FISHERY ANALYSIS ON SHORTFIN MAKO, *Isurus oxyrinchus*, OFF SOUTHEAST AND SOUTH OF BRAZIL (ELASMOBRANCHII: LAMNIDAE)[1]

Análise da pesca do anequim, *Isurus oxyrinchus*, nas regiões Sudeste e Sul do Brasil (Elasmobranchii: Lamnidae)

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RESUMO

Foi analisada a pesca do anequim capturado por barcos atuneiros sediados em Santos (SP), Brasil (18° 33' S - 35° 51' W) durante os anos de 1971 a 1990. A captura anual em peso de carcaça (sem cabeça, vísceras, guelras e nadadeiras) variou de 13,3 t , em 1975, a 138,3 t , em 1990, sendo que o peso médio de carcaça neste período variou de 41,0 kg (1984) a 51,2 kg (1977). O esforço de pesca anual esteve dentro do intervalo de 430 mil anzóis (1972) a 3 milhões (1990). A CPUE nestes anos variou de 0,6 (1982) a 1,8 indivíduos/ mil anzóis (1988). A captura acumulada mensal em peso variou de 45 t, em fevereiro a 116 t, em novembro. O esforço de pesca acumulado variou de 1,3 milhões (fevereiro) a 2,7 milhões (novembro) e a CPUE esteve dentro do intervalo de 0,4 (janeiro) a 1,1 indivíduos/ mil anzóis (setembro). De abril a novembro, as capturas em peso e em número foram maiores, porém o peso médio diminuiu. A relação peso eviscerado/ comprimento peitoral-caudal foi: $WT = 5{,}69.10^{-5} Lc^{2{,}86}$. As maiores frequências de comprimento peitoral-caudal estiveram nas classes de 90 a 150 cm, principalmente nas classes de 110 a 130 cm.

Palavras-chaves: *Elasmobranchii,* Isurus oxyrinchus, *biologia pesqueira, Sudeste/Sul do Brasil*

ABSTRACT

The mako shark fisheries by Santos (SP) longliners, operating in the area 18°33' S- 35°51' W, from 1971 to 1990, were studied. The annual catch in dressed weight (without head, gut, gill and fins) fluctuated from 13.3 t, in 1975 to 138.3 t, in 1990. The average weight ranged from 41 kg (1984) to 51.2 kg (1977). The fishing effort has increased from 430 thousand hooks (1972) to 3 million hooks (1990). The CPUE (number per thousand hooks) ranged from 0.6 (1982) to 1.8 (1988). The lowest monthly cumulative catch occurred in February (45 t and 869 fishes) and the highest in November (116 t and 2,643 fishes). The monthly cumulative fishing effort ranged from 1.3 million (February) to 2.7 million (November). The CPUE ranged from 0.4 (January) to 1.1 (September) fish per thousand hooks. From April to November the catches in weight and number were higher, but the mean individual weight decreased. The pectoral-caudal length/ dressed weight relationship was: $DW = 5.69\ 10^{-5}\ Lc^{2.86}$. The highest annual frequencies of pectoral-caudal length were in the classes among 90 and 150 cm, but mainly 110 to 130 cm classes.

Key words: *Elasmobranchii,* Isurus oxyrinchus, *fisheries biology, South-Southeastern Brazil*

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INTRODUCTION

The shortfin mako, *Isurus oxyrinchus*, is one of the most common shark species of Brazilian coast and other parts of the world. It is found in all oceans, at temperate, semi-temperate and tropical regions.

Males show sexual maturity beyond 195 cm TL, growing up to 284 cm, and the females have their sexual maturity around 280 cm, growing up to 400 cm TL. The total length at birth is around 60 to 70 cm (Bigelow & Schroeder, 1948; Stevens, 1983; Compagno, 1984).

There are few studies on the fishery of this species, although it is commercially caught around the world and also in Brazil. The main fishing effort on this species is done by longliners. The shortfin mako is among the main species of sharks caught in the North Atlantic, Pacific and Brazilian coast (Compagno, 1990; Hoff & Musick, 1990; Bonfil *et al.*, 1990; Amorim, 1992; Bonfil, 1994).

Taniuchi (1990), describing the tuna fishery of Japanese boats, reported that shortfin mako is the fourth most abundant species among the elasmobranchii, where its yield is about 6.5% of the total elasmobranch catch in the Indian Ocean, 2.9% in the Western Pacific and 6.8% in the Eastern Pacific.

Hazin *et al.* (1990), studying the distribution of pelagic sharks in the Northeastern Brazilian coast, showed that the yield of sharks corresponded to 38% of the total catch of the local longliners. The most abundant species was the blue shark, *Prionace glauca*, with 39.2% of the total shark catch, whereas the shortfin mako catch corresponded to 2.5% of this total.

Bonfil *et al.* (1990) analyzed the shark fishery in Mexico, which represents the fourth highest catch of sharks in the world. They found that the most abundant species, were *Rhizoprionodon terranovae, Sphyrna tiburo, Mustelus norrisi* and *Carcharhinus falciformis*, corresponding to 66,1% of the total yield, whereas the yield of *Isurus oxyrinchus* was very low (less than 2%). Compagno (1990) reported that in the elasmobranch fishery in the USA, shortfin mako is among the main species caught, with *Alopias vulpinus, Squatina californica, Notorynchus cepedianus* and *Galeorhinus galeus*. They added that very little is known about shortfin mako fishery in the world, and that for many sports anglers it is considered an excellent fish to be caught, being ranked with sailfish or marlin (Istiophoridae).

Based on the same data source of the present paper, Amorim & Arfelli (1992) and Amorim *et al.* (in Press) found that the main species of sharks caught were: *Prionace glauca* (blue shark), *Isurus oxyrinchus* (shortfin mako), *Alopias superciliosus* (bigeye thresher), *Sphyrna lewini, S. zygaena* (hammerhead shark), and 11 species of *Carcharhinus*. From 1971 to 1975, sharks represented 13.5% of the total yield of these boats (10 t / year). This percentage reached 51 % of the total catch in 1985.

Antero-Silva (1993), studying the occurrence of sharks in the tuna fleets landing in Rio Grande (Rio Grande do Sul state - Brazil), noticed that sharks represented 18.9% of the total catch (1971 to 1991) by the Japanese boats, 9.41% (1991) by the Taiwanese boats and 50% (1982 to 1987) of the catches by the Brazilian fleet. *Prionace glauca* (4.,8%), *Carcharhinus* spp (27.2%), *Sphyrna* spp (9.2%), *Isurus oxyrinchus* (6.9%), *Alopias vulpinus* (0.5%) and other sharks (9.4%) were the main species landed in Rio Grande.

The goal of this paper is to analyze the fishery biology of shortfin mako caught by Santos longliners in the period from 1971 to 1990.

MATERIAL AND METHODS

Individual dressed weight (without head, gut, gill and fins) of shortfin makos, from 1971 to 1990, was obtained from fishing companies settled in Santos, São Paulo State (Brazil). Data on fishing effort (number of hooks) were collected from the files of the "Instituto de Pesca", in Santos.

In order to obtain the relationship between dressed weight (DW) and pectoral-caudal length (Lc), data of 80 specimens (24 males and 56 females) examined at Santos Fishing Terminal, in 1992 were utilized (figure 1). It showed a better fit to an expression of the type:

$$Y = A X^{b},$$

where the parameters **A** and **b** were estimated by the method of minimum squares from the logarithmic transformation:

$$\ln Y = \ln A + b \ln X$$

The length-frequency distribution was done by converting the 22,827 individual dressed weight into pectoral-caudal length, and grouping by class of 10 cm interval, for the period 1971-90. The classes were identified, in the text and figures, by their respectives upper limits.

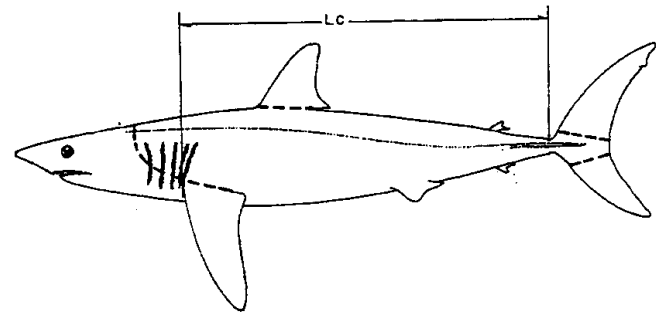

Figure 1 - Shortfin mako, *Isurus oxyrinchus*: dotted lines indicate the fish dressed (Lc= pectoral-caudal length).

The yearly length-frequency distributions from 1971-90, were very similar and therefore they were gathered in only one distribution.

In order to obtain a preliminary estimation of total length (TL) for the individuals caught by Santos fleet, to compare with literature data and identify the proportion between young and adults, it was calculated a relationship between Lc and TL. This relationship was based on data of seven specimens examined, five at a research trip, on board of the longliner TAIHEI MARU III from march 20 to 5 April of 1992, and two newborns individuals received from other longliner. It showed a better fit to an expression of the type:

$$Y = A X^{b}$$

The total catch in number of individuals was analyzed by year and by month. In the annual analysis, the total sum of the years was made by adding the individual data along the months of each year; and the total of the months was made by adding each month along all years (1971-1990).

The average pectoral-caudal length were calculated, by year, month and quarter.

The fishing effort, as the number of hooks utilized, was calculated by year and month.

The catch per unit of effort (CPUE) was calculated annually and monthly, in number of fish per thousand hooks.

The annual data of total catch (in weight) and CPUE were plotted against the correspondent effort value, for the period 1971-90.

RESULTS AND DISCUSSION

The pectoral-caudal length/dressed weight relationship (figure 2) of 80 individuals (24 males and 56 females) of shortfin mako, was:

$$DW = 5.69\ 10^{-5}\ Lc^{2.86}$$

obtained from the logarithmic transformation:

$$\ln WT = -9.77 + 2.86 \ln Lc \quad (R^2 = 0.847)$$

The range of pectoral-caudal length and dressed weight used to calculate this relationship, was 60-162 cm and 4-130 kg, respectively.

The relationship total length / pectoral-caudal length (figure 3) of seven individuals (4 males and 3 females) was:

$$Lc = 0.277\ TL^{1.15}$$

obtained from the logarithmic transformation:

$$\ln Lc = -1.29 + 1.15 \ln TL \quad (R^2 = 0.997)$$

The range of pectoral-caudal length and total length used to calculate this relationship, was 36-141 cm and 69-225 cm, respectively. Although the low number of specimens utilized to calculated this relationship, it presented a high coefficient of determination (R^2) and low dispersion of the data, and so, it was utilized for a rough estimate of the total length.

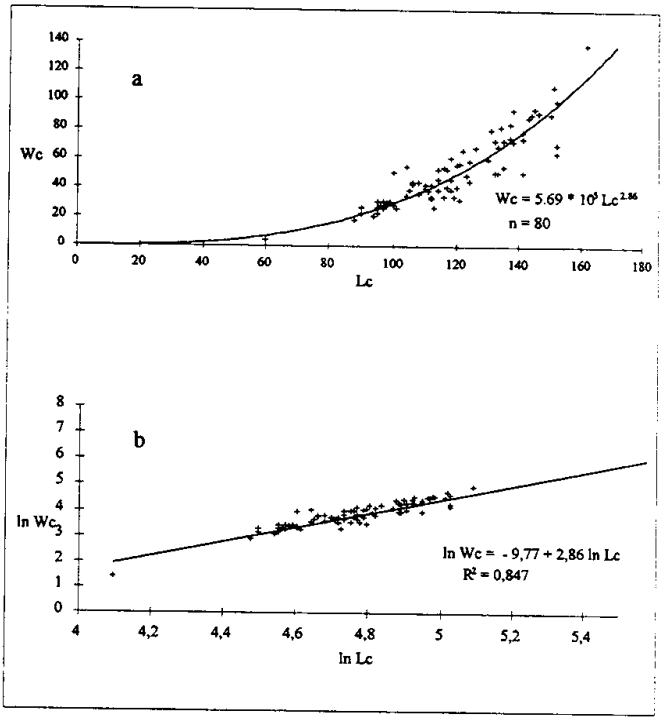

Figure 2 - Diadram of dispersion of data of dressed weight (Wd)/ pectoral-caudal length (Lc), shortfin mako, *Isurus oxyrinchus*, caught by longlines in South and Southwestern of Brazil (original data (a) e longaritimized data (b)).

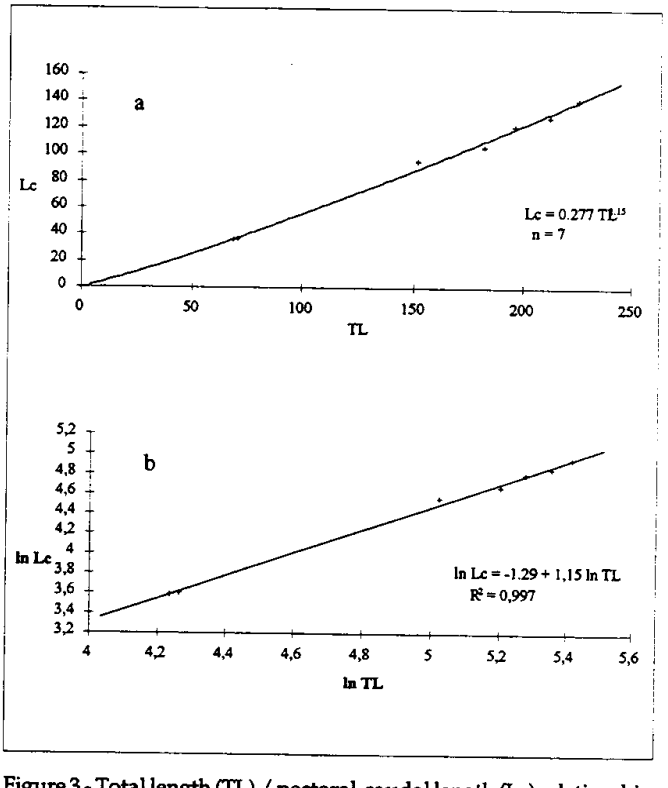

Figure 3 - Total length (TL) / pectoral-caudal length (Lc) relationship of shortfin mako, *Isurus oxyrinchus*, caught by longliners in South and Southeast of Brazil (original data (a) and logaritmized data (b)).

The dressed weight from 1971-90 ranged from 1 to 376 kg, corresponding to 30.4 and 242 cm of pectoral-caudal length, and 60 and 363 cm of total length. These data show that individuals from newborn to adult size were present in the catches since, according to Stevens (1983) and Compagno (1984), the birth size is between 60 and 80 cm of total length, and the biggest specimen caught was close to 400 cm TL, size which is in accordance with the maximum asymptotic length proposed by Bigelow & Schroeder (1948).

The length-frequency distribution of pectoral-caudal length in the period 1971-90 showed high frequencies in the classes from 80 to 150 cm, with the higher in the classes of 110, 120 and 130 cm (figure 4). The quarterly (1971-90) length-frequency distribution was similar to the distribution for the whole period, showing a highest peak in the class of 130 cm in the first quarter, 120 cm in the second and fourth quarters, and 110 cm in the third quarter. The largest amplitude of pectoral-caudal length was observed in the fourth quarter, ranging from 40 to 250 cm. Therefore, the highest frequencies were concentrated in the classes ranging from 90 to 150 cm in all quarters of the year (figure 5).

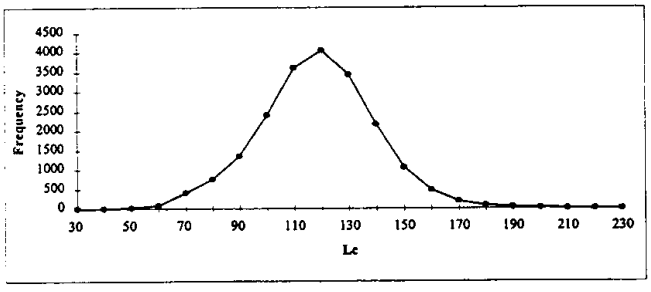

Figure 4 - Numeric frequency distribution of weight class (a) and length (b) of shortfin mako, *Isurus oxyrinchus*, caught by longliners in South and Southwestern Brazil, from 1971 to 1990, by quarter.

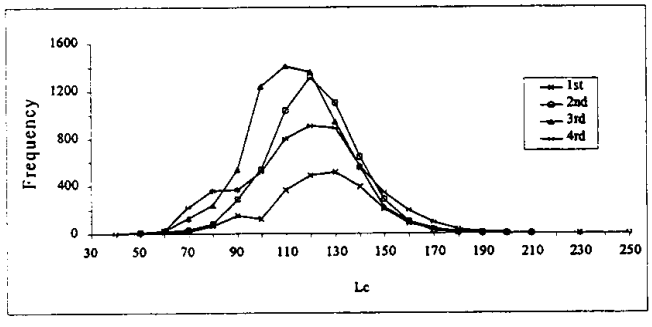

Figure 5 - Variations of average dressed weight (Wd), of shortfin mako, *Isurus oxyrinchus*, caught by longlliners in South and Southwestern of Brazil, from 1971 to 1990 (a=annual data, b=monthly data).

According to Pratt & Casey (1983) the average length at firstl maturity for shortfin mako females is 258 cm and, according to Compagno (1984), females become mature with 280 cm TL, while males maturate with 195 cm TL. The corresponding pectoral-caudal length (Lc) was estimated to be over 160 cm for females, and about 120 cm for males, based on the total length /pectoral-caudal length relationship. The highest number of shortfin mako caught in the period 1971-90 was in the classes from 90 to 150 cm (Lc). So more than half of the total individuals caught were immature.

The annual average pectoral-caudal length ranged from 108 cm in 1973 to 121 cm in 1975 (figure 6*a*). The monthly average pectoral-caudal length ranged from 103 cm in August to 122 cm in January (figure 6*b*). The remarkable decrease of monthly average length in the third quarter was probably due to the high frequency of fishes in the classes between 90 and 120 cm of pectoral-caudal length, in the third quarter (figure 5).

The annual catch in dressed weight ranged from 13.4 t in 1975 to 138.3 t in 1990, showing an increasing trend in the studied period (figure 7*a*), although there were oscillations along these years. The catch by month in whole weight (figure 7*b*) ranged from 44.9 t in February to 116.1 t in November. Two peaks of major yields was evident: the first occurred from May to July, and the second from September to November, separated by a slight decrease in August.

For the overall period (1971-90) the total yield of shortfin mako corresponds to about 3% of the longline total yield, and 11% of the shark total yield of this fleet.

The increasing trend of shortfin mako catches (figure 7*a*) followed the world elasmobranch catch trend. The data from FAO showed an increase of three times in the elasmobranch world catch from 1947 to 1985, jumping from 200,000 t to 600,000 t (Compagno, 1990), of which 350,000 t are made of sharks, 250,000 t of rays and 10,000 t of chimeras (Taniuchi, 1990). The total world catch in the same period increased around fourfold, where the chondrichthian world catch ranged from 0.7% to 1.2% of the total catch from 1950 to 1980. Clupeoids, scombrids and gadoids showed an increase around five to six times in this same time (Taniuchi, 1990).

The fishing effort from 1971 to 1990 showed a gradual increase, ranging from 432 thousand hooks (1972) to 3 million hooks (1990) (figure 8*a*). This pattern of fluctuation is similar to the one showed by the total catch. The monthly total effort from 1971 to 1990 ranged from 1.3 million in February to 2.7 million hooks in November. This effort showed its lowest value in February, and two peaks along the year, one from May to August and another from October to December (figure 8*b*).

The catch per unit effort (CPUE) ranged from 0.6 in 1982 to 1.8 individuals caught per thousand hooks in 1988 (figure 9*a*), no outstanding trend being evident. The monthly CPUE ranged from 0.4 in January to 1.1 in September, with a higher abundance from June to September (figure 9*b*).

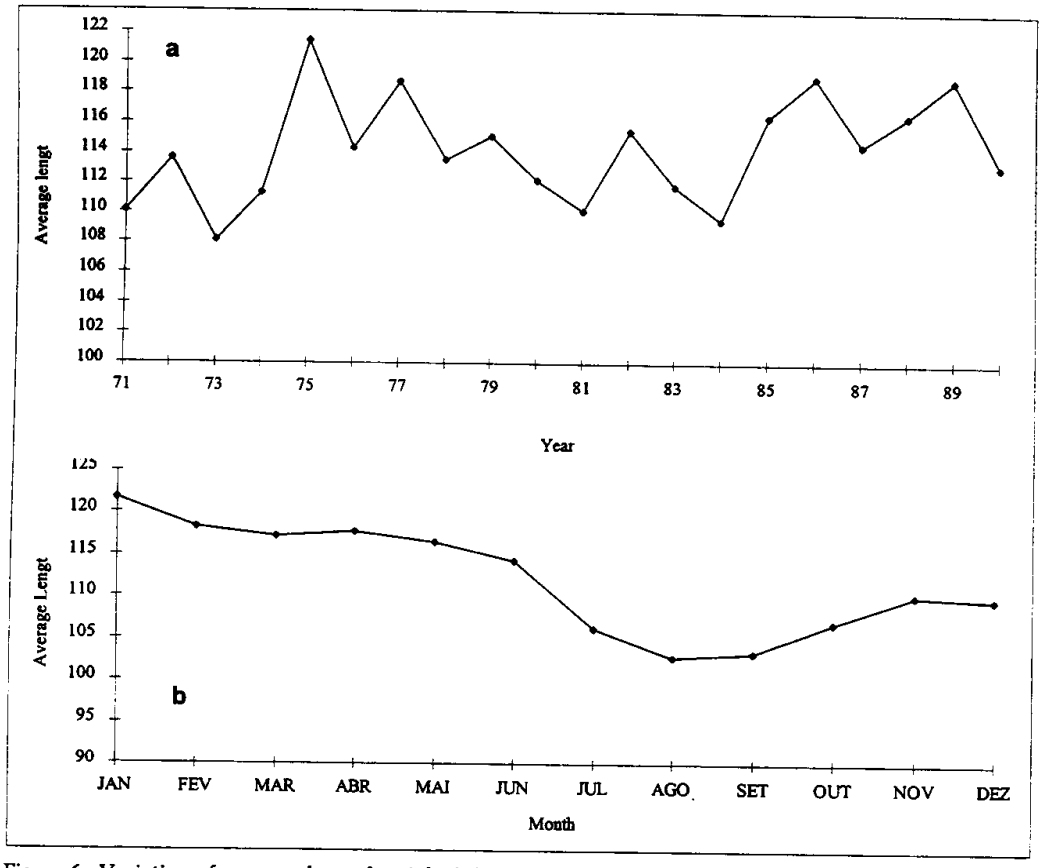

Figure 6 - Variation of average dressed weight (A) and average pectoral-caudal length (B), of shorfin mako, *Isurus oxyrinchus*, caught by longlliners in South and Southestern of Brazil, from 1971 to 1990, by quarter. Horizontal trace represent the average and the bare horizontal the avarage standard error.

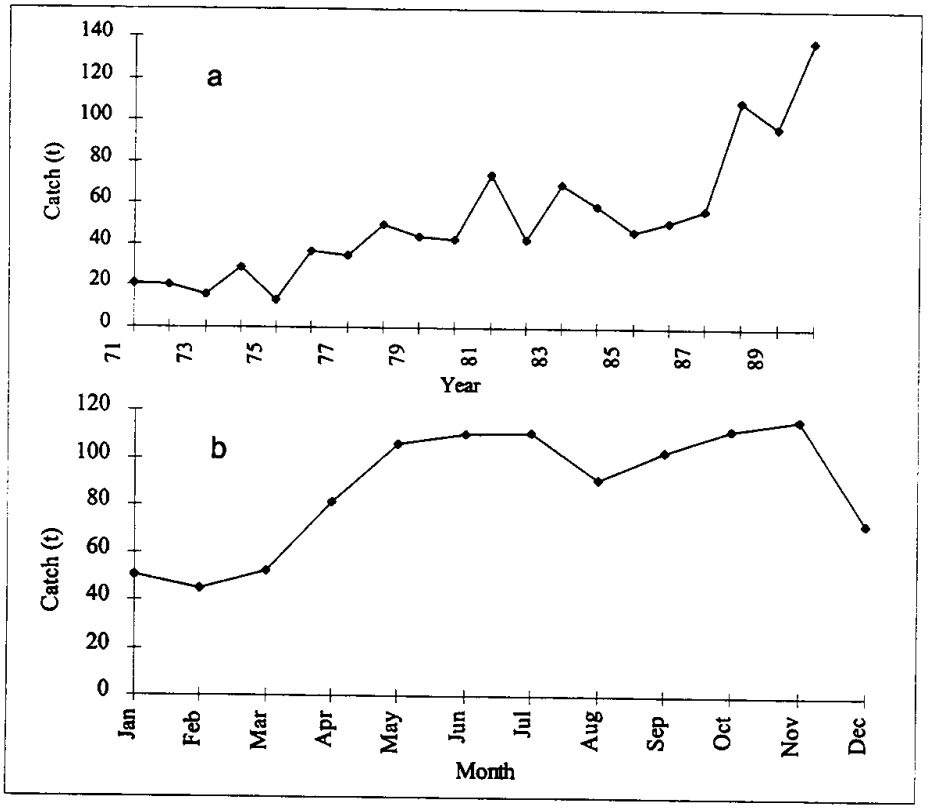

Figure 7 - Yield (t) of shortfin mako, *Isurus oxyrinchus*, by longliners off South and Southeast Brazil, from 1971 to 1990 (a=annual data, b=monthly data).

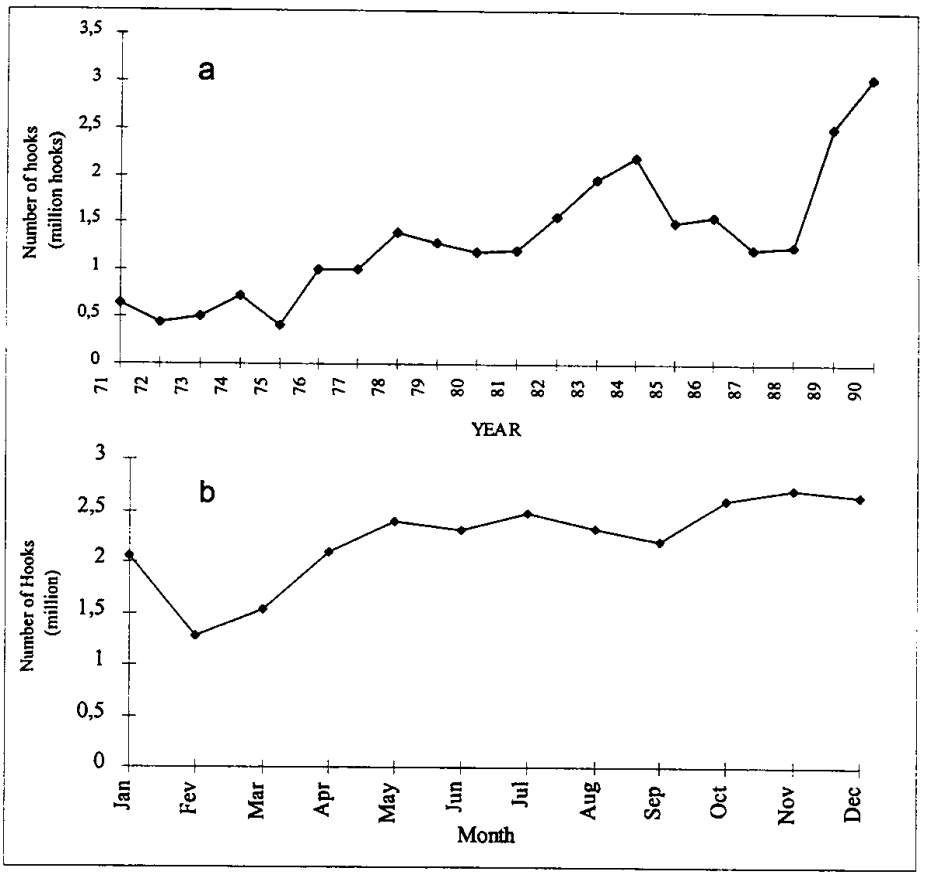

Figure 8 - Fishing effort (number of hooks) by longliners off South and Southeast Brazil, from 1971 to 1990 (a= annual data, b= monthly data).

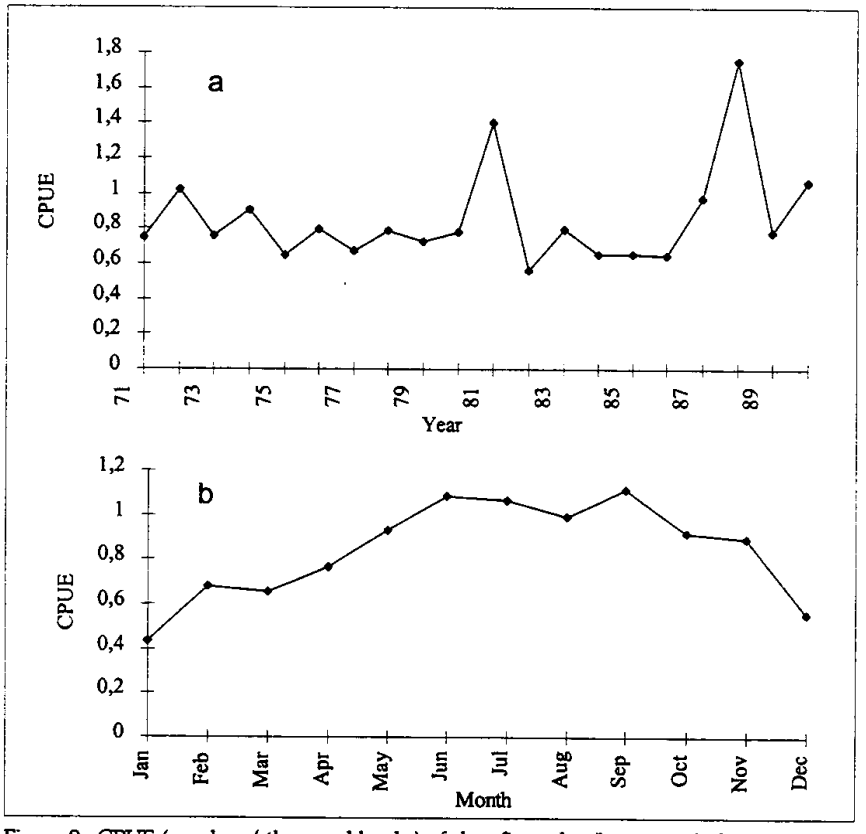

Figure 9: CPUE (number / thousand hooks) of shortfin mako, *Isurus oxyrinchus*, caught by longliners off South and Southeast Brazil, from 1971 to 1990 (a= annual data, b= monthly data).

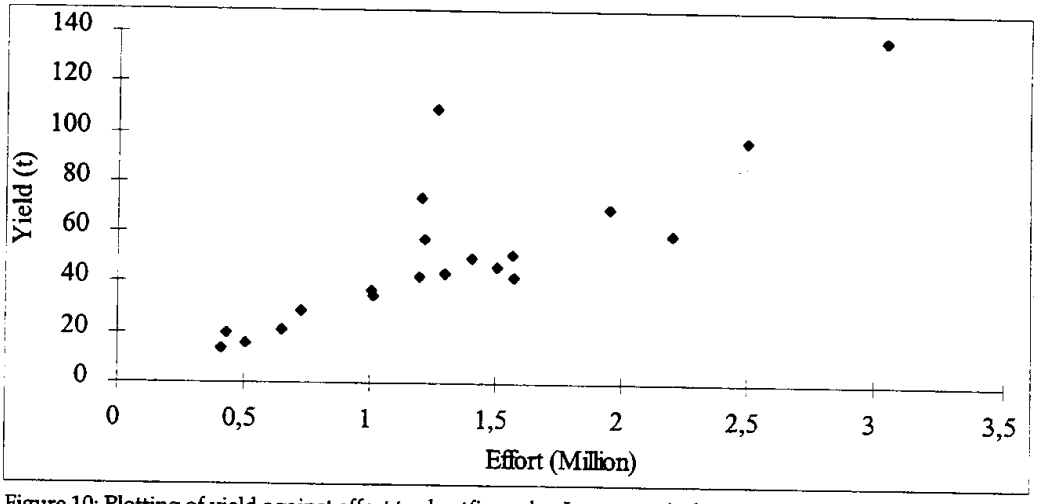

Figure 10: Plotting of yield against effort to shortfin mako, *Isurus oxyrinchus*, caught by longliners off South and Southeast Brazil, from 1971 to 1990.

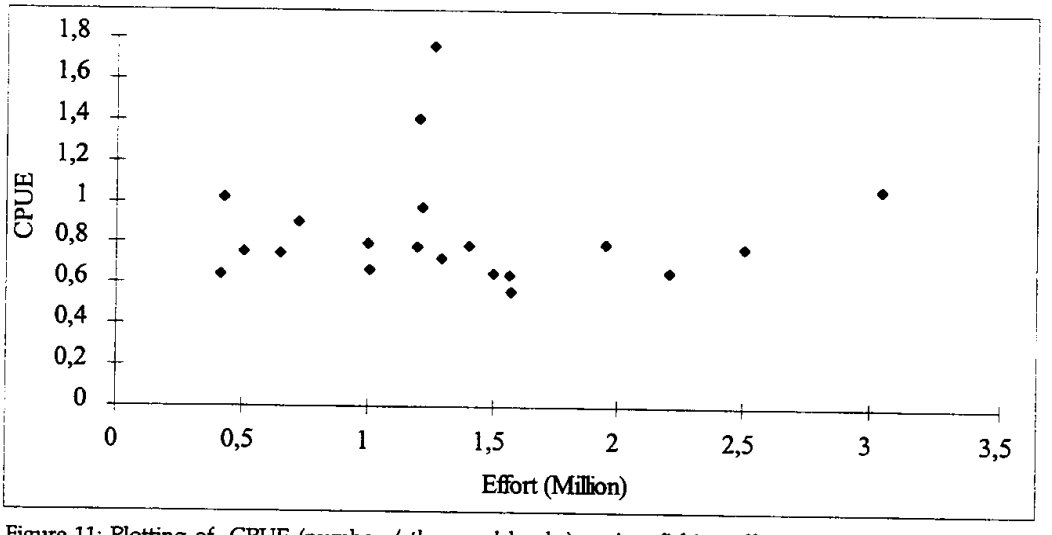

Figure 11: Plotting of CPUE (number / thousand hooks) against fishing effort of shortfin mako, *Isurus oxyrinchus*, caught by longliners off South and Southeast Brazil, from 1971 to 1990.

The highest CPUE values occurred in 1972, 1981 and 1988, corresponding to low-effort years, except in 1975, when the low effort did not correspond to a high CPUE, though high fishing effort values did not correspond to low CPUE values. Since the shorfin mako is not the main target of this fleet, the fluctuations of the CPUE values are more related to trends in the objective of the fleet, than the species distribution in this fishing area.

Plotting data of yield against the fishing effort, a positive correlation between these parameters can be seen, with an increase in the respective values of effort and catch (figure 10). The values of CPUE plotted against the respective fishing effort from 1971 to 1990 (figure 11) did not show any trend.

The fact that this fleet catches mainly immature individuals, and the average length did not show a decreasing trend, probably indicates that this fishery catches only part of the shortfin mako population.

CONCLUSIONS

1 - The increasing trend of catches of shortfin mako, *Isurus oxyrinchus*, from 1971 to 1990, was due to a similar increase in the fishing effort.

2 - The length-frequency distribution showed an occurrence of individuals from newborn stage to adults (near maximum length). Nevertheless, the higher abundance of small individuals indicates that mainly young individuals of shortfin mako are caught by Santos longliners.

3 - The distribution of the average individual size along the year showed that the recruiment of shortfin mako to the catchable stock takes place mainly from July to September.

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