SCRS/1992/030 Col.Vol.Sci.Pap. ICCAT, 41 : 309-324 (1994)

DISTRIBUTION AND RELATIVE ABUNDANCE OF TUNAS AND BILLFISHES IN THE SOUTHWESTERN EQUATORIAL ATLANTIC

Fabio H.V. Hazin[1,3], Rosangela Lessa[2,3], Roseana R. Araes[2,3]
Maria R. Coimbra[2], Rosana C. Souza[2,3], Matsui Natalino[2], and Paulo S. Pantoja[2]

ABSTRACT

The distribution and relative abundance of tunas and billfishes caught by Brazilian longliners, in the southwestern equatorial Atlantic, fron July 1983 to December 1991, were analyzed. The fishing area was located between 7° N to 17_0 *S latitude and 24° W to 47° longitude.*

The catch data comprise 2,277 longline sets, where 2,314,984hooks were used and 55,135 fish were caught, resulting in a mean catch per hundred hooks (CPUE) of 2.38. The species composition was as follows: yellowfin tuna = 41.8%; albacore = 5.4%; bigeye tuna = 2.8%; white marlin = 4.2%; swordfish = 4.0%; sailfish = 5.8%.

The yellowfin tuna had the highest CPUEs in the northrn part of the fishing area, particularly close to the equator. Its the quarterly mean CPUE showed a clear trend oh highest values in the first quarter of the year and lowest during the third quarter. The present data supports the hypothesis of two discrete east andwest populations and suggest that the fish caught by the Brazilian longliners pertain exclusively to the eastern stock.

The distribution of CPUE of albacore shows that their relative abundance was higher in the southern part of the fishing ground, particularly to the south of 5°S. Its quarterly mean CPUE shows an evident pattern of seasonal fuctuation, with peaks in the fourth quarter of the year.

The distribution of the CPUE of bigeye tuna does not show any particular concentration. The quarterly mean CPUEs exhibited higher values mainly during second and third quarters of the year.

The distributions of CPUE of billfish do not show and clear trend of concentration in the fishing area. The quarterly mean CPUE of white marlin exhibited a maximum in the third of higher CPUE in the third of fourth quarters. The quarterly mean CPUE of swordfish and blue marlin do not show and tendency of seasonal fluctuation.

RESUME

Le présent document analyse la distribution et l'abondance relative des thonidés et istiophoridés capturés par les palangriers brésiliens dans l'Atlantique équatorial sud-ouest de juillet 1983 à décembre 1991. La zone de pêche était située entre 7°N et 17°S de latitude et 24°W et 47°W de longitude.

Les données de capture comprenaient 2.277 opérations palangrières, pendant lesquelles 2.314.984 hameçons ont été mouillés et 55.135 poissons capturés, ce qui donne une prise moyenne par centaine d'hameçons (CPUE) de 2.38. La composition spécifique était la suivante: albacore 41,8 %, germon 5,4 %, thon obèse 2,8 %, makaire blanc 4,2 %, espadon 4,0 %, voilier 1,7 %, makaire bleu 0,8 %, requins 33, 6 %, autres poissons 5,8 %.

L'albacore a présenté la CPUE la plus élevée dans le secteur le plus septentrional de la zone de pêche, en particulier à proximité de l'équateur. Sa CPUE trimestrielle moyenne tendait nettement à montrer les valeurs les plus élevées pendant les premiers trimestres de l'année et les plus faibles pendant le troisième trimestre. Les données actuelles étayent l'hypothèse de l'existence de deux populations distinctes est et ouest, et suggèrent que le poisson capturé par les palangriers brésilient appartient peut-être exclusivement au stock est.

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[1] Tokyo University of Fisheries, Department of Marine Science and Technology, Laboratory of Fisheries Oceanography, 5-7, Konan-4, Minato-ku, Tokyo 108, Japan.

[2] Departamento de Pesca, Universidade Federal Rural de Pernambuco, Rua Dom Manoel de Medeiros, s/n, Dois Irmaos, Recife-PE, Brazil.

[3] Brazilian Research Council (CNPq), Conselho Nacional de Desenvolvimento Cientifico e Tecnologico.

La distribution des CPUE du germon montre que son abondance relative était plus forte dans le secteur méridional de la zone de pêche, en particulier au sud des 5°S. Sa CPUE trimestrielle moyenne montre un mode évident de fluctuation saisonnière, avec des pics pendant le quatrième trimestre.

La distribution de la CPUE du thon obèse ne montre pas de concentration particulière. La CPUE trimestrielle moyenne montrait les valeurs les plus élevées pendant les deuxième et troisième trimestres.

La distribution de la CPUE des istiophoridés ne montre pas de tendance nette à la concentration dans la zone de pêche. La CPUE trimestrielle moyenne du makaire blanc montrait un maximum pendant le troisième trimestre de l'année, alors que le voilier montrait une légère tendance à une CPUE plus forte pendant les troisième et quatrième trimestres.

La CPUE trimestrielle moyenne de l'espadon et du makaire bleu ne montre pas de tendance à des fluctuations saisonnières.

RESUMEN

Se analizó la distribución y la abundancia relativa de túnidos y marlines capturados por los palangreros brasileños en el Atlántico ecuatorial sudoeste, desde julio de 1983 hasta diciembre de 1991. La zona de pesca se encontraba entre 7°N y 17°S de latitud y 24°W a 47°W de longitud.

Los datos de captura incluyen 2.277 lances de palangre en los cuales se emplearon 2.314.984 anzuelos y se capturaron 55.135 peces, con un resultado de una media de captura de 2.38 por cien anzuelos (CPUE). La composición por especies era: 41.8% rabil, 5.4% atún blanco, 2.8% patudo, 4.2% aguja blanca, 4.0% pez espada, 1.7% pez vela, 0.8% aguja azul, 33.6% tiburón, 5.8% otros peces.

Las CPUEs del rabil mas altas se daban en la parte norte de la zona de pesca, sobre todo cerca del ecuador. La media trimestral de CPUE mostraba una clara tendencia hacia los valores mas elevados durante los primeros trimestres del año y los mas bajos en el tercer trimestre. Los datos actuales apoyan la hipótesis de dos poblaciones diferenciadas al este y al oeste y sugieren que los peces capturados por los palangreros brasileños pertenecen en exclusiva al stock este.

La distribución de la CPUE del atún blanco muestra que su abundancia relativa era mas alta en la parte sur de la zona de pesca, en particular al sur de 5°S. Su CPUE trimestral media presenta un claro esquema de fluctuación estacional, con máximos durante el cuarto trimestre del año.

La distribución de la CPUE del patudo no muestra una concentración especial. La CPUE trimestral media presentaba valores más altos, sobre todo en el curso de los trimestres segundo y tercero del año.

Las distribuciones de la CPUE de marlines no presentan tendencias claras de concentración en la zona de pesca. La CPUE trimestral media de la aguja blanca mostraba un máximo en el tercer trimestre del año, mientras que en el caso del pez vela, se observaba una ligera tendencia hacia una CPUE mas alta en los trimestres tercero y cuarto. La CPUE trimestral media del pez espada y aguja azul no muestra tendencia alguna de fluctuación estacional.

1. INTRODUCTION.

The longline fishery for tunas and billfishes in the Atlantic Ocean was begin in 1956 by Japanese longliners. In the same year Japanese tuna longline boats were leased by a Brazilian company and began to operate in the South Atlantic, from the port of Recife, in the northeastern coast of Brazil. These activities came to an end in 1964.

The tuna longline fishery from the northeast coast of Brazil was reborn in 1983, through 3 Brazilian fishing boats based in the port of Natal, Rio Grande do Norte. This study is based on catch data of these three boats based in Natal, named Argus, Rio Turi and soloncy Moura, from July 1983 to December 1991.

The fishing area was located from 7°N to 17°S latitude and 24°W to 47°W longitude (Fig. 1).

2. MATERIAL AND METHODS.

The basic characteristics of the Brazilian tuna longline boats are given in table 1, and some details of the longline gear used by them is shown in table 2. Duringthe 8.5-year period, the structure of the longline was always the same.

The major bait was frozen Brazilian sardine, *Sardinella brasiliensis*, but flying fish (Family Exocoetidae) and halfbeak (genus *Hemiramphus*) were also used occasionally.

The catch data were taken from the fishing logbooks and comprise 2,277 longline sets, where 2,314,984 hooks were used, averaging thus ca. 1016 hooks/set. The distribution of the fishing effort by year is given in table 3.

The tunas and billfishes were identified in the logbooks only by their common Portuguese names. The correspondence of these vernacular names and their English and scientific equivalents are given in Table 4.

Due to the low abundance of the longbill spearfish and its resemblance to the white marlin, their catches were frequently reported as "white marlin", and consequently the data on white marlin include both the *Tetrapturus albidus* and the *T. pfluegeri*.

The sharks were made up mainly by the blue shark and by the sharks of the genus *Carcharhinus*, which together accounted for about 95% of the total shark catches (Hazin et al, 1990). The group "Others" included a broad range of species, such as *Coryphaena sp.*, *Sphyraena sp.*, *Scomberomorus sp.*, *Seriola sp.*, etc.

The average soaking time as well as the area fished by the longline do not have a significant influence on the catch rate in this fishery (Hazin, 1991). Consequently, the CPUE (catch per unit of effort) as the number of fish caught per 100 hooks was chosen to express relative abundance.

In order to study the distribution and relative abundance, the fishing area was divided in 1^o lat. x 1^o long. squares. The mean catch per unit of effort for a square or for a quarter of the year was computed by dividing the total catch by the total effort. The distribution of the total fishing effort in the 8.5- year period is shown in Fig. 2.

With a view to avoid distortions in the distribution of relative abundance, the squares with an effort of less than 10,000 hooks were not considered. Consequently, from the 94 1^ox1^o squares fished, only 29 were used in the analysis of distribution.

3. RESULTS AND DISCUSSION.

3.1. Catch composition

Table 5 shows the species composition of the 55,135 fish caught from July 1983 to December 1991. The tunas were the most abundant species representing 50.0% of the total catch. The yellowfin tuna was the most important tuna species amointing to ca. 84% of the tuna catches, the remaining 16% being made by albacore (10.6%) and bigeye (5.6%).

The billfishes accounted for 10.6% of the total catch. White marlin, including the longbill spearfish, and swordfish were the main species representing together 76.6% of the billfish catches. The remaining 23.4% were composed by sailfish (16.2%) and blue marlin (7.2%).

Table 6 shows the average dressed weight (gilled and gutted) of tunas and billfishes caught from July 1983 to December 1986, by the Argus. The white marlin was the lightest species with a mean weight of 16 Kg, white the blue marlin was the heaviest, weighing on average 102 Kg.

3.2. Yellowfin tuna

The distribution of catches of yellowfin tuna is shown in Fig. 3. The CPUE tended to be higher in the northernmost part of the fishing area, particularly close to the equator. Four out of the five highest CPUEs were located to the north of 2°S. To the south of this parallel the distribution of CPUE was rather uniform ranging from 0.35 (35°-36°W, 4°-5°S) to 1.92 (37°-38°W, 3°-4°S).

The quarterly mean CPUE of yellowfin tuna shows a clear trend of highest CPUE in the first quarter of the year, except for the years of 1987 and 1991 (Fig. 4). During these years the quarterly mean CPUEs were much lower than average and the peak occurred in the second quarter instead of the first. The reason for this anomalous behavior relies n the targeting strategy of the fishery. Until 1986 the target species consisted solely of tunas and billfishes and high shark catches were systematically avoided. From July 1986 on, the fishing strategy changed and sharks were also included as a target species. This change in the targeting strategy was accompanied by a changer of the fishing ground. Fig. 5 Shows that the inclusion of sharks July 1986 resulted immediately in a southern incursion during the third quarter of this year into the quadrates to the south of 8°S (area b), aiming at higher catches of blue shark and also albacore. In the fourth quarter, when the abundance of blue shark starts to decresease (Hazin et al. 1990), the boats moved northwestward into the fishing ground to the west of 35°W (area C), rich in relatively shallow oceanic banks (e.g. Aracati, Guara and Sirius Bank), in order to catch sharks of the genus *Carcharhinus*. In the first quarter of 1988, the catches of yellowfin tuna increased again, this time due to the discovery of good fishing grounds in the areas D and E; the last one in the vicinity of the Rocks of São Pedro and São paulo. The higher CPUEs during the first quarters of 1989 and 1990 were due to a hihger fishing effort in this area.

According to the fishermen, the high catches of yellowfin tunas in the vicinity of the Rocks of São Pedro and São Paulo, from January to March, seem to be, at least partly, due to a feeding concentration as a result of a high abundance of flying fish during this period of the year.

During 1991 the fleet was reduced to only one boat, resulting thus in a sharp decrease in the fishing effort, which declined from 283,695 hooks in 1990 to only 83,176 in 1991. Furthermore, the remaining longliner was the smallest one and was not able to reach the Rocks of São Pedro and São Paulo. This explains the low catch rate in the first quarter of this year. Besides, the prince of sharks fins doubled from U$ 40 in 1990 to U$ 80 in 1991. As a result, 60% of the fishing effort in the first quarter of 1991 was again located in the shallow oceanic banks, west of 35°W, in order to catche a higher number of sharks.

The migratory movements of the yellowfin tuna in the Atlantic is evidently dependent on the structure of the population. Based mainly on longline data obtained from Japanese boats, several authors have advenced the hypothesis of two discrete east and west populations for the Atlantic yellowfin tuna (Wise and Le Guen, 1969; Honma and Hisada, 1971; Hayashi, 1974). This hypothesis has been spoused by the Internacional Commission for the Conservation of Atlantic Tunas - ICCAT, 1986). The Fig. 6 (after Honma and Hisada, 1971) shows the schematic mogratory routes of yellowfin tuna in the Atlantic Ocean. According to these authors, the eastern and western concentrations would intermingle with each other at about 30°W, during northern spring and summer (second and third quarters).

Wise and Davis (1973 agreed with the hypothesis of two stocks, but speculated that the dividing line between them should be placed at about 70°W, thus considerably farther west than previously suggested.

The results of hooft and Ramos (1972) from the Venezuelan tuna fishery between 1960 to 1970, indicated that the stocks of yellowfin in the Caribbean in the western Atlantic may be largely separated one from the other, setting the dividing line between them Lesser Antilles or about 61°W long.

Yanez and Barbieri (1980) showed that the gonosomatic index of the yellowfin tunas caught in the Atlantic east (15°N-10°S, coast-20°W); central (15°N-10°S, 20°W-40°W); and west (15°N-10°S, 40°W-coast) had generally two peaks, one in the first and other in the third quarter of the year, in all the three areas.

Studies on larval distribution suggest that although yellowfin tuna spawns over a vast area in the equatorial Atlantic all year round, there seems to be two peaks of maximal concentrations of larvae in western and eastern Atlantic during the first and third quarters of the year (Uda, 1971; Ueyanagi, 1971; Nishikawa et al. 1978, 1985; Fonteneau and Marcille, 1988). The highest concentrations in the eastern Atlantic occurs in the Gulf of Guinea (Fonteneau and Marcille, 1988); and in the western Atlantic in the Gulf of Mexico (Richards and Pothoff, 1980), Caribbean Sea, and off the north coast of Venezuela and Brazil (Nishikawa et al. 1978, 1985), perticularly in this last area (Fonteneau and Marcille, 1988).

A very intersting feature of the distribution of the western stock of yellowfin is that its major concentrations occur during northern winter (January - March) in the Gulf of Mexico and during summer off Cape Hatteras, in waters thus considerably cloder than the limits of distribution of the eastern stock, which is around 27°C (Fonteneau and Marcille, 1988). Kawai (1969) reported that the yellowfin tunas caught by the Japanese longliners in the equatorial Atlantic Ocean are distributed in warm waters, over 27°C in most cases, and that their migration could be well explained by the seasonal change in the distribution of sea surface temperature. Consequently, the dividing line between the eastern and western stocks may be represented by the 27°C isotherm. Fig. 7 shows the hypothetical distribution and migratory routes of the eastern and western stocks of yellowfin tuna in in the Atlantic Ocean, as implied by the seasonal variation of the position of the 24°C and 27°C isotherms, the first being the limit of distribution of larval yellowfin (Fonteneau and Marcille, 1985).

During the first quarter the eastern stock in the Gulf of Mexico, CAribbean and north coast ofSouth America. From the second to the third quarter, the eastern stock would be pushed northwestward by the displacement of the 27°C isotherm, away from the coast of Africa and into the north coast of South America, Caribbean and even into the Gulf of Mexico. Similarly, the western stock would be pushed out of the Gulf of Mexico, into the Florida Current and Gulf Stream, towards Cape Hatteras, where they would stay during the third quarter. In the fourth quarter the movements would be reversed by the southward displacement of the 27°C isotherm, returning then to the situation found in the first quarter. The low catches in the third quarter (Fig. 4) may be therefore a consequence of the fact that during this period the 27oC isotherm is located in its northernmost position, thus pushing the schools of yellowfin out of reach of the Brazilian longliners. Likewise, the highest catches during the first quarter are probably also related to the position of the 27°C isotherm, which during this period is located in its southernmost limit.

The westward movement of the eastern stock would be facilitated by the South Equatorial Current, which has a strong westward flow (about 30 cm/sec, near the Equator) (Petterson and Stramma, 1991). The eastward migration during the fourth quarter of the year, in turn, could be eased by the North Equatorial Counter Current, which is fed by the North Brazil Current (Philander and Pakanowski, 1986) and strengthens significantly from August to December (Schott and Boning, 1991); and by the Equatorial Undercurrent, which is formed when the lower part of the North Brazil Current turns back and eastward just north of the Equator (Metcalf and Stalcup, 1967). In the fisrt and second quarters, the western part of the North Equatorial Counter Current reverse to westward and merge with the cross-equatorial North Brazil Current, resulting in an enhanced northwestward flow toward the Caribbean (Johns et al., 1990), which then would again facilitate the westward migration. An schematic representation of the surface currents in the equatorial Atlantic is shown in Fig. 8 (after Richardson and Walsh, 1986). Under this hypothetical structure of yellowfin tuna population, the fish caught by Brazilian tuna longliners would pertain exclusively to the eastern stock.

Since the time lag between the westward and eastward migration would be about 6 months, the fish moving westward during the second quarter should be a little shorter than those moving easward during the fouth quarter. The length-frequency distribution of 638 yellowfin tunas measured from December 1990 to December 1991 (Fig. 9) seems to agree with this supposition.

Yang et al. (1969) found that yellowfin tuna from the Atlantic Ocean increased in length in six months from 120.0 to 132.9 cm fork length, a growth of 12.9 cm. The lengt frequency distribution of the fish caught during the second quarter of the year shows that the fork lenght of most of the specimens lay from 95 to 115 cm (ca. 70% of sample), whereas in the fouth quarter it lay mainly from 105 to 125 cm (ca. 74% of simple). The increase of about 10 cm in length thus seems to corroborate the migratory movements. The number of fish caught in the third quarter was too small and so its length-frequency distribution is not so clear. It is interesting to observe, however, that during this quarter the fork lengths showed two different modes, the first from 105 to 135 cm and the other from 135 to 180 cm. The mean size of the fish from the first mode was 116 cm, therefore between the modes of the fish from the second and fourth quarters. The second mode, with an average size of 156 cm, is composed by larger fish probably inhabiting the colder waters and in the fringe of the main population. The third quarter of the year is the period when the sea surface temperature is coldest (Fig. 7), and larger yellowfin tunas are commonly found in colder waters (Honma and Hisada, 1971). The length frquency distribution during the first quarter of the year shows the largest range of size. This is the time of the year when the sea surface temperature has its highest values and the 27°C isotherm is located in its southernmost position. Therefore the wider ranger of size may be because a larger part of the population is encompassed by the fishing ground during this quarter.

3.3. Albacore.

The distribution of catches per 100 hooks of albacore (Fig. 10) shows that their apparent abundance was higher in the southern part of the fishing ground (zones A and B of Fig. 5). In the quadrates to the west of 35°W and to the north of 3°S, the CPUE of albacore was always lower than 0.05. In the quadrates between 3°S and 5°S, and to the east of 35°W the CPUE ranged from 0.05 to 0.15 (except for the quadrate 3-4°S, 34-35°W). And finally, in the quadrates to the south of 5oS the CPUE of albacore ranger from 0.15 to 0.35 (except for the quadrate 6-7°S, 34-35°W). These results indicate that this fishing ground is located in the limit of the distribution of the albacore population, which is probably centered to the south of 5°S. This is in accordance with the data of Wise and Davis (1973) who reported very low catches for albacore between about 15°N and 5°S.

Stramma et al. (1990), quoted by Peterson and Stramma (1991), observerd that the South Equatorial Current bifurcate in the northeast coast of Brazil, close to 10°S. The present results therefore suggest the albacore population in the southwestern equatorial Atlantic is mostly restricted to the Brazil Current System.

Fig. 11 shows the quarterly mean CPUEs of albacore. There is an evident pattern of seasonal fluctuation in the CPUEs with peaks in the fourth quarters of the year. These results accords with most of the previous investigations on the albacore from this region (Aragão, 1977; Barros and Fonseca, 1965; Lima and Wise, 1962; Argào and lima, 1985; among others).

The apparent trend of the CPUE to decrease along the period, particularly after 1986, can be partly explained by a change in the fishing ground. Until this year most the fishing effort was located in area A (Fig. 5), about 50% of it to the south of 5°S. From 1986 on, the boats began to exert most of the fishing effort in the areas C and E (Fig. 5), in order to catch more sharks of the genus Carcharhinus and yellowfin tuna, respectively. The relative amount of fishing effort in the area to the south of 5°S after 1986 was as follows: 1987 = 30%; 1988 = 23%; 1989 = 17%; and 1990 = 6%; 1991 = 3%.

In the South Atlantic the albacore spawns during summer, in an area located mainly from 10°S to 25°S and from the Brazilian coast to 10°W (Bearsdley, 1969).

Le Gall (1974) found that in the Brazilian coast larvae of albacore are found mainly in December.

Koto (1969) noted that immature albacore are commonly concentrated in high latitudes, while mature fish occus mostly in low latitudes.

Based on these works, it can be inferred that the higher CPUEs of albacore during the fouth quarter of the year is likely due to a northward spawning migration.

Table 6 shows that the albacore caught from 1983 to 1985 were quite large, weighing on averange 25 Kg dressed weight.

The length frequency distribution of 28 albacore measured from December 1990 to December 1991 (Fig. 12) shows that their fork length ranged from 102 to 117 cm, 80% of them being from 108 to 116 cm.

These results confirm that these are mostly mature fish since both male and female albacore in the Atlantic Ocean mature at a fork length of about 94 cm (Collette and Nauen, 1983).

Finally, it is important to note that these results may be also influeced by vertical distribution and movements of the albacore schools, as Hazin (1991) has shown to happen for the blue shark in this same region. Unfortunately this aspect could not be investigated due to the lack of data.

3.4. Bigeye tuna

The distribution of the CPUE of bigeye tuna do not show any clear pattern (Fig. 13), varying from 0.01 (0-1°N, 29-30°W) to 0.27 (2-3°S, 32-33°W).

The quarterly mean CPUEs (Fig. 14) rangerd from 0.02 to 0.22 and showed highest values mainly during second and third quarters, and lowest during first quarters.

The ICCAT presently supports the hypothesis of a single wide stock of bigeye tuna in the Atlantic Ocean (ICCAT, 1986), but too little is yet known about their migratory movements.

Fonteneau and Marcille (1988) noted that although the bigeye spawns over a broad area of the equatorial Atlantic, an important spawning ground is located in the coast of Venezuela and northeast Brazil in the third quarter of the year. Unfortunately no data is available on the condition of the gonads of the bigeye tunas caught by the Brazilian longliners and therefore it is impossible to verify if the higher CPUEs are related to a spawning migration.

The length-frequency distribution of 24 specimens caught from December 1990 to December 1991 (Fig. 15) shows a wide range of size, from 39 to 181 cm. About 75% of the sample, however, lay between 90 to 150 cm, indicating that most of the fish were probably mature since maturity is attained at 100 to 130 cm fork length (Collete and Nauen, 1983).

3.5. White marlin and longbill spearfish.

For all the species of billfishes no data were available from quadrantes 0-1°N, 29-30°W; and 0-1°S, 29-30°W.

As previously discussed, the data on white marlin aggregate both the *Tetrapturus albidus* and the *Tetrapturus fluegeri*, the longbill spearfish, which makes interpretation difficult.
However, it is well know by thefishermen that the caches of longbill spearfish are much lower than those of white marlin. This accords with the data of Wise and Davis (1973) and Ueyanagi et al. (1970) who observerd that the spearfishes are distributed mainly in offshore waters, in the Central Atlantic. Besides, from 50 specimens of *Tetrapturus* samples from 29/07/88 to 15/02/89, only one was a *Tetrapturus pfluegeri*. Therefore we assume that most of the data is related to the white marlin *Tetrapturus albidus*.

The map of distribution of CPUE does not show any clear trend (Fig. 16). Ueyanagi et al. (1970) noted that the white marlin is relatively scarce in the intermediate tropical waters. According to the same authors, they migrate to temperate waters to feed and to subtropical waters to spawn, the peak of spawning beinh in early summer (November through January). They showed that the only area in the South Atlantic with a concentration of maturing fish is the one between lat. 20°S and 30°S and long. 20°W and the coast of South America.

Mather III et al. (1974) reported that the white marlin concentrate off the northeast coast of Brazil, centering off Recife in September and October. They reported that in November the concentration moves to south and also well to the east.

This concentration off the northeast coast of Brazil is in accordance whith the present data, since the quarterly mean CPUEs show a clear maximum in the third quarter of the year (Fig. 17).

Forty nine white marlins were measured from 29/07/88 to 15/02/89. Their eye-fork length ranged from 89 to 152 cm, but 70% of them were shorter than 140 cm (Fig. 18). Their small size is confirmed by their small mean gutted weight of only 16 Kg, from 1983 to 1985 (Table 6).

Ueyanagi et al. (1970) reported that the species attains sexual maturity at a length from orbit to fork of tail of about 130 cm, most of the mature fish being larger than 140 cm. Consequently, the fish caught by the Brazilian longliners are most likely immature.

3.6. Swordfish

The swordfish shows no clear pattern of distribution (Fig. 19) or seasonal flutuation in abundance (Fig. 20). Wise and Davis (1973) also observed that they demonstrate little difference in distribution with reference to longitude, latitude, land masses, open ocean areas or even with season.

Ueyanagi et al. (1970) reported that the swordfish spawns in a wide area in tropical and subtropical waters with surface temperatures higher than 24°C.

Larger concentrations of swordfish in the southwestern Atlantic is probably found off southeastern Brazil, from 20°S to 40°S and west of 40°W to the Brazilian coast (Nakamura, 1974).

Fig. 21 shows the frequency distribution of the orbit-fork length of 56 swordfish caught from 29/07/88 to 15/02/89. Their size ranged from 61 to 203 cm, and 86% lay between 80 to 160 cm. The males matures at about 21 Kg, and females at 74 Kg (Nakamura, 1974). Consequently, the mean gutted weight of 33 Kg (Table 6) indicate that many of the specimens caught were probably immature.

3.7. Sailfish.

Ueyanagi et al.(1970) reported that the sailfish are most densely distributed in waters close to land masses in tropical and subtropical areas. Certainly due to their small catches, the distribution of the CPUEs of the sailfish does not show any clear trend (Fig. 22). The quarterly mean COUEs, in turn exhibited a slight tendency of higher catches during the third and fouth quarters (Fig. 23).

Concentrations of sailfish occur along the coast of South America in all four quarters (Wise and Davis, 1973). Their mogratory movements, however, are not clear. Unfortunately the present data is too few and insufficient to explain the fluctuation fo the quarterly mean hooked rates.

Ueyanagi et al. (1970) found that most of the sailfish caught by the Japanese tuna longliners ranged from 120 to 170 cm. These results are close to the present situation since the length frequency distribution of 26 sailfish observed from 29/07/88 to 15/02/88 ranged from 109 to 170 cm eye-fork length.

3.8. Blue marlin.

Wise and Davis (1973) found two major concentrations of blue marlin in the Atlantic Ocean, both of them in the western part. One of the western concentrations lies off easternmost part of South America, from 5°S to 20°S and 15°W and the coast, mainly during the first and second quarters of the year. The second lies in the Gulf of Mexico and Caribbean, centered around Cuba.

Certainly due to their extremely low catches, the distribution of CPUE either by quadrates (Fig. 24) or by quarters of the year (Fig. 25) does not show any clear pattern. From a sample of 11 specimens caught between 29/07/88 and 15/02/89 their size from 124 to 240 cm eye-fork length.

4. ACKNOWLEDGMENT.

We would like to thank the Norte Pesca S/A for providing all the data used in this research. We are grateful to Alceu A. Couto and Manoel Gomes de Miranda for their valuable help in collecting the data. Tkanks also to Bulent Topaloglu and Andreia Teixeira de Siqueira for their helpfull assistance.

5. LITERATURE CITED.

ARAGÃO. J.A.N., 1977. Informacões preliminares sobre a pesca industrial de atuns no nordeste do Brasil. P.D.P., Ministério da Agricultura/ SUDEPE. Brasilia, (25):16 p.

ARAGÃO, J.A.N. and J.H.M. LIMA., 1985. Analise comparativa da atuação das frotas atuneiras (Espinhel) arrendadas na costa brasileira. SUDEPE - PDP, Série Documento Técnicos no:35 Brasilian, 185-293.

BARROS, A.C. and J.B.C. FONSECA., 1965. Analise das pescarias de atuns e espécies corelatas no Atlântico no ano de 1963. Bol. Est. Pesca. Recife, 5 (2): 23-32.

BEARDSLEY,G.L., 1969. Proposed migrations of albacore, *Thunnus alalunga*, in the Atlantic Ocean. Trans. Am. Fish. Soc., 98:589-93.

COLLETE, B.B. and C.E. NAUEN, 1983. FAO speciescatalogue. Vol.2 Scombrids of the word. An annotated and illustrated catalogue of tunas, mackerels, bonitos and related species known to data. FAO Fish. Synop., (125) vol.2. 2:137 p.

FONSECA, J.B.G., 1962. Observações sobre o emprego do espinhel "(Long-line)" na captura de tunideos. Bol East. Pesca, Recife, 2 (1):13-16.

FONSECA, J.B.G. and A.C. BARROS., 1963. Sobre as pescarias de atuns e afins e suas areas de ocorrência no Atlântico Tropical no bienio 1961-1962. Bol. Est. Pesca Recife, 3 (7):18-22.

FONTENEAU, A. and J. MARCILLE., 1988. Ressoucers, peche et biologie des thonides tropicaux de l'Atlantique centre-est. FAO Doc. Tech. Peches, (292):391 p.

HAYASHI, S. 1974. An hypothesis on population structure of yellowfin tuna in the Atlantic Ocean, based mainly on longline data. Collect. Vol. Sci. Pap. ICCAT.Recl. Doc Sci. CICTA/Collecc. Doc. Cient. CICAA, 2:40-8.

HAZIN, F.H.V., 1991. Ecology of the blue shark *Prionace glauca*, in the southwestern equatorial Atlantic. M.S. Dissertation. Tokyo University of Fisheries Departament of Marine Science and Technology; Laboratory of Fisheries Oceanigraphy. 163p.

HAZIN, F.H.V., ALCEU COUTO, KIHARA, K. OTSUKA, and M.ISHINO., 1990.Distribution and abundance of pelagic sharks in the southe - western equatorial Atlantic.Journal of Tokyo University of Fisheries, Vol. 77, No. 1, 51-64.

HOOFT, J.J and F. RAMOS, 1972. Catch and fishing effort in the Venezulean tuna fishery between 1960 and 1970. Ser. Recurs. Explot. Pesq. Venezuela., 2 (2):1-40.

HONMA, M., et K. HISADA, 1971. Structure of yellowfintuna population in the Atlantic Ocean. Bull. Far Seas Fish. Res. Lab., (4):93-124.

ICCAT, 1986. Report for biennial period, 1984-85 (Part II 1985).Madrid, Spain. International Commission for the Conservation of Atlantic Tunas, 291p.

KAWAI, H., 1969. On the relationship between thermal struture and distribution of long-line fishing-grounds of tunas in the intertropical Atlantic-1. Bull. Far. Seas Res. Lab. 2:275 - 303.

KOTO, T.,1969. Distribution and moviment of the albacore in the Indian and Atlantic Oceans based on the catch statistics of Japanese tuna longline fisheries. Bull. Far. Seas Fish. Res. Lab., 1:115-29.

LE GALL, J.Y., 1974. Expose synoptique des donnees biologiques sur le Germon *Thunnun alalunga* (Bonaterre, 1788) de l'Ocean Atlantique. Synopsis FAO Sur Les Peches No. 109,70 p.

LIMA, F.R. and J.P. WISE., 1962. Primeiro estudo da abundância e distribuição da albacora lage e da albacora branca na re- gião ocidental do oceano Atlântico Tropical (1957-1961). B. Inst. Pesca., Recife, 2(10):12-17.

MATHER III, F.J., D.C. TABB, J.M. MASON JR., and H.L. CLARK., 1974. Results of sailfish tagging in the western North Atlantic Ocean. NOAA Tech. Rep. NMFS (Spec. Sci. Fish. Ser.) (657) pt. 2:194-210.

NAKAMURA, H., 1969. Tuna distribution and migration. London, Fishing News (Books) Ltd., 76 p.

NAKAMURA, I., 1974. Some aspects of the systematics and distribution of billfishes. NOAA Tech. Rep. NMFS (Spec.Sci. Rep.Fish.Ser.) (657) Pt. 2:45-53.

NISHIKAWA, Y., S. KIKAWA, M. HONMA, and S. UEYANAGI, 1978. Distribution atlas of larval tunas, billfishes and related species. Results of larval surveys by R/V shunyo maru and shoyo maru, 1956-75. S Ser. Far. Seas Fishs. Res. Lab. (9) :99p.

NISHIKAWA, Y., 1985. Average distribution of larvae of oceanic species of scombroid fishes 1956-1981. S Ser. Far Seas Fish. Res. Lab., (12):99 p.

RICHARDS, W.J., and T. POTTHOFF, 1980. Larval distributions os scombrids (other than bluefin tuna) and swordfish in the gulf of Mexico in the spring of 1977 and 1979. Collect. Vol. Sci. Pap. ICCAT / Recl. Doc. Sci. CICTA/Colecc. Doc. Cient. CICCA, 9 (3):680-94.

RICHARDSON, P.L. and D. WALSH., 1986. Mapping climatological seasonal variations of surface current in the tropical Atlantic using ship drifts. Journal of Geophsical Research, 91:10537-10550.

STRAMMA, L., Y. IKEDA, and R. G. PETERSON., 1990. Geostrophic transport in the Brazil Current region north of 20°S. Deep Sea Research (in press).

The Japan Meteorogical Agency, 1991. Climatic charts of sea surface temperatures of the western North Pacific and the Global Ocean. 51 p.

UDA, M., 1971. Larval distribution of tunas and billfishes in the Atlantic Ocean. FAO Fish. Rep./FAO Inf. Pesca, (71.2) 297-305.

UEYANAGI, S., 1971. Larval distribution of tunas and billfishes in the Atlantic Ocean. In Symposium on Invertigations and Resources of the Caribben Sea and Adjacent Regions. FAO Fish. Rep., 71 (2):297-305.

UEYANAGI, S., S. KIKAWA, M. UTO and Y. NISHIKAWA., 1970. Distribution, spawning and relative abundance of billfishes in the Atlantic Ocean. Bull. Far. Seas Fish. Res. Lab., 3:15-41.

WISE, J.P. and C.W. DAVIS, 1973. Seasonal distribution of tunas and billfishes in the Atlantic. NOAA Tech. Rep. NMFS (Spec. Sci. Rep. Fish. Ser.), (622):24 p.

WISE, J.P., and LE GUEN., 1969 The japanese Atlantic longline fishery, 1956-63. In Proceedings of the syposium on the oceanography and fisheries resources of the tropical Atlantic. Results of the ICITA and of the GTS, organized through the joint effort of unesco, FAO and OAU, Abidjan, Ivory Coast, 20-28 October 1966. Paris, Unesco, pp. 317-48.

YANEZ, R.E., et M.A. BARBIERI, 1980. Analyse de la prise par unite d'effort "saisonniere" et de l'evolution de l'indice gonado somatique de la peche palangriere (1956-77) et de surface (1969-78) du yellowfin (*Thunnus albacares*) de l'Atlantique. Collect. Vol. Sci. Pap. ICCAT/Recl. Doc Sci. CICTA/Colecc. Doc. Cient. CICAA, 9(1):76-91.

YANG, R.T., Y. NOSE, et Y. HIYAMA., 1969. A comparative study on the age and growth of yellowfin tunas from the pacific and Atlantic Ocean. Bull. Far. Seas Fish. Res. Lab., (20): 1-21.

Table 1. **Basic Characteristics of the Brasilian tuna longline boats**

Boat Size	Length	Gross Tonn.	Crew	Baskets
Small	16 m	37 G.T.	12	102
Small	18 m	52 G.T.	16	155
Medium	26 m	136 G.T.	24	220

Table 2. Basic characteristics of the longline gear used by the Brazilian tuna longline boats

	Length	Diameter	Material	Type
Buoy line	25m	6.0mm	nylon + polyp. 1	multifil. 2
Main line	360m	6.0mm	nylon + polyp. 1	multifil. 2
Branch line	15m	4.5mm	nylon + polyp. 1	multifil. 2
"Sekiyama"	7m	2.5mm	nylon	monofil. 3
Wire	2m	1.5mm	steel	monofil. 3

1 - polypropulene: 2 - multifilament: 3 - monofilament.

Table 3. Distribution of the fishing effort the Brazilian tuna longliners in the southwestern equatorial Atlantic, from July 1983 to December 1991.

Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	Total
1,000 hooks	35	98	155	501	506	365	288	284	83	2,315

Table 4. **Local, English and scientific names of tunas and billfishes caught by the Brazilian tuna longliners in the southwestern equatorial Atlantic Ocean.**

Local Names	English Names	Scientific Names
albacore laje	yellowfin tuna	*Thunnus albacares*
albacora branca	albacore	*Thunnus alalunga*
albacora bandolim	bigeye tuna	*Thunnus obesus*
agulhao branco	white marlim	*Tetrapturus albidus*
agulhao verde	longbill spearfish	*Tetrapturus pfluegeri*
agulhao de vela	sailfish	*Istiophorus albicans*
agulhao negro	blue marlin	*Makaira nigricans*
espadarte	swordfish	*Xiphias gladius*

Table 5. Species composition of the total catch and mean catch per unit of effort.

Group	Species	Catch in number	Total (%)	% of group	CPUE
Tuna	Yellowfin	23,059	41.8	83.8	1.00
	Albacore	2,929	5.4	10.6	0.13
	Bigeye	1,551	2.8	5.6	0.07
	Total	27,539	50.0	100.0	1.20
Billfish	White marlin	2,256	4.2	38.8	0.10
	Swordfish	2,194	41.8	83.8	1.00
	Sailfish	939	1.7	16.2	0.04
	Blue marlin	414	0.8	7.2	0.02
	Total	5,803	10.6	100.0	0.26
Sharks		18,564	33.6		0.80
Others		3,230	5.8		0.14
Total		55,136	100.0		2.40

Table 6. Mean dressed weight of tunas and billfishes caught by the Argus in the southwestern equatorial Atlantic, from July, 1983 to December, 1985.

Species	Mean dressed Weight (Kg)
Yellowfin tuna	29
Albacore	25
Bigeye tuna	39
White marlin	16
Swordfish	33
Sailfish	16
Blue marlin	102

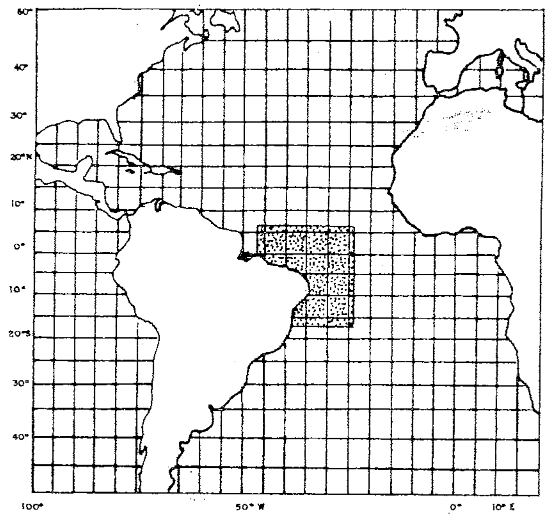


Fig. 1. Location of the fishing ground (hatched area) of the Brazilian tuna longliners in the southwestern equatorial Atlantic Ocean, from July 1983 to December 1991.

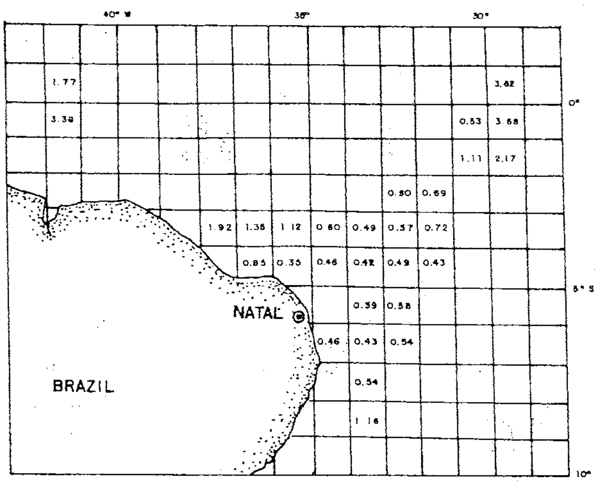


Fig. 3. Distribution of mean catch per 100 hooks of yellowfin tuna in the southwestern equatorial Atlantic Ocean, from July 1983 to December 1991.

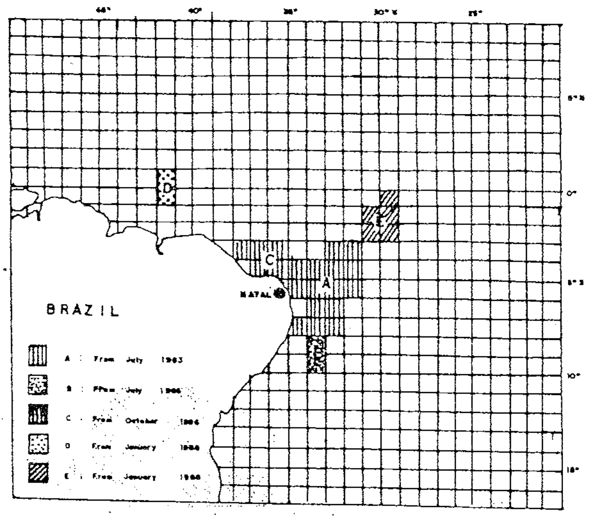


Fig. 5. Evolution of the fishing ground of the Brazilian tuna longliners in the southwestern equatorial Atlantic Ocean, from July 1983 to December 1991.

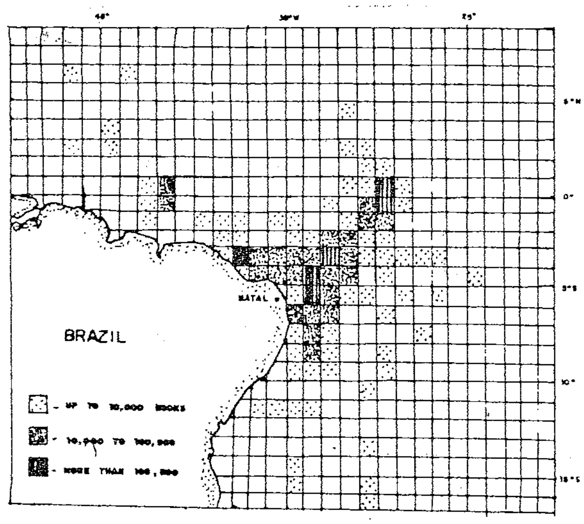


Fig. 2. Distribution of the fishing effort of the Brazilian tuna longliners in the southwestern equatorial Atlantic ocean from July 1983 to December 1991.

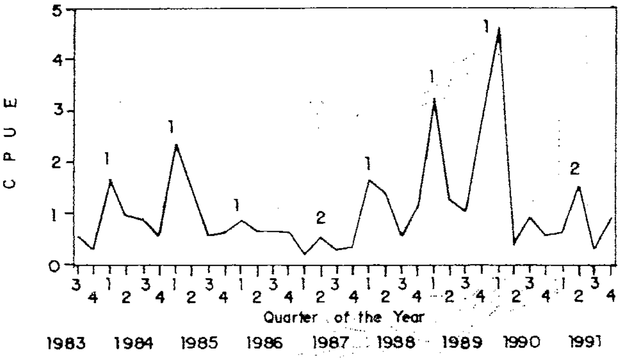


Fig. 4. Quarterly mean catches per 100 hooks of yellowfin tuna in the southwestern equatorial Atlantic Ocean, from July 1983 to December 1991. Numerals inside the figure denote quarters.

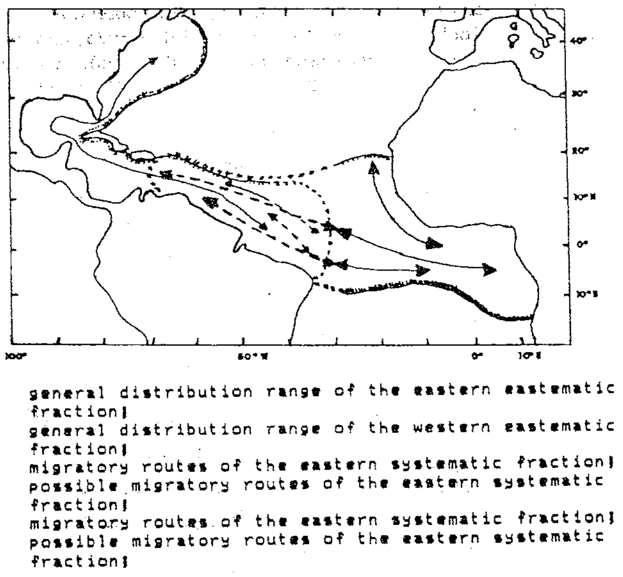
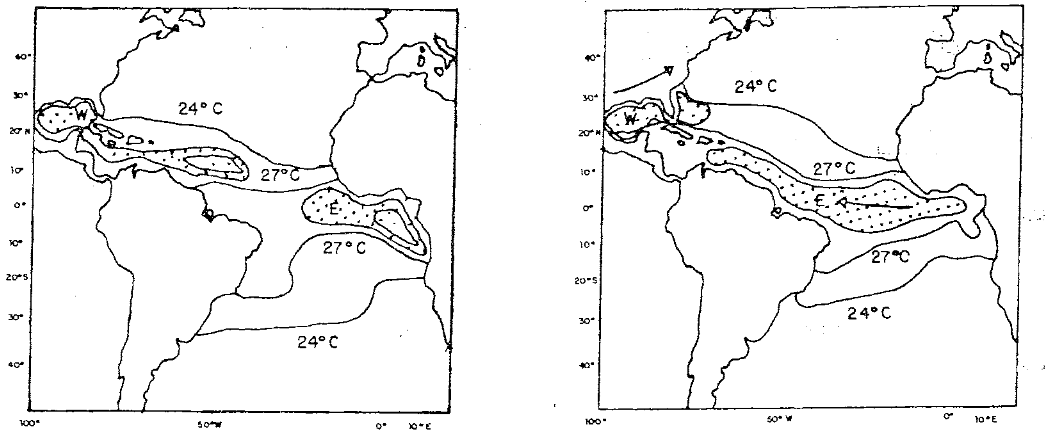


Fig. 6. Schematic migratory routes of yellowfin tuna deduced from catch statistics and length composition taken by on longliners and surface fisheries operated in the Atlantic Ocean (after Honma and Hisada, 1971).



First Quarter

Second Quarter

Fig. 7. Hypothetical distribution and migratory movements of the eastern and western stocks of yellowfin tuna, as related to the 30-year (1961/1991) mean 24°C and 27°C isotherms(after The Japan Meteorological Agency, 1991). W=western stock; E= eastern stock. The shaded areas represent the main spawning grounds as deduced from larval distribution (after Fonteneau and Marcille, 1988).

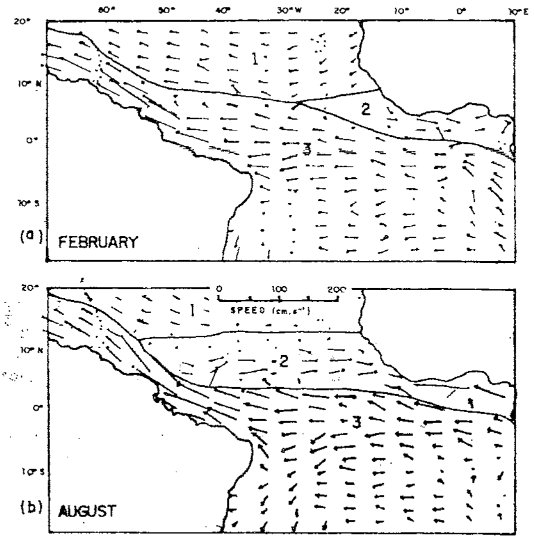


Fig. 8. Mean surface velocities from ship drift observations in 2° latitude by 5o longitude boxes for February (a) and August (b) (after Richardson and Walsh, 1986). 1= North Equatorial Current; 2= North Equatorial Counter Current; 3 = South Equatorial Current.

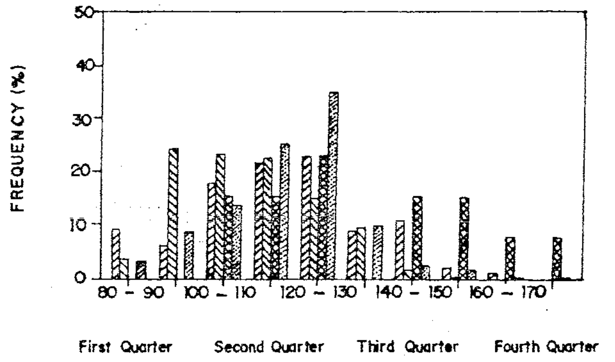


Fig. 9. Length frequency distribution of yellowfin tuna caught by longline in the southwestern equatorial Atlantic Ocean from December 1990 to December 1991, by quarters of the year.First quarter: n= 101; second quarter: n=235; third quarter: n= 13; fourth quarter: n= 289; total n= 638.

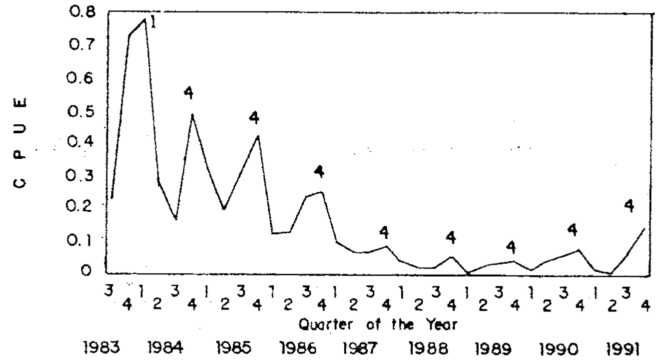


Fig. 11. Quarterly mean catches per 100 hooks of albacore in the southwestern equatorial Atlantic Ocean, from July 1983 to December 1991. Numerals inside the figure denote quarters.

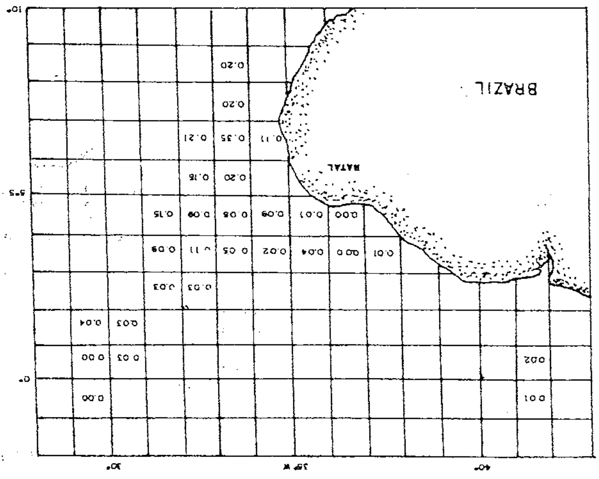


Fig. 10. Distribution of mean catch per 100 hooks of albacore in the southwestern equatorial Atlantic Ocean, from July 1983 to December 1991.

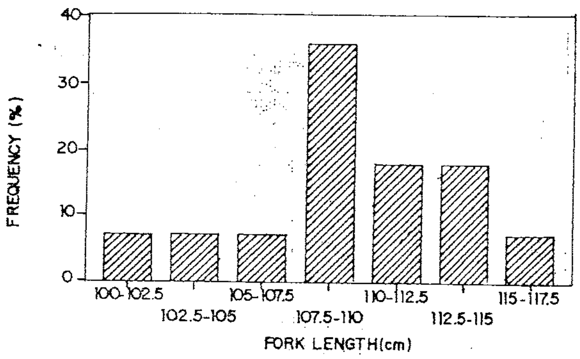


Fig. 12. Length - frequency distribution of albacore caught by longline in the southwestern equatorial Atlantic Ocean from December 1990 to December 1991. n= 28.

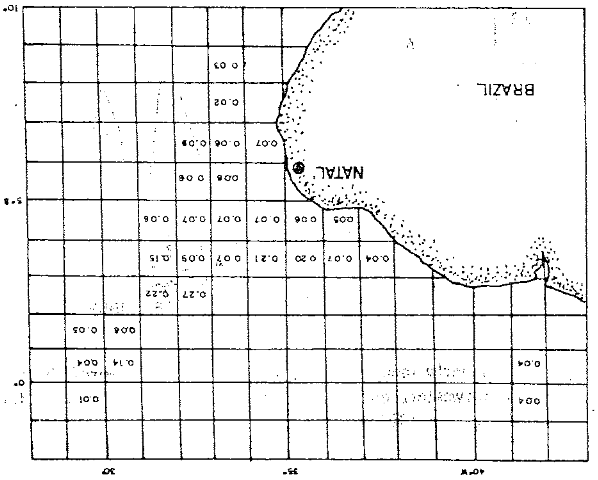


Fig. 13. Distribution of mean catch per 100 hooks of bigeye tuna in the southwestern equatorial Atlantic Ocean, from July 1983 to December 1991.

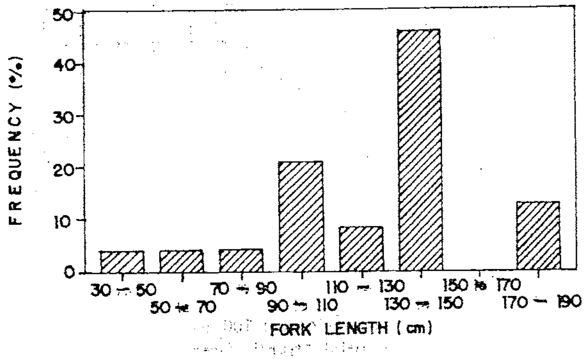


Fig. 15. Length - frequency distribution of bigeye tuna caught by longline in the southwestern equatorial Atlantic Ocean from July 1983 to December 1991 to December 1991. n= 24.

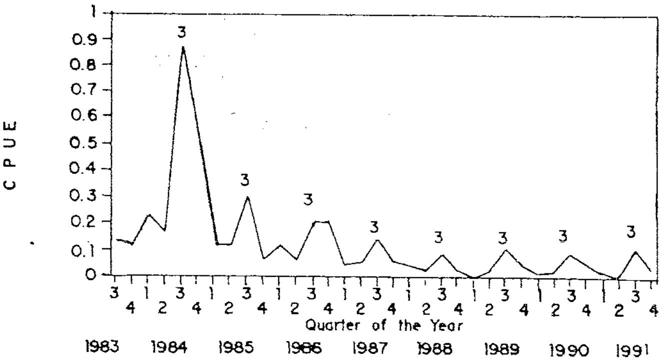


Fig. 17. Quarterly mean catch per 100 hooks of white marlin in the southwestern equatorial Atlantic Ocean, from July 1983 to December 1991. Numerals inside the figure denote quarters.

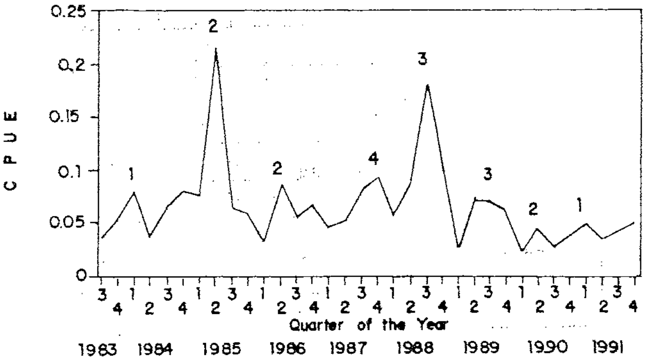


Fig. 14. Quarterly mean catches per 100 hooks of bigeye tuna in the southwestern equatorial Atlantic Ocean, from July 1983 to December 1991. Numerals inside the figure denote quarters.

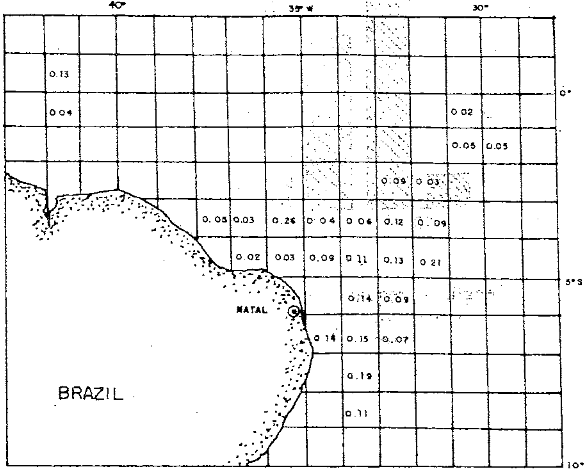


Fig. 16. Distribution of mean catch per 100 hooks of white marlin in the southwestern equatorial Atlantic Ocean, from July 1983 to December 1991.

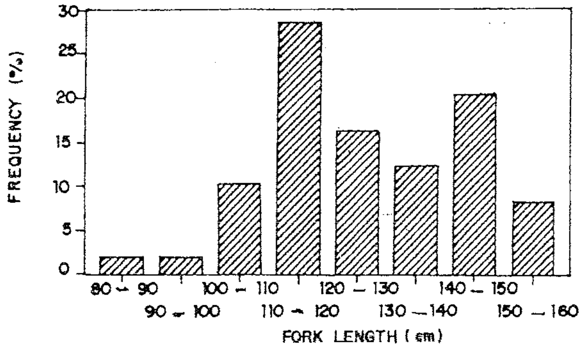


Fig. 18. Length - frequency distribution of white marlin caught by longline in the southwestern equatorial Atlantic Ocean, from July 1988 to February 1989. n= 49.

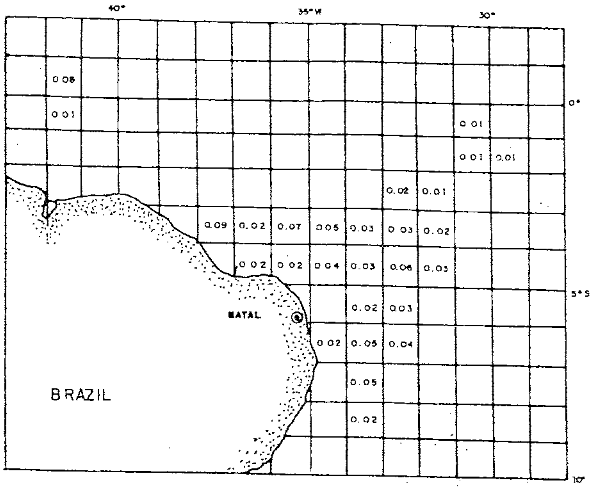


Fig. 19. Distribution of mean catch per 100 hooks of swordfish in the southwestern equatorial Atlantic Ocean, from July 1983 to December 1991.

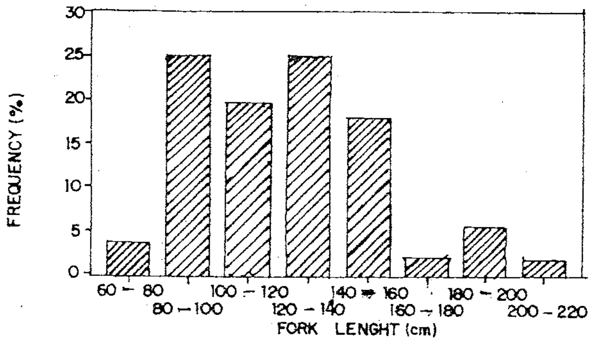


Fig. 21. Length - frequency distribution of swordfish caught by longline in the southwestern equatorial Atlantic Ocean, from July 1988 to February 1989. n= 56.

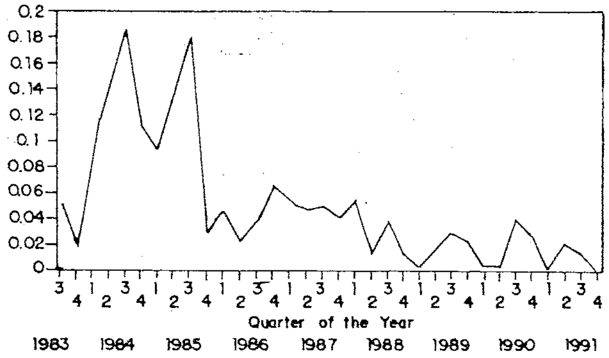


Fig. 23. Quarterly mean catch per 100 hooks of sailfish in the southwestern equatorial Atlantic Ocean, from July 1983 to December 1991.

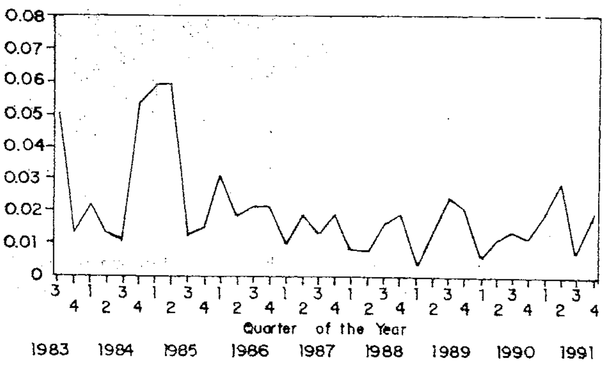


Fig. 25. Quarterly mean catch per 100 hooks of blue marlin in the southwestern equatorial Atlantic Ocean, from July 1983 to December 1991.

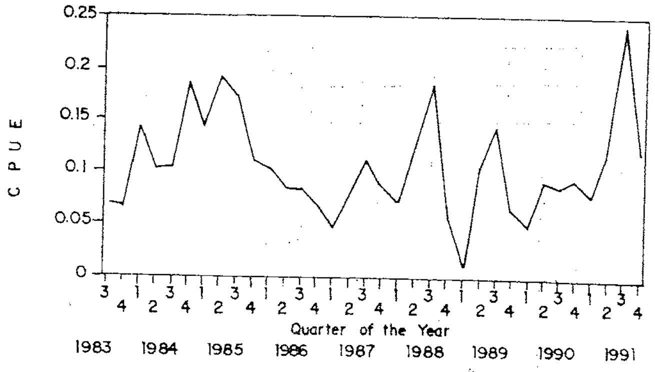


Fig. 20. Quarterly mean catch per 100 hooks of swordfish in the southwestern equatorial Atlantic Ocean, from July 1983 to December 1991.

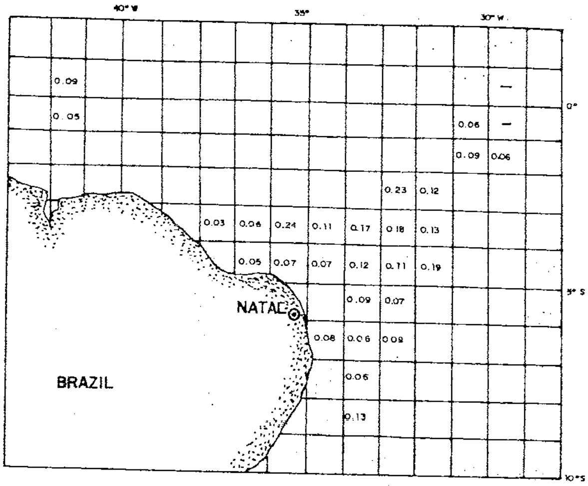


Fig. 22. Distribution of mean catch per 100 hooks of sailfish in the southwestern equatorial Atlantic Ocean, from July 1983 to December 1991.

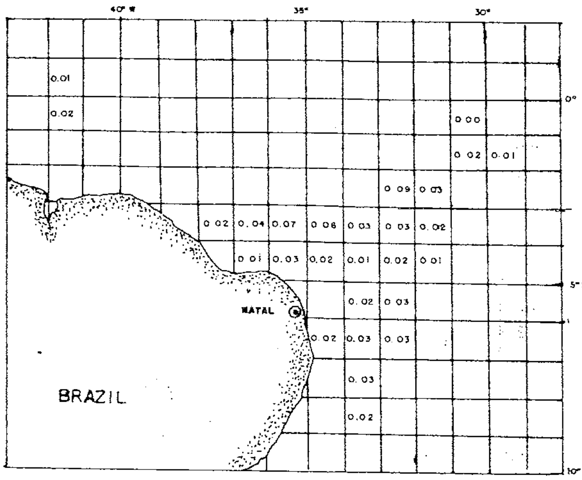


Fig. 24. Distribution of mean catch per 100 hooks of blue marlin in the southwestern equatorial Atlantic Ocean, from July 1983 to December 1991.