value and b=3 (isometric growth), presents the same pattern found by Zhu *et al.* (2010) for yellowfin tuna in the Atlantic, which indicates that larger specimens have changed their body shape to became more elongated (Froese, 2006).

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