

REPRODUCTIVE CHARACTERISTICS OF BLACKFIN TUNA *THUNNUS ATLANTICUS* (LESSON, 1831), IN NORTHEAST BRAZIL

Kácia R. Vieira¹, Jorge E. Lins Oliveira¹, Maisa C. Barbalho¹, José Garcia Jr.¹

SUMMARY

The blackfin tuna represents one of the most important fishing resources of Northeast Brazil. By the purpose of analyze the reproductive characteristics of this species, monthly samples were caught, during the period from September 2000 to January 2001. There were analyzed 632 specimens. The total length, the weight, the determination of the sexes and sexual maturity, were also considered. The obtained results were: the estimated average length for gonadal maturation showed that females reached the gonadal maturity at 51 cm. The widths of monthly values of gonado somatic relation (GSR) ranged from 42,48 in September to a maximum of 247,04 in December. The average values of the condition factor (K) ranged from 0,00339 to 0,00755; the absolute fecundity a mean of 1.541,841 oocytes; It was observed that the number of males and females in advanced process of maturation was predominant. The spawning was classified as total, considering the frequency of the oocyte diameter and the progress of oocyte development. Therefore, according to the obtained results about the reproductive aspects, we can infer that coastal waters of the Northeast of Brazil are a reproduction area for the blackfin tuna, and the migration done by this species can be characterized as reproductive.

RÉSUMÉ

Le thon à nageoires noires représente l'une des principales ressources halieutiques du Nord-Est du Brésil. Afin d'analyser les caractéristiques reproductrices de cette espèce, des échantillons mensuels ont été prélevés, entre septembre 2000 et janvier 2001 et 632 spécimens ont été analysés. La longueur totale, le poids, la détermination des sexes et la maturité sexuelle ont également été examinés. Les résultats obtenus ont indiqué que : la longueur moyenne estimée pour la maturation gonadale a montré que les femelles atteignaient la maturité gonadale à 51 cm. Les gammes des valeurs mensuelles du rapport gonadosomatique (GSR) ont oscillé entre 42,48 en septembre et un maximum de 247,04 en décembre. Les valeurs moyennes du coefficient de condition (K) ont fluctué de 0,00339 à 0,00755 ; la fécondité absolue a présenté une moyenne de 1.541,841 ovocytes. Il a été observé que le nombre de mâles et de femelles en état avancé de maturation prédominait. Le frai a été classifié comme total, compte tenu de la fréquence du diamètre de l'ovocyte et de son évolution. C'est pourquoi, d'après les résultats obtenus sur les aspects reproductifs, nous pouvons en déduire que les eaux côtières du Nord-Est du Brésil sont une zone de reproduction pour le thon à nageoires noires, et que la migration effectuée par cette espèce peut être caractérisée comme reproductrice.

RESUMEN

El atún de aletas negras se encuentra en el océano Atlántico, desde el Norte de Estados Unidos hasta el Sudeste de Brasil. El objetivo de este estudio es analizar los aspectos de una población dinámica individual capturada por los pescadores artesanales de Rio Grande do Norte, durante el periodo de septiembre de 1999 hasta enero de 2001. Los parámetros utilizados en este estudio fueron las longitudes totales, las longitudes a horquilla y el peso total de 946 especímenes. La longitud total media fue 61,1 cm para las hembras, 64 cm para los machos y 63 cm para ambos sexos combinados. La relación entre longitud a horquilla y longitud total fue: para las hembras $TL = 1,3381 + 1,0449 FL$; para los machos $TL = 1,3456 + 1,0449 FL$; y para ambos sexos combinados $TL = 1,2496 + 1,0459 FL$. La relación entre el peso total y la longitud total fue: para las hembras $TW = 0,0255 TL^{2,8438}$, para los machos $TW = 0,0108 TL^{3,0588}$ y para ambos sexos combinados $TW = 0,0128 TL^{3,0165}$. La proporción de sexos hallada fue 2,1:0,5. Los resultados permiten llegar a la conclusión de que la población de atún de aletas negras se caracteriza por un crecimiento alométrico. Muestra una proporción de sexos diferenciada con mayor abundancia de machos, lo que indica mayores promedios de longitud total y peso total.

KEY WORDS

Reproductive characteristics, Blackfin tuna, Sexual maturity, Spawning, Fecundity

¹ Oceanographic and Limnology Department, UFRN; E-mail: kaciarrv@bol.com.br

1. Introduction

The blackfin tuna (*Thunnus atlanticus*) is a pelagic fish of the Scombridae family and it is a very important resource in the Northeast of Brazil. It is the only tuna species that it is only found in the Western Atlantic, living mainly along coastal waters, in temperatures above 20°C (Collete and Nauen 1983).

There is an annual concentration of the blackfin tuna along the southern coast of Rio Grande do Norte during the second half of the year, which increases the artisanal fishing, usually done by small motorized boats and traditional sail boats.

In any fishing activity planning, from the point of view of scheduling, reproduction aspects should be considered, for this allows the planning for the best season for capture and also to be outside the spawning season (Hazin *et al.* 1997).

According to MARQUES *et al.* (2000), variations in the reproductive behavior reflect the adaptation, of certain organisms, imposed on them by the environment and can be used as a standard for the maintenance mechanism of fishing stocks.

Therefore, this study has one main objective and that is a deep understanding about the reproductive aspects of the blackfin tuna, and end result of possible legislation to regulate fishing of this species and also the maintenance of this important resource.

2. Material and methods

The present study was done on the Southern coast of Rio Grande do Norte, during the local fleet off-loading from September 2000 to January 2001. In this study, 632 specimens were sampled and analyzed by the total length (TL), fork length (FL), weight (W), and the gonads were extracted to define the sex and sexual maturity.

In the laboratory, the weight of gonads was measured and classified according to Vazzoler (1996), Campos (2000) and Vieira (2002) methodology and macroscopic characters (size, coloration, presence of blood vessels, the aspect and oocytes size, turgid stage, the arrangement among other organs and the semen presence in males) in four maturation classes I = immature or virgin, II = initial maturation, III = mature and IV = spent.

The average length of the first sexual maturity (L_{50}) was estimated in agreement with the methodology proposed by Santos (1978) and Vieira (2002).

The gonado somatic relation (GSR) was defined as the quotient between the weight of gonads and the fish weight, represented by the following equation: $GSR = Wg/W \times 100$. The condition factor was calculated using the equation proposed by VIEIRA (2002): $K = W/TL^b$.

For the estimation fecundity, 20 female gonads were used in an advanced maturity stage. For that reason, three parts of each gonad were removed weighing between 0,200 to 0,500mg. Further more, all parts were immersed in a modified Gilson solution, according to SIMPSON (1951) dissociated and then fixed in 70% alcohol and placed on Bogorov tray, where the oocytes were counted, using a stereomicroscope. The absolute fecundity was estimated using a simple rule of three, involving the weight of each part, the oocytes in each part and the weight of gonads. The total number of oocytes was calculated in each ovary.

The relationships between fecundity and the values of total length (TL), weigh (W) and the gonadal weigh (GW) were established. The spawn type was estimated according with the method proposed by Aguilar & Malpica (1993) and Vazoller (1996).

3. Results and discussion

It was observed, that the females of class II were present every month, with the higher percentage in September (83%); October showed the largest percentage of specimens on class IV (48%). No specimens in class III were observed in September. Females I were found in October and December, but in very low percentages, 9,5% and 4,4%, respectively (**Figure 1-A**).

The maturation frequency of the classes showed a higher concentration of males II and III, for the whole sampling period, being higher in December (66%) for class II and 58% in October for class III. The class IV was observed monthly, except in September. Immature specimens were only found in December (4%). (**Figure 1-B**). The gonads maturity classes found are in agreement with Monte (1964) and Freire *et al.* (1998) descriptions, in studies done also with the blackfin tuna.

According to **Figure 2**, the total length of 50% (L_{50}) of all females, that start the maturation process, is 51,0 cm. However, it was observed that, above 57,5 cm (L_{100}), all females are able to participate on the reproductive process. Monte (1964) and Freire *et al.* (1998) estimated, for both sexes of *T. atlanticus*, a L_{50} starting from 50cm of total length. The *Katsuwonus pelamis* reaches its sexual maturity at 40 cm, according to studies done in the Caribbean by Pagavina (1994).

The monthly distribution of the gonado somatic relation (GSR) indicates that a lower variation value was observed in September, for females (42,47 to 108,76) and males (7,13 to 80,98). There was a higher variation value in December, for males (8,15 to 257,04) and females (24,48 to 177,98); suggesting an advanced maturation process in the ovaries, where females are probably mature, getting ready for a possible spawn; indicating the month of higher reproduction activity. These results agree with Freire *et al.* (1998) results for the same species. Pagavino (1994), in studies done with *Katsuwonus Pelamis* in the Caribbean Sea, obtained similar results.

The average monthly value of the condition factor (K) was low, varying from 0,00339 to 0,00755. According to Agostinho (1985), the reduction in the value of the condition factor, during the spawn season, has been attributed to species that perform courting habits, migration, spawn area construction and care of offspring. The blackfin tuna is within the category of the migratory species.

When the condition factor is related to the GSR, it was verified that an inverse relation doesn't occur in any month (**Figure 3**). In this way, high values of GSR and low values of the condition factor were found, it can be concluded that this is the probable reproduction season of the blackfin tuna.

The lowest absolute fecundity value observed was of 224,708 oocytes of a specimen that was 52 cm of total length, 1800g of total weight and 18,58 mg of gonadal weight. The higher fecundity was 4.874,389 oocytes of a specimen with 72,2cm, 5800g of total weight and 260,06mg of gonadal weight. The average absolute fecundity was 1.451,841 oocytes.

There are few studies about the *T. atlanticus* fecundity. It can be verified that a large variations are in the fecundity values are found on in this study and in similar studies of the same species (**Table 1**).

The variation in the fecundity factor can be explained through several reasons: the size of the sample used, the oocytes count starting from different ovary sizes, different methods used to estimate the fecundity, and other reasons. Báez-Hidalgo & Bécquer (1994) mention that this species can reach high fecundity values because of its biology, e.g., its life habits, adaptation for migratory activities, being a characteristic that denotes this group. It can be considered a reproductive strategy, seeking a guaranty for the maintenance of the population.

The estimated fecundity by the *T. atlanticus* was associated to the total length (TL), weigh (W) and gonad weight (GW). It was verified that these relationships were positive, and considered as a potential type for the total and lineal length either for the female weight or for the weight of gonads. However, the fecundity has a better relationship with the weight of gonads (**Figure 4**).

Analyzing the frequency distribution of the oocyte diameter of *T. atlanticus*, two oocytes lots were verified: a reserve stock and another in the maturation process. This frequency distribution can be classified as total spawning. The hypothesis of the total spawning was also confirmed by microscopic analysis, which show that the gonad maturation process found in the ovaries of the blackfin tuna allowed the classification of the ovaries as synchronic. According to Wallace & Sellman (1981), there is a relationship between the type of the ovarian development and the type of spawn so species that have synchronic ovaries are those with total spawn. Hunter (1986), in studies done with the *Katsuwonus pelamis*, also confirmed the type of spawn using histological analysis.

4. Conclusions

The most abundant classes were II and III of maturation, increasing the gonado-somatic relation (GSR) values, but with a low condition factor (K). These parameters were used as indicators of a probable reproduction season,

which was the whole study period, with a peak in December, where the largest variation values of GSR were obtained. The fecundity was very high and the spawn was classified as total, which was demonstrated by the synchronic evolution of the oocytes.

Therefore, according to the obtained results about the reproductive aspects, we can infer that coastal waters of the Northeast of Brazil are a reproduction area for the blackfin tuna, and the migration done by this species can be characterized as reproductive.

References

- AGOSTINHO, A.A. 1985. Estrutura da população, idade, crescimento e reprodução de *Rhinelepis aspera* (AGASSIZ, 1829) (Osteichthyes, Loricariidae) do rio Paranapanema, Paraná. Brasil. Dissertação de doutorado. Universidade Federal de São Carlos, São Carlos 229p.
- AGUILAR, E.TA and Z.G.C. Malpica. 1993. Biología Pesqueira. 1^o Edição. Trujillo : Editora Libertad, 432p.
- BÁEZ-HIDALGO, M. and Bécquer, U. 1994. Fecundidade del bonito *Katsuwonus pelamis* (Linnaeus) y la albacora *Thunnus atlanticus* (Lesson) en Cuba. *Rev. Invest. Mar.* 15(3). 218- 222p.
- CAMPOS, C.E.C. 2000. Aspectos populacionais e reprodutivos do saramuneto, *Pseudupeneus maculatus* Bloch, 1973 (Osteichthyes: Mullidae), em Ponta de Pedra, Pernambuco. Dissertação de Mestrado. UFRN. 99p.
- COLLETTE, B.B. and C.E. Nauen. 1983. FAO species catalogue Scombrids of the world. An annotated and illustrated catalogue of tunas mackarels, bonitos and related species known to date. FAO Fish. Synop, 125 (2):137 pp.
- FREIRE, K.M.F., J.E. Lins Oliveiira and R.P.T. Lessa. 1998. Aspectos reprodutivos da Albacorinha (*Thunnus atlanticus*) no Nordeste do Brasil. *II Workshop REVIZEE Nordeste. Univ.Federal de Pernanbuco*, Pág: 93.
- HAZIN, F.H.V., S.M.G. Matos, B.M.J. Pedrosa, J.E. Lins Oliveira and J.A. Vascoscelos. 1997. Diagnóstico da pesca artesanal marítima do Estado do Rio Grande do Norte. FUNPEC-UFRN, 78 p.
- HUNTER, J. R, B.J. Macewicz and J.R. Sibert. 1986. The Spawning frequency of Skipjack tuna, *Katsuwonus pelamis*, from the South Pacific. U. S. Fish. Bull.84 (4): 895-903.
- MARQUES, D.K.S., I.L. Rosa and H.C.B. Gurgel. 2000. Descrição histológica de gônadas de traíra *Hoplias malabaricus* (Bloch) (OSTEICHTHYES, ERYTHRINIDAE) da barragem do Rio Gramame, Alhandra, Paraíba, Brasil., *Ver. Brás. Zool.* 17 (3): 573-582.
- MONTE, S. 1964. Observações sobre a estrutura histológica das gônadas da albacorinha, *Tinos atlanticus* (Lesson), no Nordeste do Brasil. *Biol. Inst. Mar.* UFRN, V.1p. 17-31.
- PAGAVINO, M. 1994. Nota sobre la reproducción del atún listado (*Katsuwonus pelamis*) Instituto Oceanográfico de Venezuela.SCRS/94/182.
- SANTOS, E.P.dos. 1978. Dinâmica de populações aplicadas à pesca e piscicultura. São Paulo, HUCITEC, USP. 129 p.
- SIMPSON, A.C. 1951. The fecundity of the plaice. *Fish. Invest. London*, ser. 2, 17 (5): 27.
- VAZZOLER, A.E.A.M. 1996. Biología da Reprodução de peixes Teleósteos: Teoria e prática. EDUEM, Maringá. 169p.
- VIEIRA, R.R.K. 2002. Dinâmica populacional e reprodutiva da albacorinha, *Thunnus atlanticus* (LESSON, 1831) no Município de Baía Formosa (Rio Grande Do Norte –Brasil).Dissertação de Mestrado. UFRN. 106p.

WALLACE, R.A. and K. Sellman. 1981. Cellular and dynamic aspects of oocyte growth in teleosts. *Amer. Zool.*; V.21, P. 325-343.

Table 1. Distribution of the lengths minimum, maximum and it measured of blackfin tuna for combined sex.

<i>Authors</i>	<i>Local</i>	<i>TL Minimum</i>	<i>TL Maximum</i>	<i>TL Mean</i>
CRUZ & PAIVA (1964)	Brazil (Northeast)	51	80	65,5
MONTE (1964)	Brazil (Northeast)	51	80	65,6
COOL (1987a)	Cuba	26,5	78,5	45,5
ZAVALA-CAMIM (1991)	Brazil (Southeast)	36	73	54,5
BÁEZ-HIDALGO & BÉCQUER (1994)	Cuba	27	79	52,3
FREIRE <i>et al</i> (1998)	Brazil (Northeast)	36,5	86	61,3
This study	Brazil (Northeast)	46	86	63

Table 2. Equations of the correlations among fork length (FL)/total length (TL), total weigh (TW)/total length (TL).

<i>Sex</i>	<i>Equations</i>	<i>R²</i>
Females	TL = 1,3381 + 1,0432 FL	0,980
	TW = 0,0255 TL ^{2,8438}	0,884
	Ln TW = - 3,6687 + 2,8438 ln TL	0,884
Males	TL = 1,3456 + 1,0449 FL	0,980
	TW = 0,0108 TL ^{3,0588}	0,902
	Ln TW = - 4,5251 + 3,0588 ln TL	0,902
Combined sexes	TL = 1,2496 + 1,0459 FL	0,980
	TW = 0,0128 TL ^{3,0165}	0,902
	Ln TW = - 4,3589 + 3,0165 ln TL	0,902

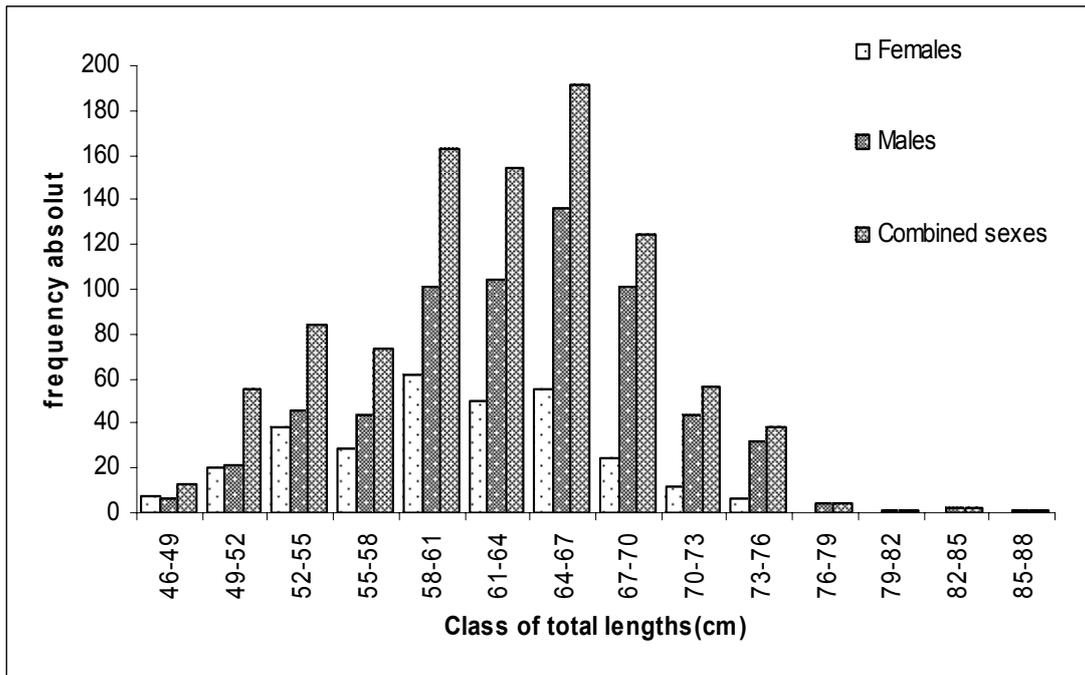


Figure 1. Distribution in class of total length for females, males and combined sexes of blackfin tuna.

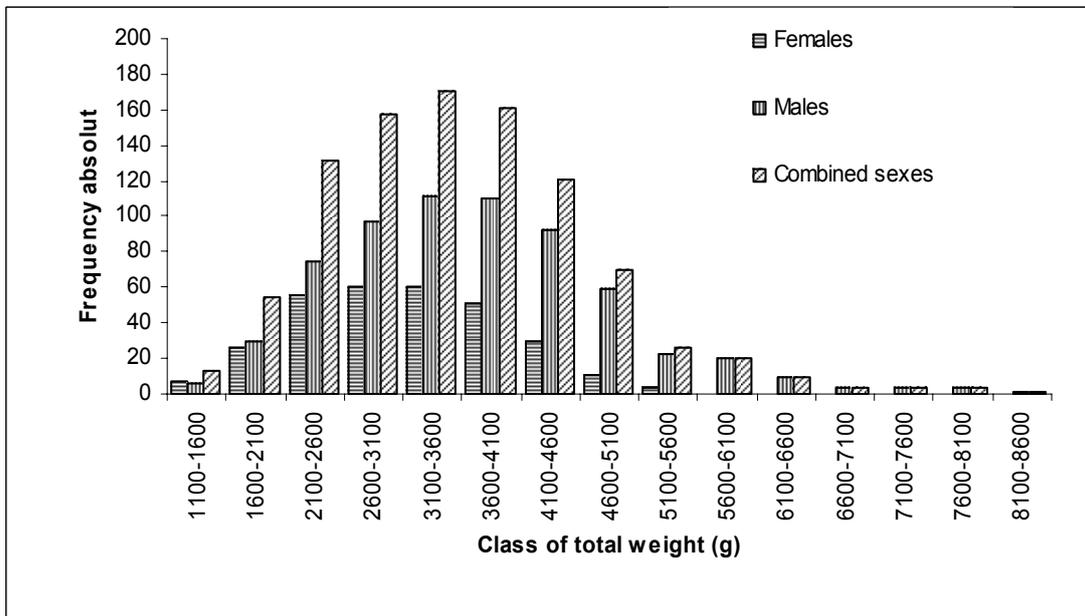


Figure 2. Distribution of class of total weight for females, males and combined sexes of blackfin tuna.