

FISHERY BIOLOGY OF *TETRAPTURUS* (OSTEICHTHYES, ISTIOPHORIDAE) CAUGHT BY SÃO PAULO LONGLINERS OFF SOUTHERN BRAZIL¹

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SUMMARY

In the southern Atlantic Ocean, three species of Tetrapturus are grouped and traded as white marlin by longliners based in Santos/Guaruja Cities, São Paulo State, Brazil. To identify this genus, 18 landings were monitored from January to December, 2009. A total of 85 samples were analyzed. Tetrapturus albidus represented 84.7% of the samples and the highest CPUE was observed in October (0.83 per thousand hooks). Tetrapturus georgii was 10.6% and November (0.15) was the most representative CPUE. Tetrapturus pfluegeri was 4.7% with higher CPUE in September (0.15). The largest individuals were T. albidus, with carcass length between 93 and 159 cm. Individuals of T. georgii ranged from 111 to 159 cm and of T. pfluegeri, from 108 to 135 cm. This study aimed to analyze the participation of the T. albidus, T. pfluegeri and T. georgii caught from a fleet of longliners from São Paulo State, Brazil. The misidentification of the three species in the longline fishing activity may affect the management plan, conservation policy and population assessment of these species, requiring strict monitoring to determinate the rates of individuals for this genus.

RÉSUMÉ

Dans l'océan Atlantique Sud, trois espèces de Tetrapturus sont regroupées et commercialisées comme makaira blanc par les palangriers basés dans les villes de Santos/Guaruja, état de Sao Paulo, Brésil. Afin d'identifier ce genre, 18 débarquements ont fait l'objet d'un suivi de janvier à décembre 2009. Un total de 85 échantillons a été analysé. Le Tetrapturus albidus représentait 84,7% des échantillons et la plus forte CPUE a été observée en octobre (0,83 pour mille hameçons). Le Tetrapturus georgii représentait 10,6% et c'est en novembre (0,15) que la CPUE était la plus représentative. Le Tetrapturus pfluegeri représentait 4,7% et la plus forte CPUE s'est produite en septembre (0,15). Le plus gros spécimen était le T albidus, la longueur de la carcasse s'établissant entre 93 et 159 cm. Les spécimens de T. georgii oscillaient entre 111 et 159 cm et ceux de T. pfluegeri entre 108 et 135 cm. La présente étude visait à analyser la distribution du T. albidus, du T. pfluegeri et du T. georgii dans les captures d'une flottille de palangriers originaires de l'état de Sao Paulo, Brésil. L'identification erronée des trois espèces dans les activités de pêche palangrière pourrait affecter le plan de gestion, la politique de conservation et l'évaluation des populations de ces espèces, nécessitant un strict suivi pour déterminer les proportions de spécimens pour ce genre.

RESUMEN

En el océano Atlántico meridional, tres especies de Tetrapturus spp. se agrupan y comercializan como aguja blanca por parte de los palangreros con base en las ciudades de Santos/Guaruja, Estado de São Paulo, Brasil. Para identificar este género, se realizó un seguimiento de 18 desembarques desde enero a diciembre de 2009. Se analizaron en total 85 muestras. El Tetrapturus albidus representaba el 84,7% de las muestras y la mayor CPUE se observó en octubre (0,83 por mil anzuelos). El Tetrapturus georgii representaba el 10,6% y noviembre (0,15) era la CPUE más representativa. El Tetrapturus pfluegeri representaba el 4,7% y la CPUE más elevada era en septiembre (0,15). Los ejemplares más grandes eran de T. albidus, con una talla de carcasa entre 93 y 159 cm. Los ejemplares de Tetrapturus georgii oscilaban entre 111 y 159 cm y los de T. pfluegeri entre 108 y 135 cm. Este estudio tenía como objetivo analizar la distribución del T. albidus, T. pfluegeri y T. georgii capturados por una flota de palangreros del Estado de São Paulo, Brasil. La identificación errónea de las tres especies en las actividades pesqueras del palangre podría afectar al plan de ordenación, a la

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política de conservación y a la evaluación de la población de estas especies, por lo que se requiere un seguimiento más estricto para determinar la proporción de ejemplares para este género.

KEYWORDS

Billfish, Marlin, Spearfish, Body size, Catch/effort, Tuna fisheries, Commercial fishing

Introduction

According to Arocha and Ortiz (2006), the genus *Tetrapturus* consists of six species and three of them occur in the Southern Atlantic Ocean such as *Tetrapturus albidus* Poey, 1860; *Tetrapturus georgii* Lowe, 1840; and *Tetrapturus pfluegeri* Robins and de Sylva, 1963.

T. albidus, known as agulhão-branco by longliners and as white marlin in sport fishing (Arfelli *et al.*, 1994). It occurs in tropical and subtropical regions, including the Brazilian coast (Miyake and Hayasi, 1972; Antero-Silva *et al.*, 1994). *T. albidus* also occurs occasionally in the Mediterranean Sea and in temperate zones of the Atlantic Ocean (Arocha and Ortiz, 2006). It is consumed in countries in the Caribbean, Africa and especially in Japan, where it has good commercial value (ICCAT, 2001). In Brazil, the *Instrução Normativa-IN N° 12, SEAP* (Secretaria Especial de Aquicultura e Pesca), 14/07/2005 prohibits the marketing of this species, which it is included in Lista de Espécies Constantes na Tabela de Produção da Pesca Extrativa Marinha – IBAMA (2007).

T. georgii (*roundscale spearfish*) was first recorded in the Mediterranean Sea, in the Sicily and the Strait of Gibraltar regions, and in North Atlantic waters of Madeira Islands (Nakamura, 1985). Perhaps this species is widely distributed in the Atlantic, but due to the similarities with *T. albidus*, it may not have been identified in commercial catches. This is because most identification guides does not include the description of the roundscale spearfish (Shivji *et al.*, 2005), since only recently was it validated using molecular biology by Shivji *et al.* (2006). In the Southeast and South of Brazil, morphological differences in both pectoral and dorsal fins of white marlin were notice by Arfelli *et al.* (1986). In the South Atlantic, the first records of roundscale spearfish occurred during the sport fishing tournament of "Cabo Frio Marlin Invitational XVI", Rio de Janeiro State, and landings of the tuna fleet based in São Paulo State (Piva-Silva *et al.*, 2009). Domingo *et al.* (2009) reported the occurrence of *T. georgii* in the southwest Atlantic, based on longline fleet catches in Uruguay.

T. pfluegeri (longbill spearfish) is widely distributed in tropical, subtropical, and occasionally in temperate waters of the Atlantic (40°N to 35°S). This species has concentrations in Venezuela and Suriname and dispersions in the Gulf of Mexico and Southeastern U.S.A. (Arocha and Ortiz, 2006). Despite its rare occurrence, the longbill spearfish is captured in tuna fishing in the Southeast and South of Brazil (Arfelli *et al.*, 1994).

The lack of differentiation between *T. albidus* and *T. georgii* in statistics of sporting and commercial fishing population may affect the assessment to quantify the species and, consequently, to implement management plans for billfish. Therefore, it is important to determine the occurrence rates of each species in the yield.

This study aimed to obtain fishery-biological data on the genus *Tetrapturus* to identify and quantify *T. albidus*, *T. pfluegeri* and *T. georgii* marketed as white marlin, based on landings of the longliners fleet in São Paulo State.

Materials and Methods

The samples were collected from January to December 2009, by monitoring landings of tuna fishing boats that use a surface longline as fishing gear. The boats belong to the fishing company ItaFish Transporte e Comércio de pescado Ltda., located in the city of Guarujá, São Paulo State.

The coordinates of fisheries of the genus *Tetrapturus* were obtained from board maps used by the fishermen in the boats. The capture points were plotted in a map using the ArcGIS software.

We carried out the biometrics and weighing of carcasses (fish are gutted and headless) at the place of landing. To measure the length, we considered the distance from the rear of the operculum to the fork length (OPL). The distance between the anus position, the origin of the first anal fin (AP-OAF1), and the height of the first anal fin (HAF1) were also measured. All the measurements were taken using a measuring tape in centimeters, and are shown in **Figure 1**. The carcass weight was obtained in kilograms using the scale of the company.

The identification was based on morphological differences. The fish were identified by the distance of the anus position to the origin of the first anal fin and the height of the anal fin according to Arocha and Ortiz (2006), as follows: White Marlin (*T. albidus*): AP-OAF1 distance less than 50% of HAF1; Roundscale spearfish (*T. georgii*): AP-OAF1 distance between 50-75% of HAF1; Longbill spearfish (*T. pfluegeri*): AP-OAF1 distance similar to HAF1

The billfish occurrence in tuna catches in 2009 was calculated using the weight of the total yield based on log commercial sheets of the referred company. We calculated the relative rate for each species of the genus *Tetrapturus* based on the number of identified individuals landing from January to December in 2009.

Length frequency distributions were made monthly, quarterly and annually for the three species, with 10 cm class amplitude. To compare with other studies, the lengths were converted into LJFL (lower jaw - fork length, **Figure 1**). To obtain the relation with OPFL and LJFL, we measured 15 individuals of *T. albidus*, eight during the 2010/2011 sport fishing season at the Iate Clube do Rio de Janeiro, in the city of Cabo Frio, Rio de Janeiro State and seven from a research cruise conducted in December 2009, in the Oceano Brasil boat, belonging to the longliner fleet based in São Paulo State. The data generated an expression:

$$OFL = 1.572 * (LJFL)^{0.85858}$$

which was logarithmized :

$$\ln OFL = \ln 1.572 + 0.8558 * \ln LJFL$$

Where:

OFL: distance from the rear of the operculum to the fork length

LJFL: distance from the lower jaw to the fork length

The Catch Per Unit Effort (CPUE) was calculated monthly and yearly for the number of the three species of the genus *Tetrapturus* using only data from fishing trips when catches were observed. To compare the CPUEs of previous periods, we also calculated the CPUE for the three species grouped. The CPUE measured for number of fish per thousand hooks is represented by the following equation:

$$CPUE = (C / E) * 1000$$

Where:

C= number of fish

E= number of hooks

Results and Discussion

During the year 2009, the total yield of longliner fleet of São Paulo State was 291.1 t, being 99.8 t (34.3%) of billfish. Among the billfish, swordfish (*Xiphias gladius*) represented most catches (93.8%), followed by species of the genus *Tetrapturus*, which accounted for 4.1% of the catches, blue marlin (*Makaira nigricans*) 1.9% and sailfish (*Istiophorus platypterus*) 0.2%.

Eighteen landings were monitored (54.5% of total) of the longliner fleet based in São Paulo State, which operated between 23°-33°S and 33°-49°W (**Figure 2**), from January to December 2009. We identified 85 individuals of *Tetrapturus*, 72 (84.7%) of *T. albidus*, nine (10.6%) *T. georgii* and four (4.7%) *T. pfluegeri*.

In 2009, the landing probably did not reflect the occurrence of *T. albidus*, because of the implementation of *IN 12*, which prohibits the commercialization of white and blue marlin (*Makaira nigricans*). Part of the catch of these species was rejected. According to Antero-Silva *et al.* (1994), between 1971-1991, the rate of species in the genus *Tetrapturus* that landed in São Paulo was 2% of the total catch, and in this study, we observed a rate of 2.1% (4.1 t). Possibly all fish caught were sold. After the prohibition, billfishes began to be marketed headless, hindering its identification. According to ICCAT (2001), even after the implementation of *IN 12*, these fish species continue to be marketed, not only in São Paulo, but also throughout the country, as the national catches recorded for the period 2005-2010 amounted 509 t.

The three species investigated in this study are distributed throughout the Atlantic Ocean and because of their migratory characteristic; they are captured in several countries, in different areas (Oliveira *et al.*, 2007). Domingo *et al.* (2009), studied tuna fisheries in Uruguay (19°-40°S and 20°-54°W) and identified 301 *T. albidus*, being 9% at 34°S, 80% between 25°-31°S and 40°-48°W, and 11% between 23°-31°S and 20°-36°W.

Bernard *et al.* (2012) identified 14 specimens of *T. georgii* using DNA sample analyses and confirmed its occurrence between the 37°41'N and 28°52'S and 56°00'W to 27°58'W, in Central North and Southwestern Atlantic. Domingo *et al.* (2009) registered the occurrence of the *T. georgii* further South (31°58'S). *T. pfluegeri* has geographical limits of occurrence between 40°N and 35°S (Arocha and Ortiz, 2006). According to Domingo *et al.* (2009), most catches this species (n=191) occurred between 25°- 33°S and 40° - 48°W, at the Rio Grande Bank, Rio Grande do Sul State, Brazil. The area where the individuals in our study were captured overlays the area cited in the literature.

In our study, we observed differences of occurrence of *Tetrapturus* compared to reports from Domingo *et al.* (2009), who observed between 1998 and 2007, 61.3% (n = 301) of *T. albidus*; 1.2% (n = 7) *T. georgii* and 37.5% (n=191) of *T. pfluegeri*. *T. georgii* had a relatively low occurrence because this species started to be identified in the Uruguayan tuna fishing only in November 2007. The major difference in participation of *T. pfluegeri* is probably because this species is more oceanic (Arocha and Ortiz, 2006) and the longliner fleet based in São Paulo operates closer to shore.

The specimens of *T. albidus* measured 93- 159 cm, with an average of 123.3 ± 10.1 cm and most individuals (n = 66) remained between classes 110.1- 140 cm (**Figure 3**). The *T. georgii* sampled ranged from 111- 156 cm, with an average of 130.1 ± 13.3 cm and the highest occurrence (n = 6) was observed between classes from 120.1- 140 cm. The four specimens of *T. pfluegeri* identified were between 108- 135 cm long, with an average of 119 ± 11.5 cm.

T. albidus occurred throughout the year, showing a wide size variation with specimens from 90.1- 100 cm class to 150.1- 160 cm class. Its occurrence was higher in the 2nd quarter (n = 23) in the 110.1- 120 cm class, and the 4th quarter (n = 31), in the 120.1- 140 cm class. The smallest individuals were recorded in the 1st quarter and the largest ones in the 4th quarter. *T. georgii* occurred in the 3rd quarter (n = 1), in the 150.1- 160 cm class, and 4th quarter (n = 8), in the 110.1- 140 cm class. The specimens of *T. pfluegeri* occurred in the 2nd quarter (n = 2) in the 110.1- 120 cm class, and 3rd quarter (n = 2) in the 100.1- 110 cm and 130.1- 140 cm classes (**Figure 4**).

Catches of *T. albidus* occurred mainly in May (n = 11), June (n = 9) and October (n = 22). The smallest specimens were caught in May, November and December, in the length classes from 90.1 to 110 cm (OFL) and the largest, in the 140.1 to 160 cm class in October. *T. georgii* occurred mostly in July (n = 9) and November (n = 4). The smallest fish (110.1 to 120 cm) was identified in October and November, and the largest in September (150.1 to 160 cm) and November (130.1 to 140 cm). *T. pfluegeri* was captured only in June (n = 2), August (n = 1) and September (n = 1). The smallest specimen of *T. pfluegeri* (110.1 to 110 cm) was recorded in August and the largest (130.1 to 140 cm) in September. The monthly frequency of distributions by length of the three species can be observed in **Figure 5**.

The catches of *T. albidus* recorded in this study do not seem to reflect the seasonality of the species, because according to Arfelli *et al.* (1986), it is most abundant from October to December. *T. albidus* was present throughout the year, with most occurrences in the 2nd and 4th quarters. Arfelli *et al.* (1986) reported that the species is found throughout the Brazilian coast, and in the Southeast-South, it is caught throughout the year, with increased frequency in the 3rd and 4th quarters. The specimens collected by Arocha *et al.* (2007) in the 4th quarter were mainly in 150- 175 cm length class (LJFL), similar to most individuals analyzed (160 to 190 cm LJFL).

T. albidus was more frequent and abundant in the warm months, probably due to the time and area for reproduction (Arfelli *et al.*, 1986). Catches of *T. georgii* and *T. pfluegeri* were very little making it impossible to establish a distribution pattern.

After converting OFL to LJFL, *T. albidus* showed lengths between 118-220 cm with an average of 162.1 ± 15.9 cm. Its main occurrence was in 2nd quarter (n = 19), in the 150.1 to 160 cm class and in the 4th quarter (n = 31), in the 160.1 to 170 cm class.

In tuna fishing in Venezuela, carried out in the Caribbean Sea and western Atlantic, the range of lengths for *T. albidus* was lower than that obtained with a 150 cm average (LJFL) (Arocha *et al.* 2001). According to Arocha and Ortiz (2006), the size of first maturation for *T. albidus* is 153.2 cm LJFL, which allows to infer that the samples studied here were mostly adult fish, since the average length obtained was 162.1 + 15.9 cm.

The grouped species of *Tetrapturus* shows monthly CPUE peaks in January (1.6) and October (2.3) and reached 0.6 (number/per thousand hooks) annual CPUE. The nominal CPUE of *T. albidus* showed peaks in June (0.68) and October (0.83), *T. georgii* in September (0.08) and November (0.15). The catch of *T. pfluegeri* was concentrated in the months of June (CPUE = 0.15), August (0.03) and September (0.08) (**Figure 6**).

According to Amorim *et al.* (1998), CPUE (kg/per thousand hooks) of *T. albidus* landed by the longliner fleet of São Paulo State showed a decreasing trend from 1972 (77.2) to 1982 (12.2), followed by an increasing trend until 1991 (73.6), decreasing again until 1994 (21.4). This study showed that the CPE of *T. albidus* in this tuna fishing was low (0.02 kg/1000 hooks) in 2009, compared to CPUEs in previous years. However, the CPUEs presented by Amorim *et al.* (1998) were obtained from log commercial sheets in which the three species are grouped by the lack of identification. Probably these CPE values only for *T. albidus* must be even smaller.

T. georgii and *T. pfluegeri* are not included in the list of species in the Tabelas de Produção da Pesca Extrativa Marinha – IBAMA, which can lead to inadequate management, possibly because they are grouped as *T. albidus*. Due to the grouping of these species, it is necessary to monitor and correctly identify these species.

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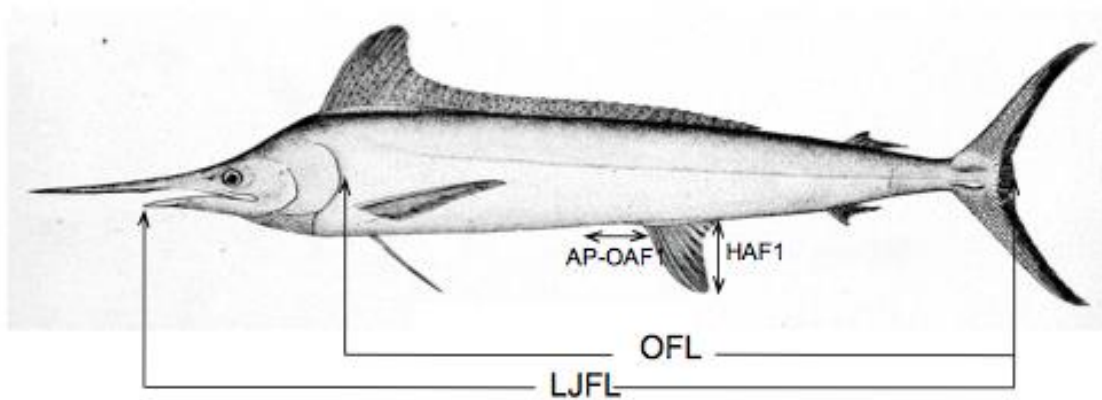


Figure 1. Biometrics (LJFL: lower jaw fork length; OFL: operculum fork length; AP-OAF1: distance from anus position to 1st anal fin; HAF1: high of 1st anal fin).

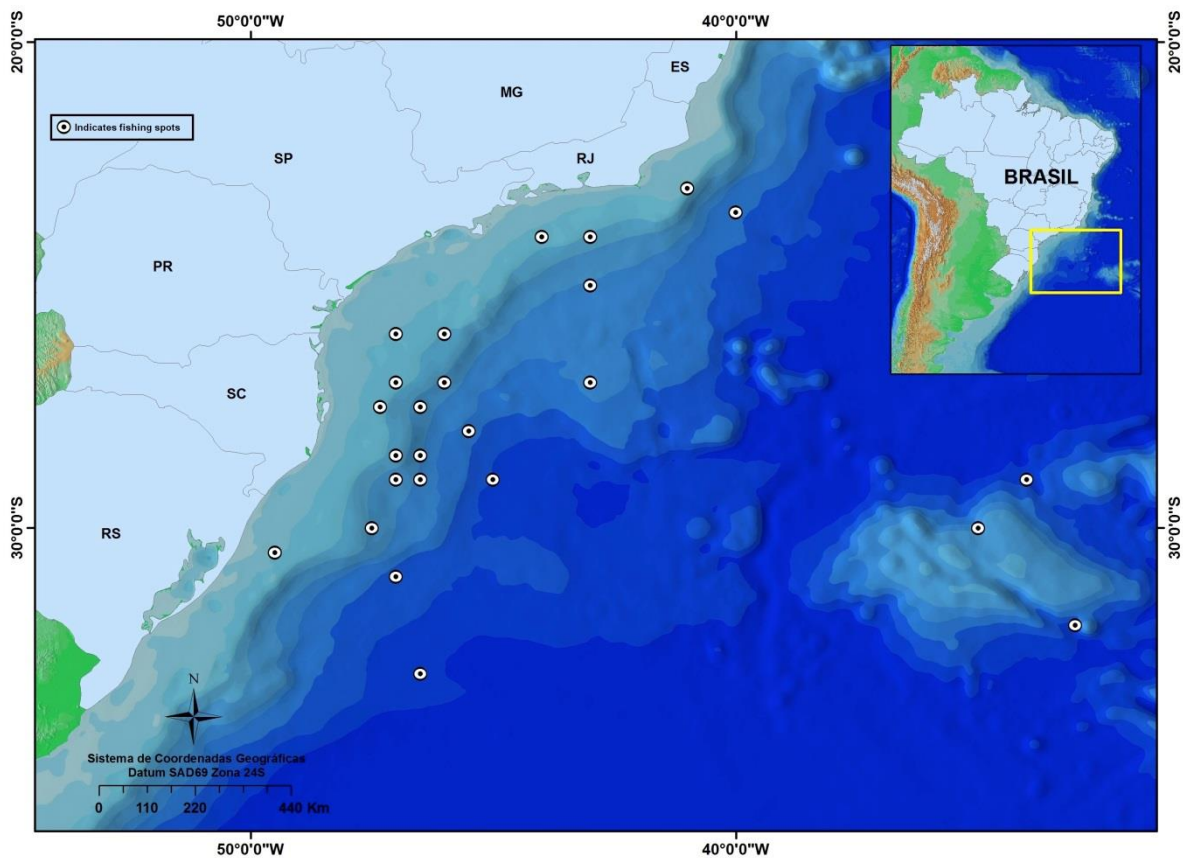


Figure 2. São Paulo longliner fishing area (Jan-Dec/2009).

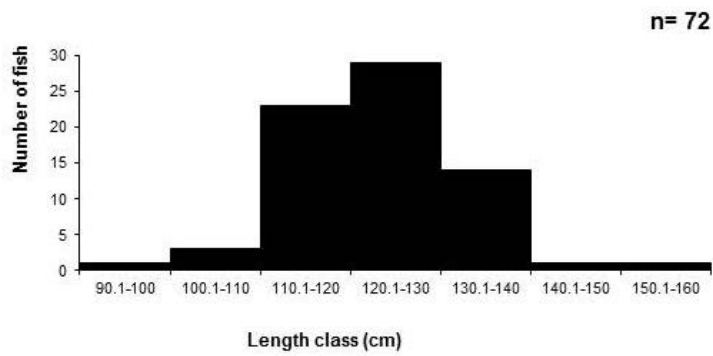


Figure 3. Frequency of annual length distribution frequency of *Tetrapturus* (Jan-Dec/2009).

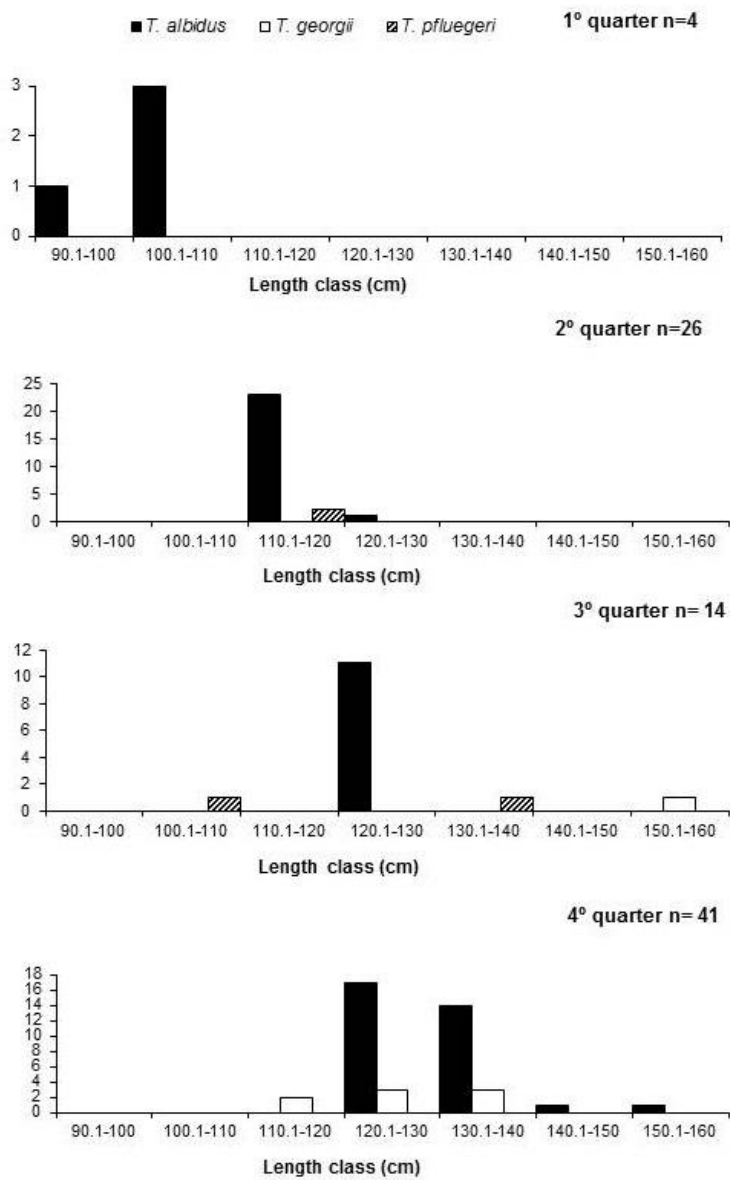


Figure 4. Length distribution frequency of *Tetrapturus* (Jan-Dec/2009) per quarter.

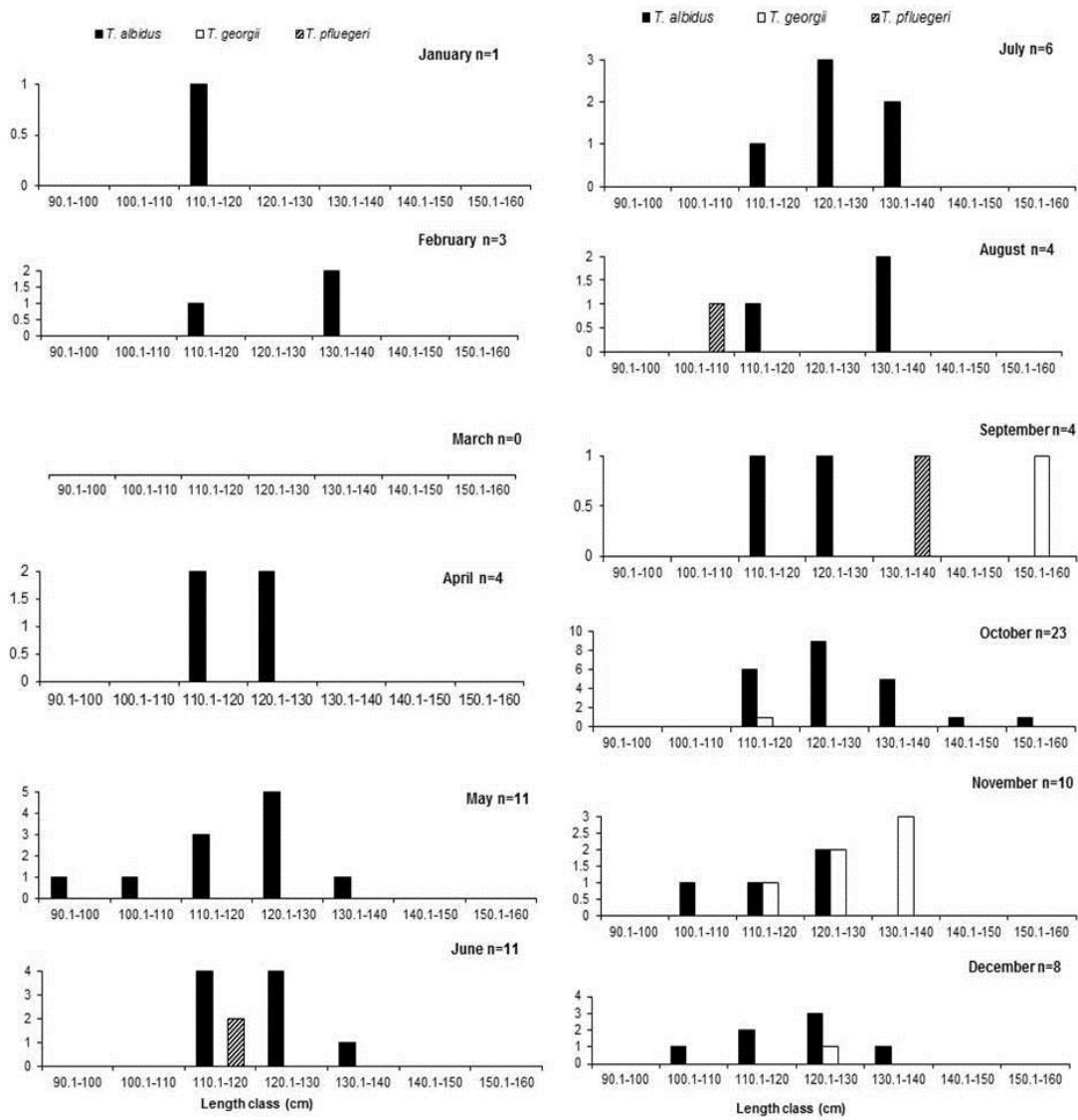


Figure 5. Length distribution frequency of *Tetrapturus* (Jan-Dec/2009) per month.

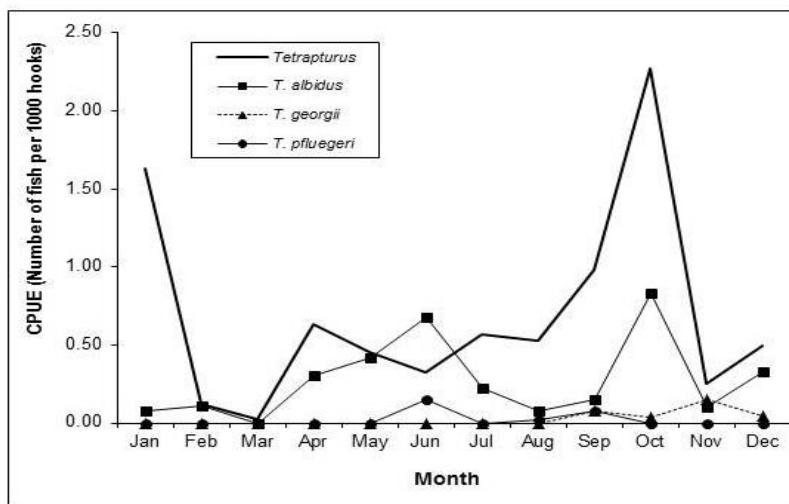


Figure 6. CPUE in number of *Tetrapturus* (Jan-Dec/2009) per month.