FIRST STUDIES ON AGE AND GROWTH OF SAILFISH (*Istiophorus albicans*) CAUGHT OFF NORTHEASTERN BRAZIL

[Primeiros estudos sobre idade e crescimento do agulhão-vela, I*stiophorus albicans*, no Nordeste do Brasil]

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ABSTRACT

Sailfish, *Istiophorus albicans*, is the most exploited species among billfishes of the Family Istiophoridae off Northeastern Brazil by industrial, artisanal and sport fisheries. The goal of this paper is to estimate both age and growth curve of this species. Samples were collected from August/1996 to March/1997 from fishing companies, research vessels, artisanal landings, commercial vessels and sport fisheries. Specimens have been caught by drift longline and gillnet, handline and trolling. Total length - TL (cm), eye-keel length - EKL (cm) and dressed weight - Wd (kg) were determined for 126 specimens. Anterior spines of the first dorsal and anal fins were collected in order to analyze the size pattern of these spines, but just the fourth dorsal spine was collected to proceed the counting of the translucent *annuli*. These individuals were 107 to 288 cm long and weighed between 13 and 29 kg. Ages 3 through 10 were observed and a well developed vascularized core matrix was responsible for hiding a high number of first *annuli*. Von Bertalanffy growth curve in length was estimated using FISHPARM Program: $EKL_t = 179.6\,(1 - e^{[-0.1466\,(t + 1.246)]})$, for both males and females together.

Key words: *Istiophorus albicans*, age, growth, billfish, sailfish, Northeast Brazil

RESUMO

O agulhão-vela, *Istiophorus albicans*, é a espécie da Família Istiophoridae mais capturada na Região Nordeste do Brasil, tanto pela pesca industrial como pela pesca artesanal e esportiva. O objetivo deste trabalho foi estimar a idade e a curva de crescimento desta espécie em águas do litoral do Nordeste brasileiro. De agosto de 1996 a março de 1997 amostraram-se 126 agulhões em desembarques de empresas de pesca, em embarcações de pesquisa, a bordo de embarcações comerciais, em desembarques da pesca artesanal e na pesca esportiva. As artes utilizadas na captura dos exemplares foram espinhel e rede de emalhar de superfície, linha de corso e molinete. O comprimento total - TL (cm), o comprimento olho-quilha - EKL (cm) e o peso eviscerado - Wd (kg) foram determinados para cada exemplar. Coletaram-se os primeiros espinhos da primeira nadadeira dorsal e anal para acompanhamento da disposição dos espinhos, selecionando-se o 4º espinho da nadadeira dorsal para contagem dos anéis etários. Os exemplares apresentaram entre 107 e 288 cm, e entre 13 e 29 kg, com idades entre 3 e 10 anos, observando-se uma matriz de absorção muito desenvolvida no espinho, responsável pelo mascaramento dos primeiros anéis. A equação de crescimento de Von Bertalanffy estimada pelo programa FISHPARM foi: $EKL_t = 179,6\,(1 - e^{[-0,1466\,(t + 1,246)]})$, para machos e fêmeas em conjunto.

Palavras-chave: *Istiophorus albicans*, idade, crescimento, agulhão-vela, nordeste do Brasil

Introduction

Since the seventies, the International Commission for the Conservation of Atlantic Tunas (ICCAT) has gathered information about billfishes with the aim of preventing overfishing. More than 90% of landings of this group correspond to incidental catches of longliners that are interested in tunas and swordfishes. According to Hazin (1993), tuna and tuna-like fishery in Western Equatorial Atlantic Ocean from 1983 to 1992 was represented in numeric frequency by: tunas (48.4%), sharks (35.6%) and billfishes (10.5%).

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Nowadays tuna fishery has faced a severe decline and fishery has turned to sharks that represent up to 90% of total landings because of the high price of their fins and flesh.

Since 1995, longliners have also been utilizing drift gillnets responsible by an increase in catches of billfishes off Northeastern Brazil. Because of their wide distribution, being captured by several fishing gears, the study of this specific group, considered as incidental catch, is highly recommended.

In the South Equatorial Atlantic Ocean five species of billfishes are found: sailfish - *Istiophorus albicans*; white marlin - *Tetrapturus albidus*; longbill spearfish - *Tetrapturus pfluegeri*; and blue marlin - *Makaira nigricans* (all belonging to Family Istiophoridae); and swordfish - *Xiphias gladius* (Family Xiphiidae). Sailfish is the most captured species among billfishes of the Family Istiophoridae off Northeastern Brazil, by industrial, artisanal and sport fisheries because of its great abundance over the continental shelf (Nakamura, 1985). It is widely distributed in the tropical and temperate waters (50^0 N to 40^0 S), being usually found in the upper layers of warm water above thermocline.

In Brazil, studies on billfishes have mostly focused on relative abundance, distribution, feeding habits and reproduction. The goal of the present study is to estimate the age and growth curve of sailfish (*Istiophorus albicans*) off Northeastern Brazil.

Material and Methods

The sampling area corresponded to the Northeastern Brazilian Exclusive Economic Zone, limited to the north by Parnaíba River/Piauí State - 2º 40’ S and 41º51’ W - and to the south by Salvador City/ Bahia State - 12º 30’ S and 39º 10’ W (Figure 1).

Sailfishes (*Istiophorus albicans*) were sampled from August/1996 to March/1997, from: a) fishing companies (Norte Pesca S.A./UFRPE Agreement); b) RV.Riobaldo (CEPENE/IBAMA); c) artisanal landings in Natal, Baía Formosa and Caiçara do Norte (RN), and in São José da Coroa Grande (PE); d) by observers on board; e) sport fishery (Natal/RN).

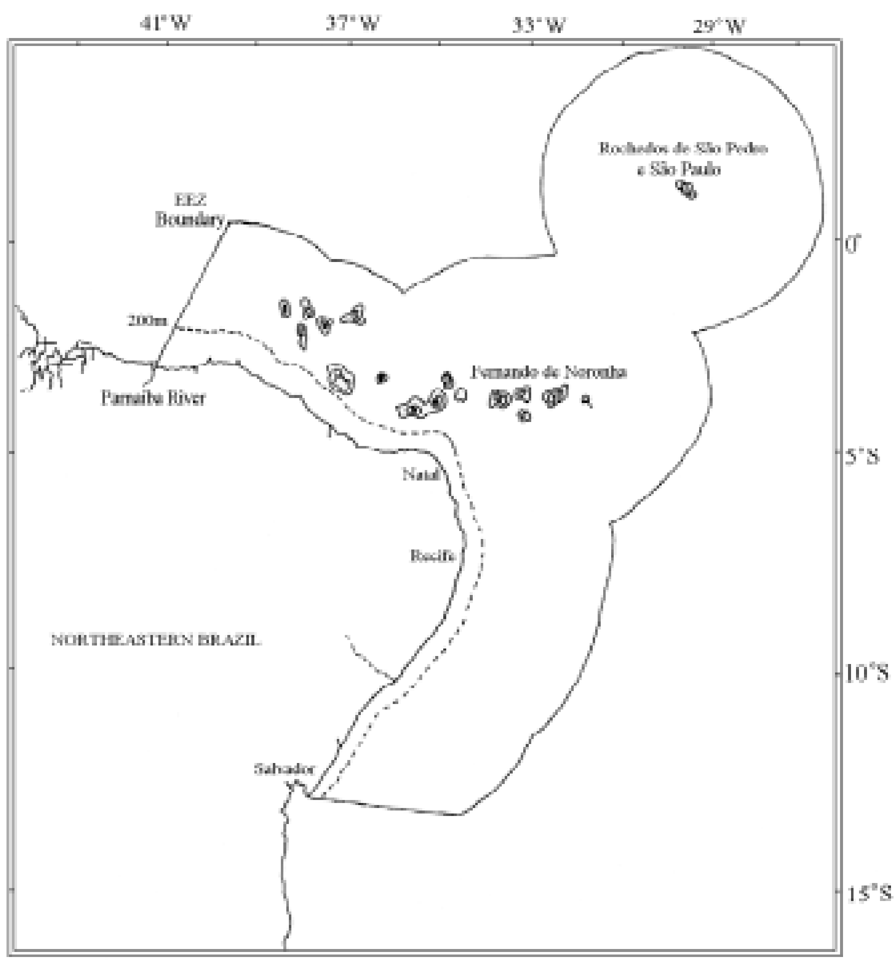

Figure 1. Sampling area of sailfish (*Istiophorus albicans*) off Northeastern Brazil

Fishing gears have included drift longline and gillnet, handline and trolling.

Morphometric data were collected according to Nakamura (1985): a) TL - Total length (cm); b) EKL - Eye-keel or trunk length (cm). A relationship between EKL and TL was estimated.

Structure of the anterior spines of both first dorsal and anal fins was analyzed in order to standardize the methodology for collection. Three small spines were observed in the most anterior part of the first dorsal fin but just the fourth one, bigger than others, was collected to be used in the growth studies (Figure 2). According to Jolley (1977) there are just two of these small spines resulting in some problems in our sampling mainly because sometimes fins were cut in their most basal part. By the other hand, the anal fin has just two small anterior spines.

The fourth spine of the first dorsal fin was collected for the age and growth study and kept frozen. A total of 84 spines were firstly cut just above the condyle by means of hand saw in sections 1cm wide (Table 1). Secondly, these sections were included in polyester resin resulting in small ice-like blocks. These blocks were then cut by hand saw or emery down to 3-5 mm wide and finally had their width decreased down to 1mm using sand paper. Afterwards, these fine sections received a layer of gum (with cyanoacrilate) in each side for protection and better viewing of *annuli*.

Translucent *annuli* were counted under stereoscopic microscope using both transmitted and incident light. For consistency, three independent readings were carried out. The precision of this analysis was assessed using the average percent error (APE) approach: $APE = 100\{1/N*S\{1/R[S(|X_{ij}-X_j|/X_j)]\}\}$ where: X_{ij} = i^{th} count for the j^{th} fish; X_j = average count for the j^{th} fish; R = number of counts for each fish; N = total number of fishes aged (Beamish and Fournier, 1981).

Spine radius (SR) and distance between each *annulus* (R_n) and spine focus were determined. Relationship between these measurements was estimated using the average observed EKL to each spine radius range according to the methodology presented by Jolley (1977): EKL = a + bSR, where: a = intersection to y axis; b = slope. The significance of the correlation coefficient of this relationship was tested using Student t-test (Zar, 1984). In this step, 51 spine sections were considered; the others were not included due to inconsistency in the independent readings.

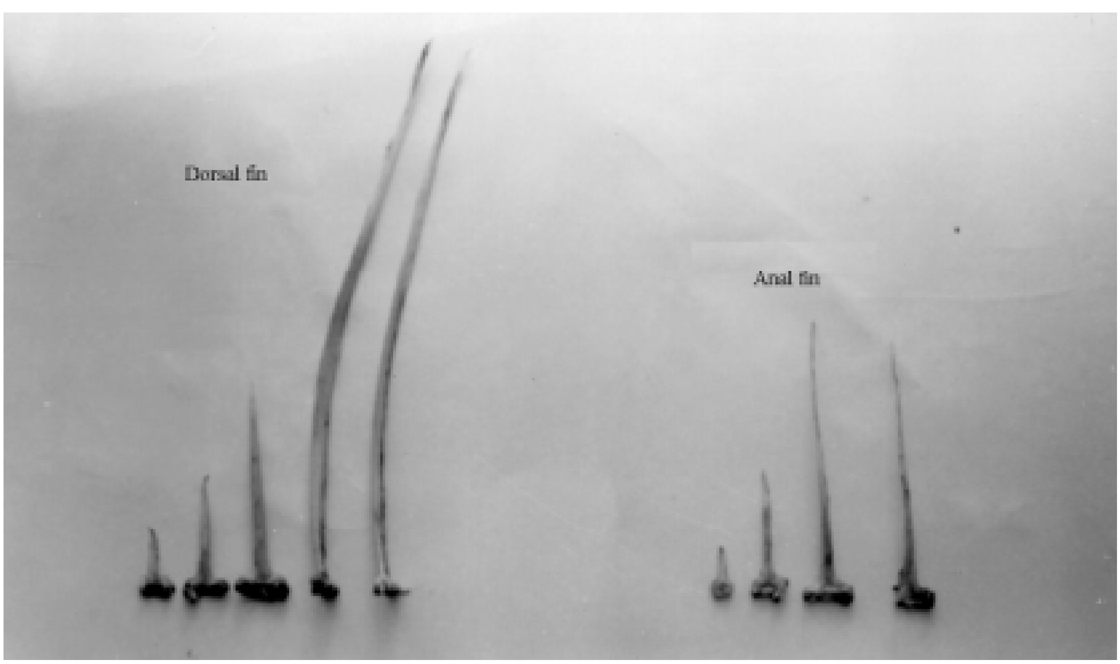

Figure 2. Structure of the first spines of the dorsal and anal fins of sailfish, *I. albican,* (left to right)

Table 1. Number of sections of the fourth dorsal spine of sailfish *Istiophorus albicans* in each month

	1996				1997			TOTAL
Date	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	
Number of spine sections	4	56	12	0	4	5	3	84

The back calculated eye-keel length was estimated according to Bagenal and Tesch (1978): $EKL_n - a = (R_n/SR) * (EKL - a)$, where: EKL_n = eye-keel length in the moment of the formation of the n^{th}-*annulus*; EKL = eye-keel length in the moment of the catch; a = correction factor (from previous equation); R_n = distance between each *annulus* and the spine focus; SR = spine radius.

The number of lost rings because of vascularized matrix was estimated through the displacement of the back calculated eye-keel length to each age in electronic sheet. This displacement was made in order to coincide the maximum number of length measurements for each age class, using the spine with the first *annulus* visible as a pattern (restricted vascularized matrix). The number of empty cells was related to the number of missing rings, and thus, it was possible to estimate the real age for each fish sampled (Mello, 1992).

Vascularized central matrix was very wide and it was responsible for the great difficulty in the reading of the *annuli*. In some cases double *annuli* were observed and some spines seemed to have two nuclei with concentric *annulii* around each of them. In other cases spines were too soft like a ray and it is suggested that fourth spine of dorsal fin was not always collected but some posterior.

Finally, the average back calculated lengths in each age class were utilized in Fishparm Program (Prager, Saila and Recksiek, 1989) in order to estimate the von Bertalanffy growth curve: $EKL_t = EKL_{\infty} (1- e^{-K(t-to)})$, where: EKL_t = eye-keel length related to age t (cm); EKL_{∞} = asymptotic eye-keel length (cm); K = curvature parameter; t = age (years); to = initial condition parameter that determines the point in time when the fish has zero length.

Results and Discussion

A total of 126 sailfishes were sampled, ranging between 107 and 288 cm TL, 89 and 160 cm EKL, and 12.9 and 28.8 kg Wd (Figure 3 **a** and **b**). Most of them were between 160 and 260 cm TL, with a frequency distribution unimodal for length and bimodal for weight.

Relationship between spine radius (SR) and eye-keel length (EKL) was: EKL = 44.138SR - 37.843 (Figure 4). The correlation coefficient (r = 0.72) was considered statistically significant ($p<0.05$). The average percent error (APE) was 11.2%, indicating the precision of three independent readings.

Back calculation was just developed to 51 spine sections and back-calculated lengths for each age class are presented in Table 2. A maximum of 6 *annuli* were hidden by vascularized matrix and estimated age ranged from 3 to 10. Approximately 55% of all spine sections analyzed corresponded to 7 and 8 age class. Jolley (1977) has found age classes from 0 to 8 years to the Northwest Atlantic sailfish (*I. platypterus*) but it was suggested a maximum of 9 or 10.

No validation method was attempted and the usage of the marginal increment method was not possible as 80% of specimens were sampled between October and November (Table 1). However *annulus* formation was considered to be annual according to Jolley (1977).

After the displacement of back calculated eye-keel length in electronic sheet, length range, average value and intervals between average minus and plus standard deviation were analyzed (Figure 5). An increase in average length related with age class was

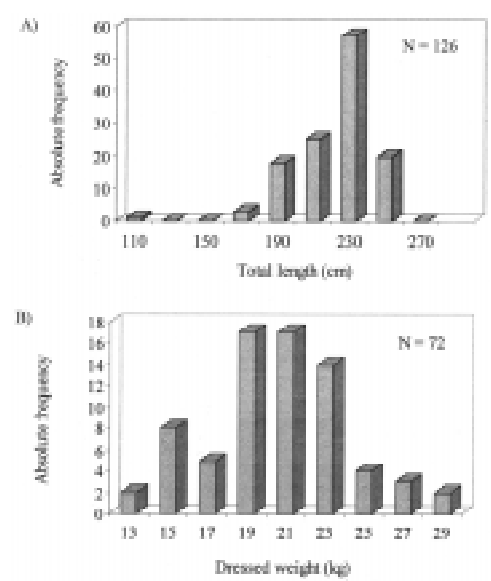

Figure 3. Absolute frequency distribution: A) Total length (cm) e B) Dressed weight (kg) for sailfish, *I. albicans*

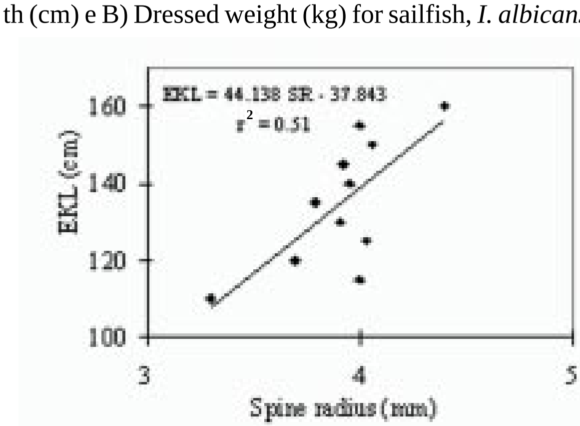

Figure 4. Relationship between eye-keel length (EKL) e spine radius (SR) for sailfish, *I.albican*

Table 2. Absolute (FA) and relative (FR) frequency of age classes observed and the average EKL (cm)

Age class	1	2	3	4	5	6	7	8	9	10	TOTAL
FA	0	0	1	0	1	8	16	12	9	4	51
FR (%)	0	0	2.0	0	2.0	15.7	31.4	23.5	17.6	7.84	100
Average EKL	50.9	64.1	88.0	96.8	107	117.1	125.5	130.9	140.6	146.1	-

observed following the pattern of a von Bertalanffy growth curve. The small overlap among these ranges indicates that the method of displacement could be considered acceptable.

Average back calculated eye-keel length related with each age class according to Table 2 was used to estimate von Bertalanffy growth curve for both males and females together (Figure 6):

$$\mathbf{EKL_t = 179.6\ (1 - e^{[-0.1466\ (t + 1.246)]})}$$

Hedgepeth and Jolley (1983) have found different growth curves to males and females of the Northwestern Atlantic sailfish (*I. platypterus*): $EKL = 147(1 - e^{[-0.3014 (t + 1.959)]})$ and $EKL = 183 (1 - e^{[-0.1586 (t + 3.312)]})$, respectively (Figure 7). Growth of sailfish in Brazilian waters seems to be slower than in North Atlantic. The asymptotic length corresponds to 350 cm TL according to equation below (Figure 8) and the maximum registered for this species is 315 cm TL (Nakamura, 1985). According to Taylor (1958), the observed maximum length corresponds to 95% of the asymptotic length that can be estimated as 167.9 cm EKL, very close to that estimated by Fishparm.

Prince *et al.* (1986), based in tag-recaptured sailfish, have pointed out that it has a longevity of 13-15 years. This result indicates that this species has slow growth, resulting in a low k-value, that is related to highly migratory pelagic teleosts. Vaske Jr. (1992) has found a growth coefficient (K) of 0.145 (FL_{∞} = 207.3 cm) to yellowfin tuna (*Thunnus albacares*) and Mello (1992) has obtained a value of 0.075 to female swordfish with $LJFL_{\infty}$ = 290.3 cm (*Xiphias gladius*).

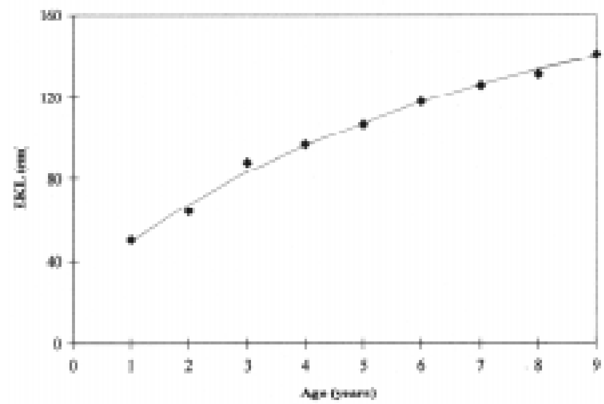

Figure 6. Growth curve in length for sailfish (*I. albicans*) off Northeastern of Brazil (EKL = eye-keel length)

Growth curve estimated in this study must be considered as the first attempt to analyze growth of *Istiophorus albicans* in Brazilian waters, as males and females were grouped.

Conclusions

- Estimated age was from 3 to 10 years and average was 7.5.
- Fourth spine of first dorsal fin was considered suitable for age readings although vascularized matrix is very

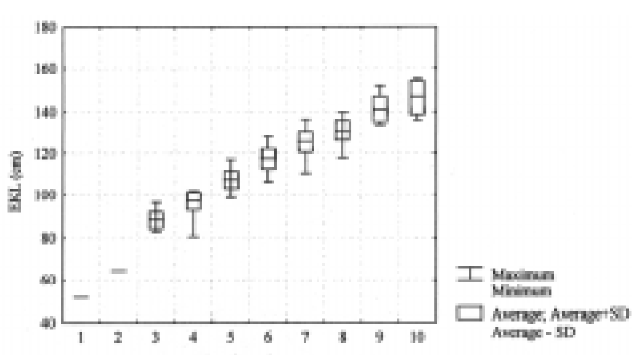

Figure 5. Values of eye-keel length (EKL) minimum, maximum, average and average plus/minus standard deviation (SD) for each age class of sailfish (*I.albicans*), based in back-calculated lengths

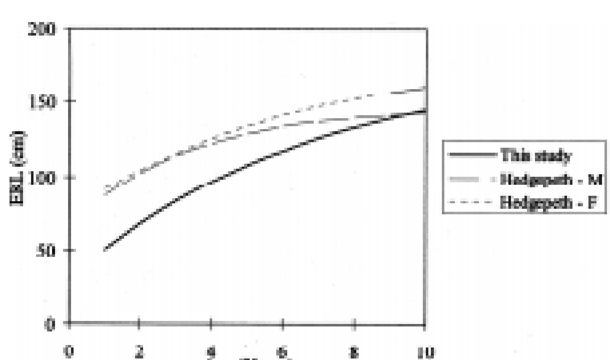

Figure 7. Comparison between the growth curve estimated in this study and those estimated by Hedgepeth and Jolley (1983) for males (M) and females (F)

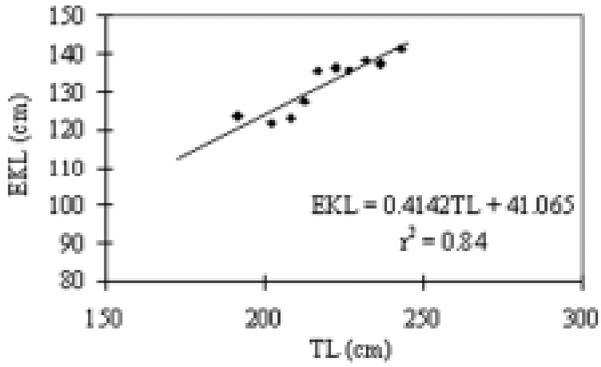

Figure 8. Relationship between eye-keel length and total length for sailfish (I. albicans)

developed and responsible for hiding up to 6 *annuli*.
- Estimated von Bertalanffy growth curve of *Istiophorus albicans* for males and females together was: $EKL_t = 179.6\ (1 - e^{[-0.1466\,(t+1.246)]})$.

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