

**BLUE MARLIN (*Makaira nigricans*) and WHITE MARLIN (*Tetrapturus albidus*)
CAUGHT OFF THE BRAZILIAN COAST**

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SUMMARY

Blue marlin and white marlin are caught off the Brazilian coast all year round by longliners, in the warm period (October to February) by sport fishing. In Area C (20° to 35° S and 25° W to coast), blue marlin spawn at least in January and February in the area 17° - 23° S to 37° - 42° W; and white marlin spawn at least from November to March in the area 18° - 26° S and 40° - 46° W. Unusually large blue marlin males, 237 and 240 kg, were recorded off Vitoria City (18° - 21° S). Blue marlin in Area C were heavier and less abundant than in Area A (0° to 10° S and 30° to 40° W). The relationship obtained for blue marlin was: $Wt = 7 \times 10^7 LJFL^{3.47}$. For white marlin, $Wt = 2 \times 10^5 LJFL^{2.78}$, $EFL = 0.854 LJFL$, and Wt (total weight) = 1.12 Wd (dressed weight). Blue marlin were much more susceptible to the shallow longline than the regular, especially from October to May (spring/summer). After 1991, the annual white marlin CPUE presented a decreasing trend along the Brazilian coast. The highest abundance of white marlin was found in Areas B (10° to 20° S and 30° W to coast) and A. In Area C, white marlin occur mainly in the fourth and first quarter, especially from October to January.

RÉSUMÉ

Le makaire bleu et le makaire blanc sont capturés au large des côtes brésiliennes tout au long de l'année par les palangriers, et pendant la saison chaude (octobre-février) par la pêche sportive. Dans la zone C (de 20° à 35° de latitude sud et de 25° de longitude ouest à la côte), le makaire bleu fraye au moins pendant les mois de janvier et février dans le secteur 17°-23°S/37°-42°W, et le makaire blanc au moins de novembre à mars dans le secteur 18°-26°S/40°-46°W. Des makaires bleus mâles d'une taille particulièrement grande, pesant de 237 à 240 kg, ont été enregistrés au large de Vitoria City (18°-21° de latitude sud). Les makaires bleus de la zone C étaient plus gros et moins abondants que dans la zone A (0°-10°S/30°-40°W). Le rapport obtenu pour le makaire bleu était : $Wt = 7 \times 10^7 LJFL^{3.47}$. Et, pour le makaire blanc : $Wt = 2 \times 10^5 LJFL^{2.78}$, $EFL = 0.854 LJFL$, et Wt (poids total) = 1.12 Wd (poids manipulé). Le makaire bleu était bien plus accessible à la palangre d'eaux peu profondes qu'à la palangre normale, en particulier entre octobre et mai (période estivale). Depuis 1991, la CPUE annuelle du makaire blanc le long des côtes brésiliennes présente une tendance décroissante. La plus forte abondance de cette espèce a été observée dans la zone B (de 10° à 20° de latitude sud et de 30° de longitude ouest à la côte) et dans la zone A. Dans la zone C, le makaire blanc est surtout observé pendant les premier et dernier trimestres, en particulier d'octobre à janvier.

RESUMEN

La aguja azul y la aguja blanca se captura frente a la costa de Brasil durante todo el año, por palangreros, en el período cálido (octubre a febrero), con pesca deportiva. En el Area C (20° a 35°S y 25°W a la costa), la aguja azul desova por lo menos en enero y febrero en el área 17°-23°S a 37°-42°W; y la aguja blanca desove por lo menos desde noviembre a marzo en el área 18°-26°S y 40°-46°W. Se registraron agujas azules inusualmente grandes, machos de 237 y 240 kg, frente a la ciudad de Vitoria (18°-21°S). Las agujas azules en el Area C fueron de mayor peso y menor abundancia que el área A (0° a 10°S y 30° a 40°W). La relación obtenida para la aguja blanca era: $Wt = 7 \times 10^7 LJFL^{3.47}$. Para la aguja blanca, $Wt = 2 \times 10^5 LJFL^{2.78}$, $EFL = 0.854 LJFL$, y Wt (peso total) = 1.12 Wd (peso eviscerado). La aguja azul se mostró mucho más susceptible al

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palangre de superficie que al palangre regular, especialmente desde octubre a mayo (primavera/verano). Después de 1991, la CPUE anual de aguja blanca presentó una tendencia decreciente a lo largo de la costa de Brasil. La abundancia mayor de aguja blanca estaba en el Area B (10° a 20°S y 30°W a la costa) en A. En el Area C, la aguja blanca aparece principalmente en el cuarto y primer trimestre, especialmente desde octubre a enero.

1. INTRODUCTION

Blue marlin is extensively distributed throughout the tropical and subtropical seas. Its most frequent place of habitat is in the western part of the Atlantic. In the eastern Atlantic it occurs from the French coast to the Cape of Good Hope (Ovchinnikov, 1971).

According to Ueyanagi *et al.* (1970), in the Atlantic, the latitudinal range of this species varies seasonally and extends from about 45° N to about 35° S. Monthly distribution of catches by Japanese longliners shows two main seasonal concentrations: one in the northwestern Atlantic and the other in the southwestern Atlantic, between 5° and 30° S (off the Brazilian coast), from January through April.

White marlin, *Tetrapturus albidus*, is widely distributed across the Atlantic Ocean from about 45° N to 40° S (Miyake and Hayasi, 1972), and is also found in the Mediterranean Sea (Mather *et al.*, 1975; Miyake and Hayasi, 1972). This species is most densely found from May to October in the Gulf of Mexico, off Florida and northeast Brazil, and from November to April off southern Brazil (Ueyanagi *et al.*, 1970).

According to Ueyanagi *et al.* (1970) and Mather *et al.* (1972), the major concentration of white marlin in the Atlantic Ocean, based on records of the Japanese longline fishery (1956-67), occurred off the northeast to southeast Brazilian coast, from September to January.

In the 1970s and 1980s, white marlin caught by Japanese longliners showed a marked decline. The main area of concentration was in the northwest Atlantic. In the south Atlantic, a small concentration of white marlin was observed off the southeast of Brazil (Uozumi and Nakano, 1994).

The longline fishery in Brazil started with Japanese longliners based at Recife city, Pernambuco State, in 1956, and operated until 1964. A Japanese leased fleet based in Santos city, Sao Paulo State, operated with three boats from 1958 to 1961, and in 1965/66 a Brazilian company started to operate with two boats in the same port (Arfelli and Amorim, 1988). Some leased boats (with Honduran, Panamanian and Barbadian flags) have been operating since 1992, also in Santos. Based in Rio Grande city, Rio Grande do Sul State, the tuna longline fishery operated from 1977 to 1995 with leased Japanese boats, and from 1982 to 1992 with national boats. A Taiwanese leased fleet based at Rio Grande, operated from 1991 to 1994, and a Korean leased fleet during 1994-1995. In Natal city, Rio Grande do Norte State, the fishery with small longliners started in 1983 (Hazin *et al.*, 1994). In Belem city, Para State, a Taiwanese leased fleet started operating in 1992.

The Santos longliners used to operate with the traditional Japanese longline, nevertheless from May 1994, part of this fleet started to change this equipment to the surface longline (monofilament with light stick attraction), directed towards swordfish (Arfelli, 1996).

The Brazilian vernacular blue marlin name is *agulhao-negro*. It is caught in low quantities all year round, mainly in the fourth quarter, by Santos longliners (Amorim and Arfelli, 1987) and by national and leased longliners, off the Brazilian coast (Amorim *et al.*, 1994). It is also caught by sport fishing during the warm period (October to February) by the “*Iate Clube do Espirito Santo*”, Vitoria city, “*Costa Azul Iate Clube*”, Cabo Frio city, “*Iate Clube do Rio de Janeiro*”, Rio de Janeiro city, and “*Yacht Club de Ilhabela*”, Ilhabela city (Paiva and Pires-Junior, 1983; Arfelli *et al.*, 1994).

Off the Brazilian coast, the white marlin, called *agulhao-branco*, is caught by longliners, all year round (Antero Silva *et al.*, 1994). According to Arfelli *et al.* (1994), this species is also caught by sport fishing tournaments conducted by yacht clubs, mainly off Vitoria city (18° to 21° S) but is also caught in Rio de Janeiro (22° to 23° S) and Ilhabela (24° S) cities, from October to February (spring/summer).

Southeast and south of Brazil is an important area for blue marlin spawning (Bartlett and Haedrich, 1968; Ueyanagi *et al.*, 1970).

Ueyanagi *et al.* (1970) cited that the area off southeast Brazil (20° - 30° S and 20° - 50° W) was a major spawning area for white marlin in the Atlantic. Arfelli *et al.* (1986) also observed females with running ripe gonads from December to March off southeast Brazil.

The present paper contains analysis and results of relationships between lengths and weights, season and area of spawning, sex ratio, average weight, yield and CPUE of the Brazilian blue marlin and white marlin fishery (national and leased).

2. MATERIAL AND METHODS

In order to establish relationships between different length and weight, based on the methodology of Miyake and Hayasi (1972) and Miyake (1990), the following data were obtained:

- 48 pairs of lower jaw-fork length and total weight of blue marlin, collected from October 1974, to February 1996, during three research trips on Santos longliners, and from tournaments at Vitoria (CEPEMAR, 1990, 1992), Cabo Frio and Ilhabela cities;
- 154 pairs of total weight and lower jaw-fork length of white marlin, collected from February 1974 to December 1994, at Santos, Ilhabela and Vitoria (CEPEMAR, 1990, 1992) cities;
- 134 pairs of lower jaw-fork length and eye-fork length of white marlin, collected from February 1977, to December 1994, at Santos, Ilhabela and Vitoria (CEPEMAR, 1990, 1992) cities;
- 31 pairs of dressed weight and total weight of white marlin, collected from February 1974, to February 1977, during three research trips on Santos longliners.

The empirical data were used to fit the following general expression:

$$Y = aX^b$$

The sex ratio, as well as reproductive stages of 43 blue marlin specimens, was examined during tournaments at Vitoria (CEPEMAR, 1989, 1990, 1992 and 1993), Cabo Frio and Ilhabela cities, and three research trips on Santos longliners, between 1974 to 1996.

During 15 tournaments of “*Iate Clube do Espirito Santo*” (CEPEMAR, 1990, 1992) and “*Yacht Club de Ilhabela*” and seven research trips, between January 1974 and December 1994, the gonads of 252 white marlin specimens were examined for sex ratio and reproductive stages.

For the annual yield and CPUE analysis for the whole Brazilian coast, data were included from all fleets: national (Natal, Santos and Rio Grande cities) and the leased boats from Barbados (Santos city), Honduras (Itajai and Santos cities), Japan (Rio Grande city), Korea (Recife and Rio Grande cities), Panama (Santos city), Portugal (Belem city) and Taiwan (Belem and Rio Grande cities).

The other analyses in this paper are from data from: national longliners, from 1971-95, and leased boats (Honduran, Panamanian and Barbadian flags) from 1992 to 1995, based in Santos City, Sao Paulo State; Japanese boats, from 1977 to 1995, national fleet from 1982 to 1992, Taiwanese fleet, from 1991 to 1994, and Korean fleet from 1994 to 1995, based in Rio Grande city, Rio Grande do Sul State; and national longliners based in Natal city, Rio Grande do Norte State, from 1983 to 1994 (IBAMA, 1996; HAZIN *et al.*, 1994). The data of the Taiwanese leased fleet settled in Belem city, Para State, from 1992 to 1994 (IBAMA, 1996), was only used for annual yield and CPUE.

In this paper, blue marlin and white marlin were evaluated separating the Brazilian coast into three areas, according to Antero Silva *et al.* (1994): for Area A (north and northeast of Brazil, 0° to 10° S and 30° to 40° W) data from the leased Japanese, Taiwanese and Korean (based in Rio Grande) and national fleet from Natal were included; for Area B (northeast and southeast of Brazil, 10° to 20° S and 30° W to the coast) only the leased fleet based in Rio Grande was studied; and for Area C (southeast and south of Brazil, 20° to 35° S and 25° W to the coast), the fleets based in Rio Grande (including the national boats), and the longliners from Santos were analyzed.

The CPUE was given in total weight (kg) per thousand hooks. The annual CPUE from 1971 to 1995 was analyzed for Areas A, B and C. The quarterly CPUE, for the available data, were grouped in two periods: 1986-90 and 1991-95, by 5° squares, only for Area C. The 5° square areas were obtained according to the ICCAT methodology (Miyake and Hayasi, 1972).

To analyze the blue marlin and white marlin fisheries by the regular and shallow longlines of the Santos fleet, the monthly CPUE (kg per thousand hooks) from May 1994 to December 1995, and the quarterly CPUE grouped for 1992-95 (regular) and 1994-95 (shallow), by 5° squares, were compared.

To show the seasonal pattern of these species in Area C, the monthly CPUE values, grouped for the 1971-1995 period, from the regular longline of the Santos fleet, are presented.

3. RESULTS AND DISCUSSION

3.1. Blue Marlin

In the studied area, some authors have reported the occurrence of black marlin, *Makaira indica*, (Miyake and Hayasi, 1972; Nakamura, 1975). However, this species has never been seen and all the yield presented belongs to blue marlin.

Talbot and Penrith (1962) and Shannon (1987) cited that the water temperature at the Cape of Good Hope region is not a barrier for transoceanic migrations, except for tropical fish in winter. In the summer, the waters of Agulhas Current bend around the tip of Africa mixing with the subtropical south Atlantic waters. The confirmation of a migration from the Atlantic to Indian Ocean was through a blue marlin tagged off the coast of Delaware, in the Wilmington Canyon (off northeast U.S. coast) and recaptured after three years, off Mauritius Island (Indian Ocean) in September 1992 (Dugger, 1994; ICCAT, 1995).

The lower jaw-fork length/total weight relationship (Figure 1) obtained was:

$$\begin{aligned} Wt &= 7 \times 10^{-7} LJFL^{3.47} \\ r^2 &= 0.936 \end{aligned}$$

Few female gonads of this species were observed, and just two, brought by longliner fishermen in February 1995 and one observed in January 1996 in Cabo Frio city (23° S - 42° W), were at a ripe stage. According to the fishermen they found the females in area 17° 42' S / 37° 25' W. This information agrees with that presented by Ueyanagi *et al.* (1970). These authors cited that in the south Atlantic a concentration of maturing blue marlin occurs in the first quarter, between 10° S and 30° S along 0° to 50° W, mainly 20° to 30° S and 20° to 50° W. These authors also found larvae between November to April in the 10° to 30° S and 10° to 40° W area. Bartlett and Haedrich (1968) recorded 85 larvae off Brazil between 8° and 26° S.

The sex ratio of 43 specimens was 1.15:1 (male/female) on the basis of Santos longliners and especially of sport fishing. Sex ratio of this species varies considerably with season, area and size, and females attain a much larger size than males (Rivas, 1975). Data from the Japanese longline fishery show that males seldom exceed 116 kg and that most males weigh from 39 to 80 kg (Ueyanagi *et al.*, 1970). Nevertheless, males were recorded weighing 140 kg in the Bahamas (De Sylva, 1963), and 237 and 240 kg in Vitoria (CEPEMAR, 1992).

From 1971 to 1985, in Area C, blue marlin caught by Santos longliners included specimens between 155-160 cm (EFL) and 330-335 cm classes, with the most frequent annual classes from 170-175 cm (Amorim and Arfelli, 1987). These length classes converted by the equation $Wd = 1.03 \times 10^{-6} EFL^{3.46}$, (Amorim and Arfelli, 1987) resulted in 39-44 kg (dressed weight-Wd) to 533-562 kg (Wd) limits with 54-59 kg (Wd) as the lower limit of the most frequent classes. Considering that male blue marlin attain sexual maturity at a weight of 35 to 44 kg, and females at 47 to 61 kg total weight (Rivas, 1975), the majority of fish caught by Santos longliners were of a mature size. Nevertheless, blue marlin for Area A Natal longliners are of a smaller size, ranging from 124-240 cm (EFL), with an average of 102 kg (Wd), according to HAZIN *et al.* (1994). This range corresponds to about 18 to 177 kg. Also, in Area A the average weight of the fish caught by the Japanese fleet ranged from 66-88 kg (Wd). Amorim *et al.* (1994) analyzing the Brazilian longliners observed that blue marlin were heavier (average weight of 174 kg - Wd) and less abundant in Area C than in Area A. The average weight from sport fishing in Area C, 99 kg (Paiva and Pires-Junior, 1983), was similar to that of Area A.

For the whole period mentioned, the smallest fish found was 22 kg, in December 1992, and the largest 636 kg in February 1992, caught by sport fishing off Vitoria (CEPEMAR, 1993).

Along the whole Brazilian coast the blue marlin annual yield (Figure 2) of the national fleet fluctuated between 3 MT (1973) and 30 MT (1989). For the leased fleet, the annual yield was about 23 MT from 1977-91, increasing to about 118 MT in the next two years and decreased again in 1994 to 57 MT.

The annual CPUE (kg per thousand hooks) for the national fleet showed a decreasing trend from 1972 (32.7 MT) to 1984 (4.0 MT), and was relatively stable through 1994 (Figure 3). The leased fleet showed an increasing trend from 1979 (3.5 MT) to 1985 (21.8 MT), and a decreasing trend for the following period through 1994. The CPUE of the leased boats after 1983 was always higher than that of the national boats.

In Area A (Figure 4), only the yield from the Japanese fleet in 1978 (15 MT), and the Taiwanese fleet in 1992 (11 MT) presented significant quantities.

For blue marlin in Area B (Figure 5), only the Taiwanese fleet had high values, in 1991 and 1992 (18 and 23 MT respectively).

The Santos annual yield in the Area C (Figure 6) showed high fluctuation from 3 MT (1973) to 26 MT (1989). Also, the leased fleet yields varied from a high of 13 MT in 1982 to 2 MT in 1994.

In Area A (Figure 7) the highest values of CPUE, 188 MT (1982) and 115 MT (1987) were obtained by the Japanese fleet. In Area B (Figure 8) the highest value of CPUE, 52 MT (1980) was also from the Japanese fleet. In Area C (Figure 9) the Santos longliners showed the highest yield of 33 MT (1972) with a decreasing trend. In this area the Santos longliners presented the highest CPUE in the early 1970s while the Japanese fleet obtained their highest CPUE in the 1990s. The Korean and Taiwanese fleets had their highest values in 1994. Also, the Santos longliners with shallow gear operating from 1994, presented CPUE values very much higher than the ones with regular longline.

Comparing all areas, Area A presented the highest values of CPUE, obtained by the Japanese fleet. Also, the Natal fleet (Area A) obtained higher values than Santos fleet (Area C), in the period 1983-94.

The monthly blue marlin CPUE (May/94 to December/95) for shallow longlines from the Santos fleet (Figure 10) were much higher than for the regular longlines, especially from October to May (spring/summer). This probably occurred because, according to Nakamura and Rivas (1972), blue marlin feed more intensively at the surface in the morning.

Analyzing the monthly CPUE from 1971-95 for the Santos fleet using regular longline (Figure 11) it was observed that blue marlin is more abundant from October to March.

The quarterly CPUE (total weight - kg/thousand hooks), by 5° squares, for blue marlin caught in the south and southeast of Brazil, in the periods 1986-90 and 1991-95, are presented in Figures 12 to 18. Comparing the CPUE of the 1986-89 and 1992-95 periods, from Santos longliners with regular gear (Figures 12 and 13), in the latter period the fleet fished in more areas and showed higher values in all quarters. The highest CPUE for both periods, 21.6, was registered in the fourth quarter (area 1535) of 1992-95. The highest CPUE for the Santos fleet using shallow longlines, 379.7 in the first quarter (area 1535 - Figure 14) was 17 times higher than the highest CPUE of the regular longline. The highest quarterly CPUE of the shallow longline always occurred in the area 15° - 25° S and 25° - 40° W.

The Japanese fleet showed the highest CPUE values of 65.0 (area 2035) in the period 1986-90 (Figure 15) and 63.7 (area 3045) in the period 1991-95 (Figure 16), both in the first quarters. This fleet operated in few squares, mostly at 25° - 35° S and 40° - 50° W.

The highest CPUEs for the Taiwanese fleet (1991-94), 30.0 (area 2035) and 19 (area 2040), occurred in the third and second quarters respectively (Figure 17).

The Korean fleet (Figure 18) showed high values of CPUE (1994-95), 39.8 (area 3045) and 33.5 (area 2540) in the first and fourth quarters. This fleet usually fished at 25° - 30° S, 40° - 50° W.

Comparing Figures 12 to 18, the highest values of CPUE south and southeast of Brazil (1986-95) were generally in the first quarter.

The shallow longline of the Santos fleet presented higher CPUEs than other analyzed fleets in all quarters, except in the third quarter when that of the Taiwanese fleet was slightly higher.

The Japanese fleet showed the highest CPUE of all regular longliners (65.0 and 63.7). However, its highest value (65.0 kg/thousand hooks) refers probably to only one set (2,585 hooks) with one blue marlin caught.

3.2. White Marlin

In the studied area, morphological differences were observed in some specimens which presented pectoral, dorsal and anal fins, likely *Tetrapturus audax*, but the anus position was similar to *T. albidus*. The existence of some morphological differences in white marlin was also mentioned by Dr. Robins during the Billfish Workshop (ICCAT, 1981). In spite of Ueyanagi and Wares (1975) having cited the presence of *T. audax* in the studied area, no specimen was found. John Graves⁴ (personal communication) studying the mitochondrial DNA of fish hearts, believes that white marlin off Brazil and the USA Atlantic coast belong to the same population. Like blue marlin, white marlin enter the Indian Ocean, probably in the summer (Penrith, 1964; Ovchinnikov, 1971). Therefore all the yield presented belongs to white marlin.

The lower jaw-fork length/total weight relationship (Figure 19) obtained was:

$$\begin{aligned} \text{Wt} &= 2 \times 10^{-5} \text{LJFL}^{2.78} \\ r^2 &= 0.678 \end{aligned}$$

The lower jaw-fork/eye-fork length relationship (Figure 20) obtained was:

$$\begin{aligned} \text{EFL} &= 0.840 \text{LJFL}^{1.003} \\ r^2 &= 0.963 \end{aligned}$$

The dressed weight/total weight relationship (Figure 21) obtained was:

$$\begin{aligned} \text{Wt} &= 1.148 \text{Wd}^{0.9932} \\ r^2 &= 0.980 \end{aligned}$$

The value of the angular coefficient “b” of the eye-fork length/lower jaw-fork length and total weight/dressed weight relationships did not show significant difference from one; therefore, the following expressions were derived:

$$\begin{aligned} \text{EFL} &= 0.854 \text{LJFL} \quad (r^2 = 0.965) \quad \text{and} \\ \text{Wt} &= 1.12 \text{Wd} \quad (r^2 = 0.983) \end{aligned}$$

According to Ueyanagi *et al.* (1970) the only area in the south Atlantic with a concentration of maturing white marlin is the one between 20° S and 30° S along 20° W. These authors also found one larva off Rio de Janeiro State (22° S - 32° W). By the analysis of 52 females it was possible to observe that from April to August all gonads were in the early development stages (II and III); the developing and running ripe gonads (stage IV and V) were collected from December to March off southeast Brazil (Arfelli *et al.*, 1986). Off Vitoria from November/December 1988 to 1992, 84 females were observed, 28% of them were at stages II and III, 61% at stages IV and V, and 1% at stage VI (CEPEMAR, 1989, 1992 and 1993). White marlin probably spawn at 18° - 26° 20' S and 40° - 46° W. White marlin, sailfish, swordfish, dolphin and others were spawning in the Santa Martha Cape (25° 55' - 26° 20' S and 45° 10' - 45° 50' W), in February 1977. Large yellow-orange spots probably containing eggs and seaweeds were observed in this area during a research trip. These eggs are probably moved away from this area by some current, because juveniles were not found in the stomach contents of the tunas and related species caught by Santos longliners (Arfelli *et al.*, 1986). Stomachs of these species were also analyzed from 1972 to 1980 by Zavala-Camin (1982) and no white marlin was found. This suggests that the south and southeast of Brazil is not a growing area for white marlin. This is reinforced by the absence of young (less than 85 cm) specimens in the catch of longliners and the sport fishing boats. During 1971 to 1984 in Area C, white marlin catch included specimens in the 85-90 cm and 200-205 cm classes, with the 135-140 cm to 145-150 cm (EFL) being the most frequent (Arfelli *et al.*, 1986). Nevertheless, for the whole period the smallest fish found was 8.5 kg (dressed weight) in April 1973. The largest was the specimen weighing 83 kg (dressed weight) in July 1971 (Amorim and Arfelli, 1979). This weight corresponds to about 93 kg in total weight, being higher than the maximum weight for this species (88.8 kg) presented by Ovchinnikov (1971).

The sex ratio of 252 white marlin was 2.9:1 (males and females). Sex ratio of this species varies considerably with season, area and size, and males appear to be predominant in most areas. However, females reach larger sizes and are heavier than males of the same size (De Sylva and Davis, 1963; Ueyanagi *et al.*, 1970; Nakamura and Rivas, 1972).

Considering that this species attains sexual maturity at around 130 cm (EFL) (Ueyanagi *et al.*, 1970), about 89% of the white marlin caught by Santos longliners have attained their first maturity stage (Arfelli *et al.*, 1986).

⁴ John Graves Ph.D., Virginia Institute of Marine Science, Gloucester Point, Virginia, USA.

According to Arfelli *et al.* in the 1971-84 period the annual average dressed weight of white marlin caught by Santos longliners fluctuated from 27.7 to 24.0 kg until 1983, decreasing to 21.1 kg in 1984. For the 1992-95 period it fluctuated from 22.2 to 18.6 kg.

White marlin represented about 3% of the catch (in weight) from the Japanese fleet, 0.4% of the national fleet from Rio Grande, 2% of Santos longliners and 4.2% (number of fish) from national based Natal city (Antero Silva *et al.* 1994).

Observing the annual yield of national and leased fleets over the whole coast of Brazil (Figure 22), a stable catch from the national fleet from 1971-82 period (average of 25 MT) was observed, followed by an increasing trend until 1991 (280 MT), decreasing again until 1994 (73 MT). The leased fleet showed two peaks, the first in 1978 (146 MT) and the second in 1993 (224 MT).

The white marlin annual CPUE (kg per thousand hooks) for the national fleet shows a decreasing trend from 1972 (77.2) to 1982 (12.2), followed by an increasing trend until 1991 (73.6), and then decreased until 1994 (21.4) (Figure 23). The leased fleet exhibited two high peaks, in 1978 (100.1) and in 1979 (94.8). After these peaks, the CPUE fluctuated from 33.6 (1985) to 3.3 (1994).

Analyzing the annual yield of white marlin from Area A (Figure 24), only the Natal fleet fished regularly in this area, reaching a maximum of 21 MT (1985) and decreasing to 0 (1994). The leased fleets only attained high catches in 1978 (17 MT by the Japanese) and in 1992 (12 MT by the Taiwanese). In Area B (Figure 25) the Japanese fleet recorded high catches only in 1979 (21 MT) and 1982 (16 MT), while the Taiwanese fleet showed two high values, in 1991 (45 MT) and 1992 (38 MT) followed by a sharp decrease through 1994 (1 MT). In Area C (Figure 26) the data from Santos longliners were very similar with those national longliners (Figure 7) because the Santos longliners fished during the whole period with a higher number of boats than the other national fleets. This similarity is also observed between the data of the Japanese leased fleet from Area C and the data of the leased fleet of Figure 14, from 1977 to 1990, because in this period the Japanese were practically the only leased fleet operating in Brazil, and operated mainly in Area C. The highest catches of white marlin by sport fishing occurred off Vitoria (Areas B/C).

Analyzing the annual white marlin CPUE in Areas A (Figure 27), B (Figure 28), and C (Figure 29), it is observed that the Japanese fleet obtained the highest values in all areas: 843 (1979) and 715 (1982) in Area B, 120 (1982) in Area A, and 115 (1978) in Area C. The CPUEs of the Taiwanese fleet were always lower than 37 (1991, Area B) and the Korean fleet never exceeded 0.9 (1995, Area C). The CPUE of Natal longliners (Area A) presented values around 20 in the first three years (1983 - 1985), and around 7 in the subsequent years. The CPUE of the Santos longliners (Area C) showed a similar pattern to that of the national fleet from Figure 23, as did the yields. The Japanese CPUE showed a decreasing trend from 1978 to 1995 (Area C).

Comparing the monthly white marlin CPUE from May 1994 to December 1995 from the regular and shallow longlines of the Santos fleet (Figure 30), white marlin was more susceptible to the shallow longline than to the regular, especially in the fourth quarter. In November 1994, the CPUE of the shallow longline was almost three times higher than that of the regular. Nevertheless in the first quarter the regular longline presented higher CPUEs (Figures 30).

The monthly white marlin CPUE grouped for the 1971-95 period shows that the highest values (Figure 31), in the south and southeast of Brazil, occur from October to January, when this species comes to this area to spawn (Arfelli *et al.*, 1986).

The white marlin quarterly CPUE, by 5° squares for Area C, for the national and leased fleets, are shown in Figures 32 to 38. The CPUE of the Santos fleet, with regular longline, for the 1986-89 and 1992-95 periods (Figures 32 and 33) showed that white marlin were more concentrated between 20° and 30° S in the third and fourth quarters, and between 25° and 35° S in the first and second quarters. The CPUE for shallow longlines for this fleet, for 1994-95 (Figure 16), showed almost the same quarterly distribution pattern.

The highest Santos CPUE was recorded in the first quarter of 1992-95 (132.0 kg/thousand hooks) and in the fourth quarter of 1986-89 (96.1) with regular longline (Figures 33 and 32), and in the fourth quarter of 1994-95 (101.5) with shallow longline (Figure 34). Although the regular longline showed the highest value of CPUE, the shallow longline showed more areas with high values and consequently higher monthly CPUE than the regular (Figure 30). Also, the average weight of fish caught by shallow longline was higher.

The Japanese fleet fished in few squares; nevertheless it had the highest CPUE values of all fleets: 359.4 (area 2540) and 257.5 (area 2040), respectively, in the fourth and second quarters of 1986-90 (Figure 35). However in these

squares the effort was lower than 10,000 hooks. In the period 1991-95 this fleet obtained its highest CPUE, 58.5 (area 3050), in the first quarter, operating only in two other squares: 2545 and 3045 (Figure 36).

The Taiwanese fleet in the period 1991-94, had the highest CPUE of 128.1 (3040) in the fourth quarter. In this area the effort was only 2,700 hooks, but in this quarter another high CPUE value (92.0) occurred, in an intensely exploited square. The other quarters showed low values (Figure 37).

The Korean fleet fished in 1994-95 and presented the highest CPUE value, 16.0 (obtained from only 2,000 hooks) in the third quarter (Figure 38). This value was the highest of all leased fleets in the third quarter.

Comparing the Figures 32 to 38, the highest values of CPUE south and southeast of Brazil (1986-95) were generally observed in the fourth and first quarters.

In the period 1986-90, the highest quarterly CPUE values by 5° squares were obtained by the Japanese leased fleet, whereas in the period 1991-95, they were generally obtained by the Santos fleet with shallow longline.

4. CONCLUSIONS

Blue marlin spawns off the Brazilian coast, at least in January and February, in the area 17°- 23° S to 37°- 42° W. White marlin probably spawns from November to March, at least in the area 18°- 26° 20' S and 40°- 46° W. In the south and southeast of Brazil males were predominant.

Unusual blue marlin males, 237 and 240 kg, were recorded off Vitoria city (18° - 21° S). Blue marlin in the south and southeast (Area C) was heavier and less abundant than in the northeast (Area A) of Brazil. The annual blue marlin CPUE of leased boats after 1983 was always higher than that of national boats, and the Japanese fleet generally obtained the highest values. Blue marlin was much more susceptible to the shallow longline than to the regular, especially from October to May (spring/summer).

After 1991 the annual white marlin CPUE presented a decreasing trend along the Brazilian coast. The highest abundance of white marlin was verified in Areas B and A. In Area C white marlin occurs mainly in the fourth and first quarters, especially from October to January. The annual white marlin CPUE of national longliners after 1986 was always higher than that of the leased boats, due mainly to Santos longliners influence. White marlin was more susceptible to the shallow longline than the regular longline of Santos fleets, especially from October to December 1994.

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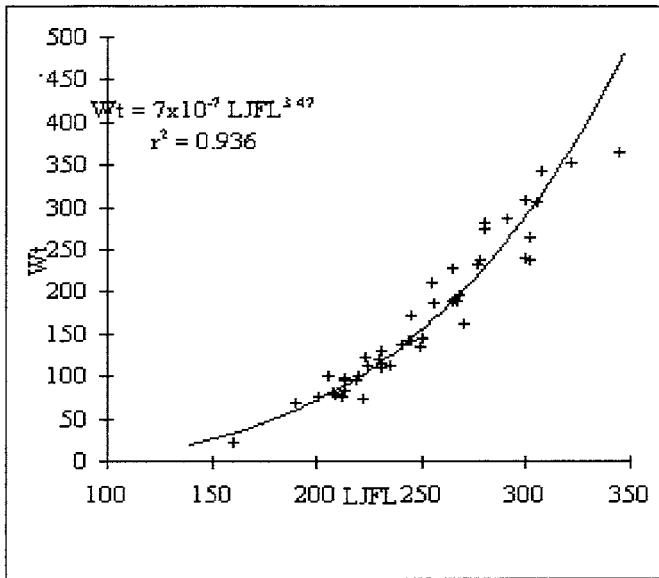


Fig. 1. Lower jaw-fork length/total weight relationship of blue marlin caught off the south and southeast of Brazil.

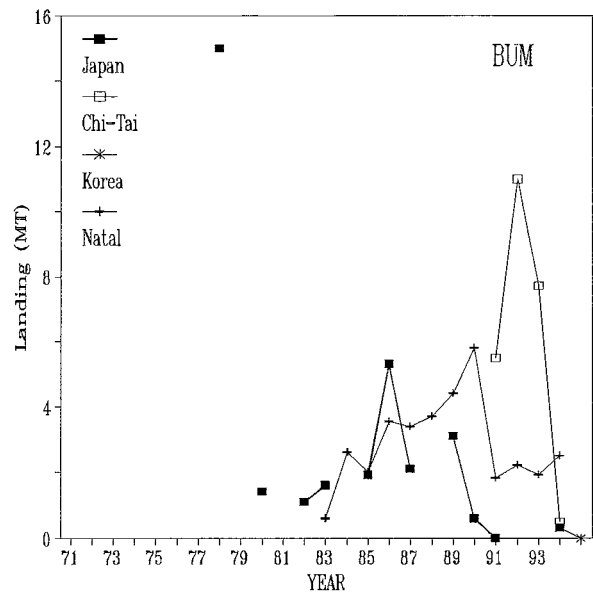


Fig. 4. Blue marlin landing (total weight in metric tons) from Area A, by the regular longline leased fleets from Rio Grande and Natal.

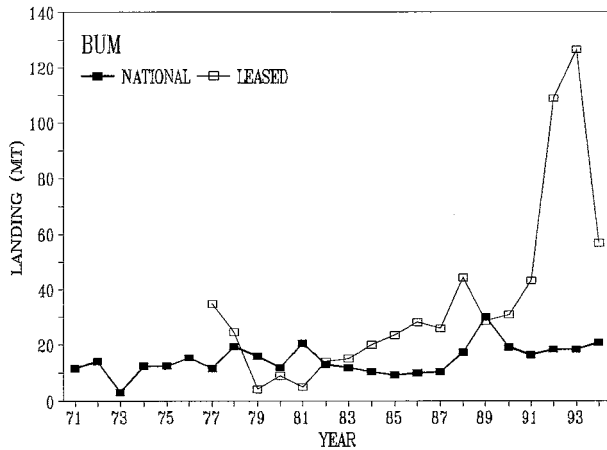


Fig. 2. Blue marlin landing (total weight in metric tons) of national and leased fleets from Brazil.

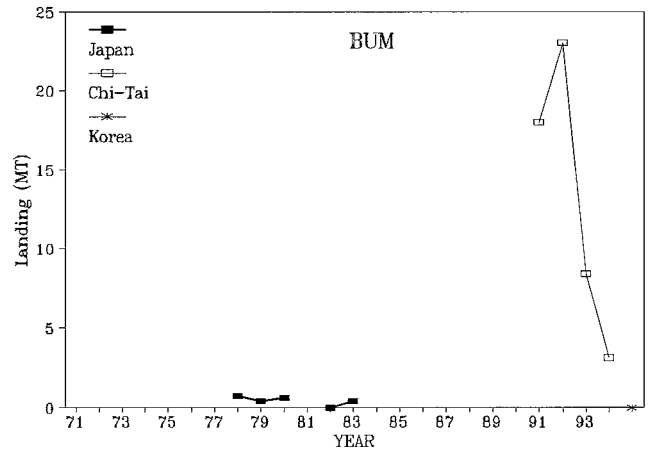


Fig. 5. Blue marlin catch (total weight in metric tons) from Area B by the regular longline leased fleet of Rio Grande.

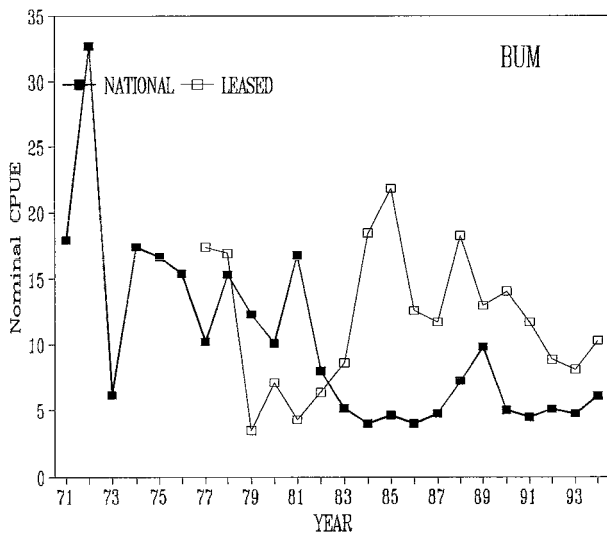


Fig. 3. Blue marlin nominal CPUE (total weight in kg / thousand hooks) of national and leased fleets from Brazil.

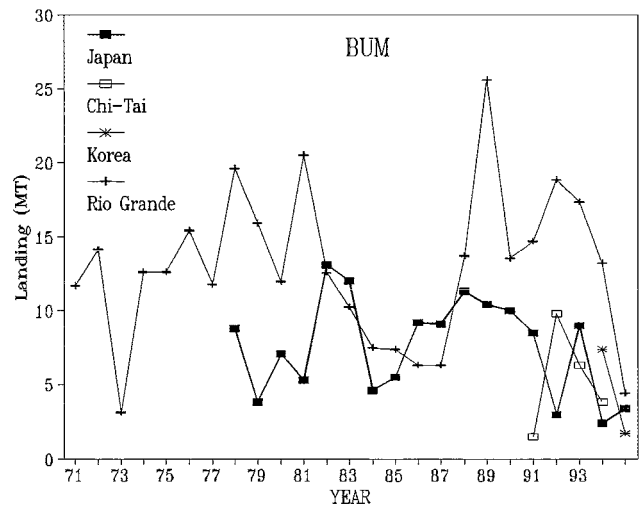


Fig. 6. Blue marlin catch (total weight in metric tons) from Area C by regular longline national and leased fleets from Rio Grande and Santos.

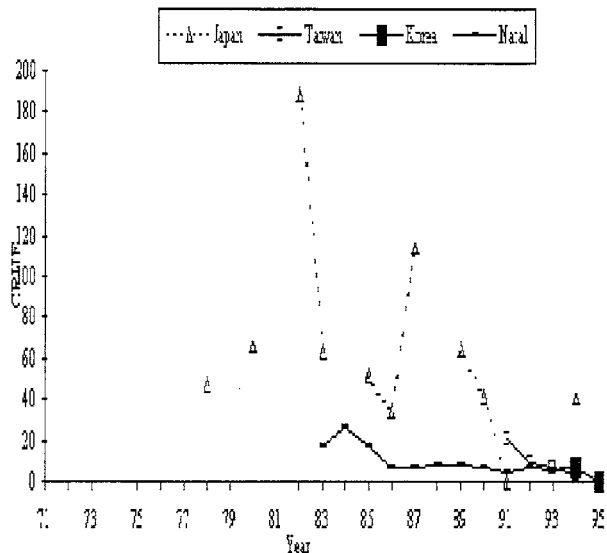


Fig. 7. Blue marlin nominal CPUE (total weight in kg / thousand hooks) from Area A, by regular longline leased fleet of Rio Grande and Natal.

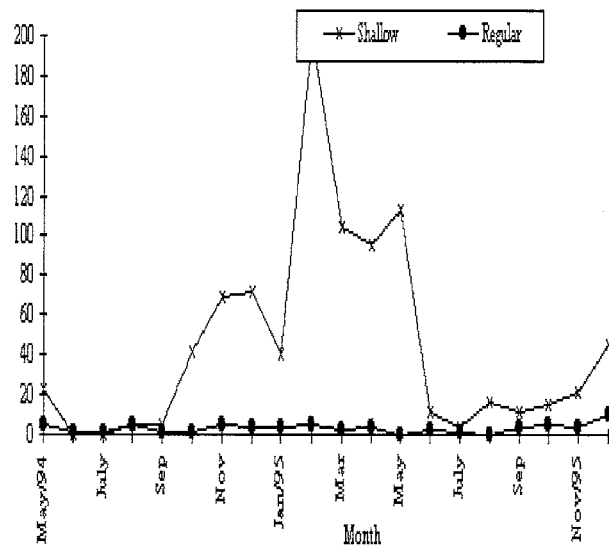


Fig. 10. Blue marlin nominal CPUE (total weight in kg / thousand hooks) by Santos fleet of regular and shallow longlines (1994-1995).

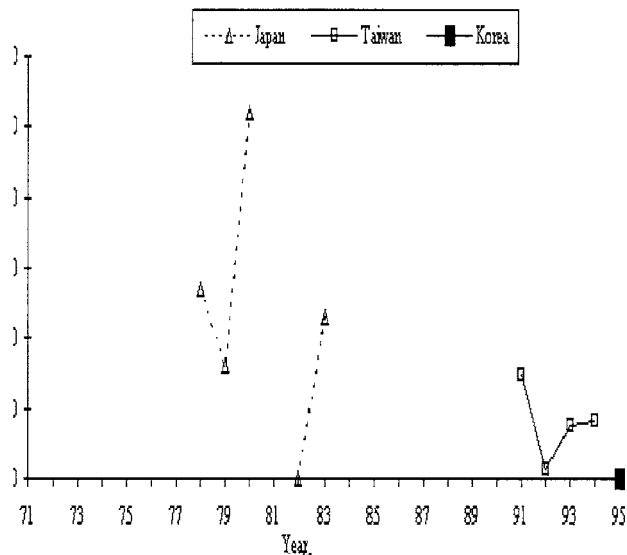


Fig. 8. Blue marlin nominal CPUE (total weight in kg / thousand hooks) from Area B by regular longline leased fleet of Rio Grande.

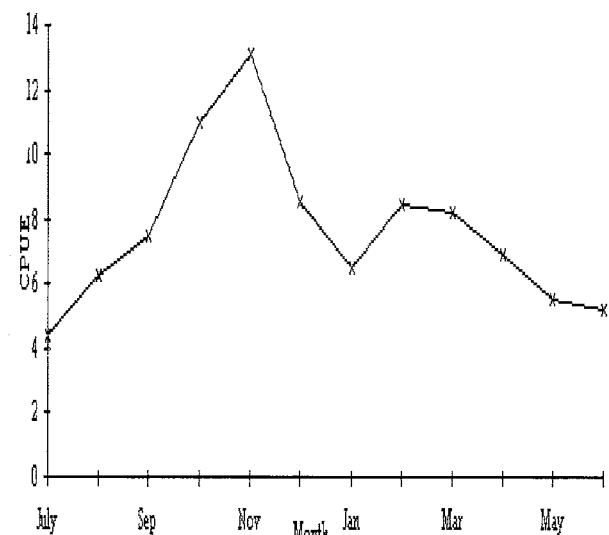


Fig. 11. Blue marlin monthly nominal CPUE (total weight in kg / thousand hooks) of 1971-1995 period by Santos fleet of regular longline.

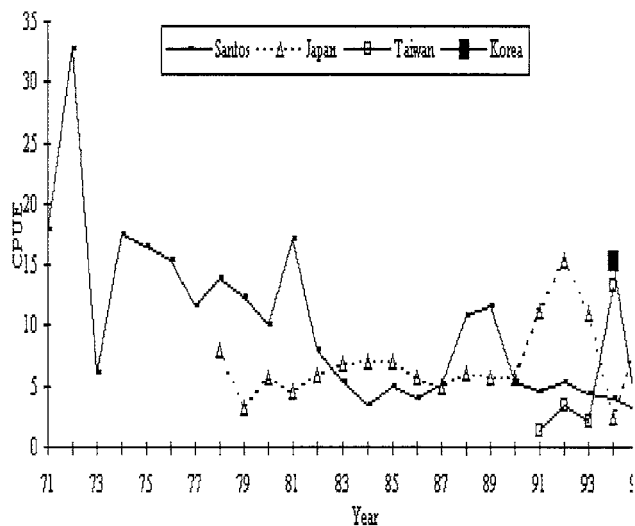


Fig. 9. Blue marlin nominal CPUE (total weight in kg / thousand hooks) from Area C by regular longline leased fleet of Rio Grande and Santos.

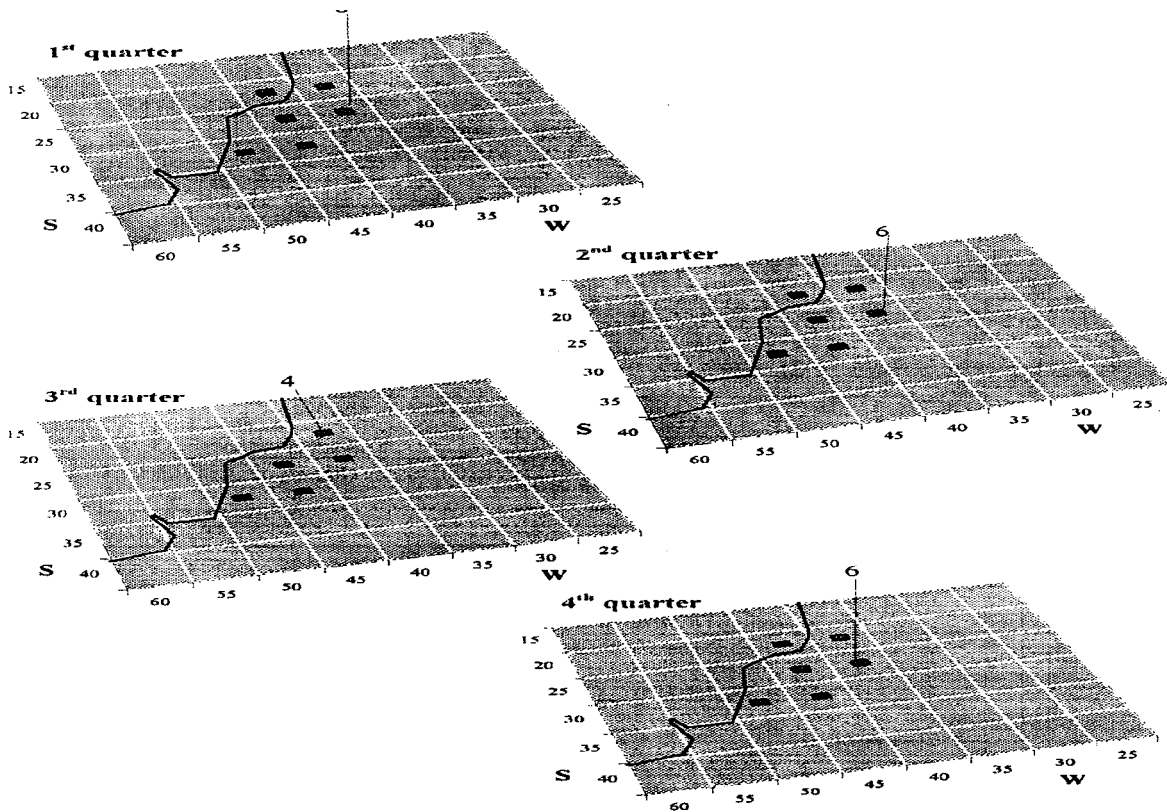


Fig. 12. Blue marlin quarterly nominal CPUE (total weight in kg/ thousand hooks) by Santos Fleet with regular longline, by 5 degrees area, 1986-1989.

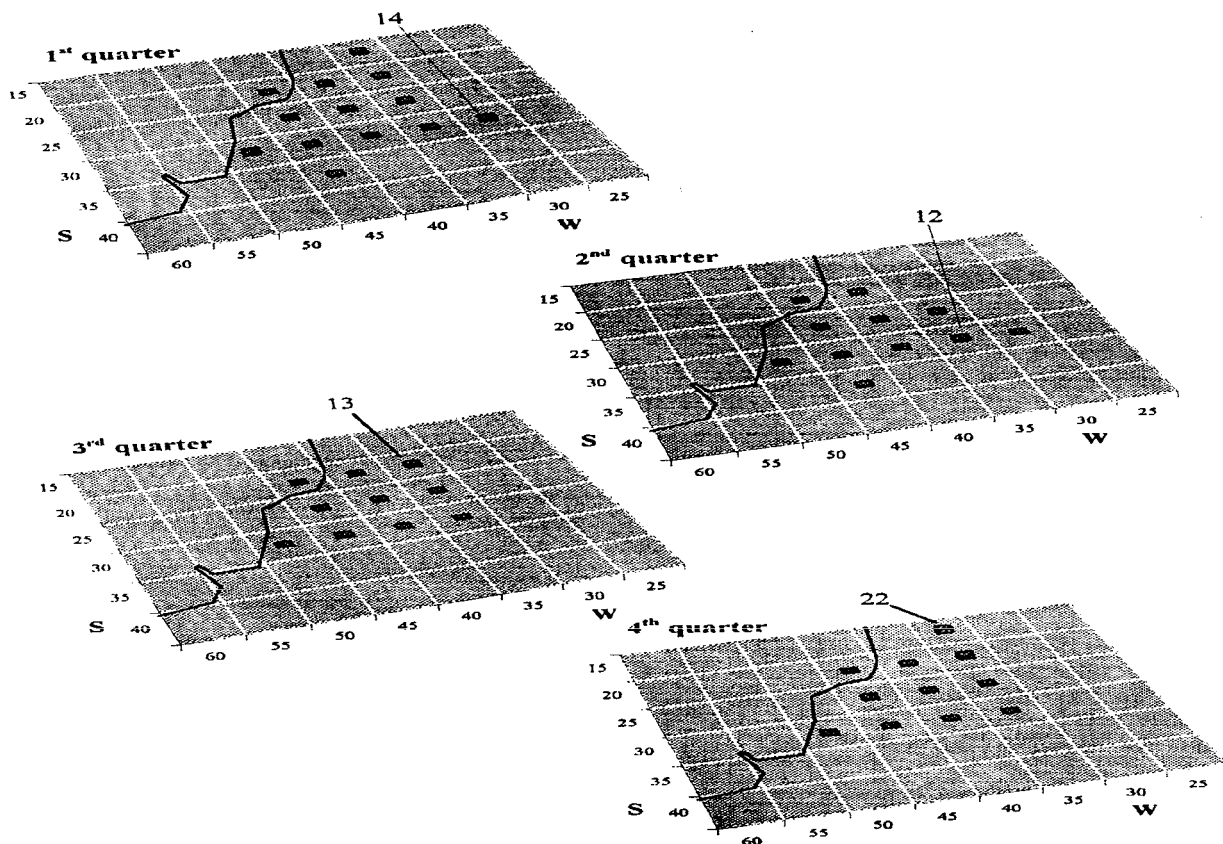


Fig. 13. Blue marlin quarterly nominal CPUE (total weight in kg/ thousand hooks) by Santos Fleet with regular longline, by 5 degrees area, 1992-1995.

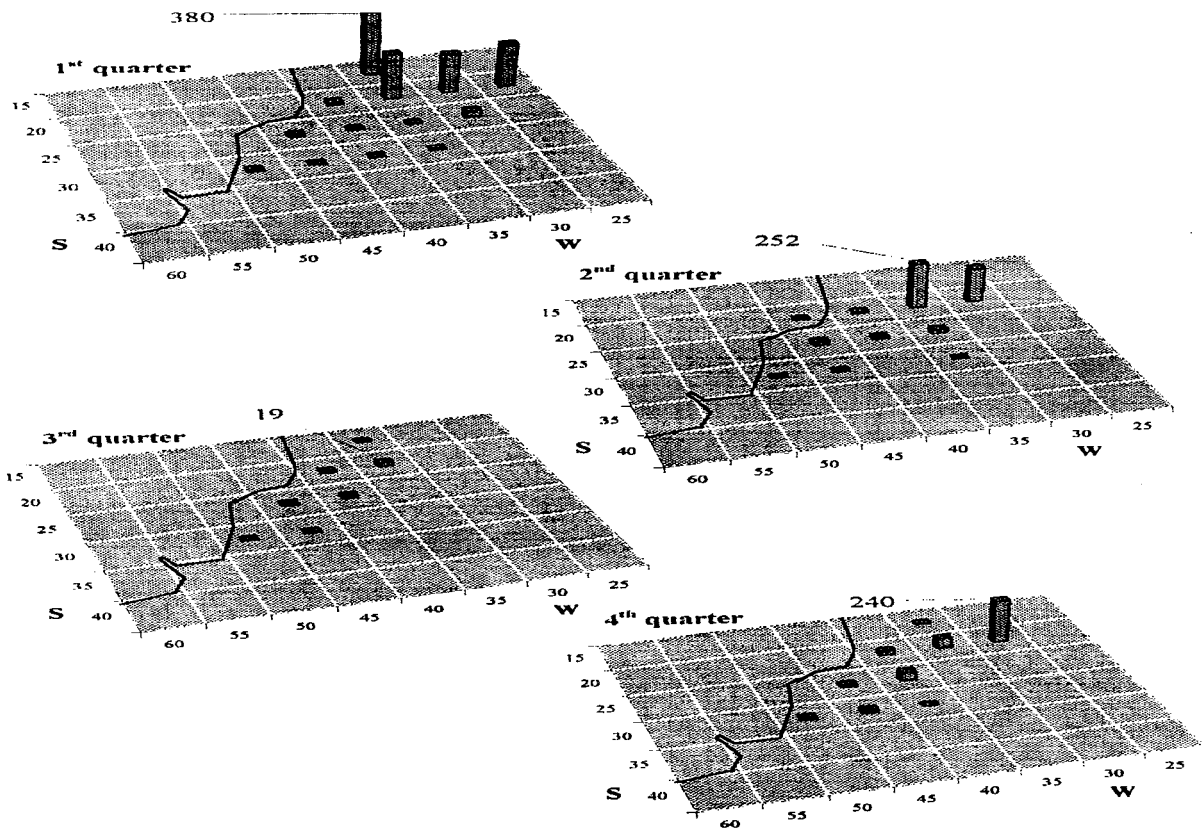


Fig. 14. Blue marlin quarterly nominal CPUE (total weight in kg / thousand hooks) by Santos Fleet with shallow longline, by 5 degrees area, 1994-1995.

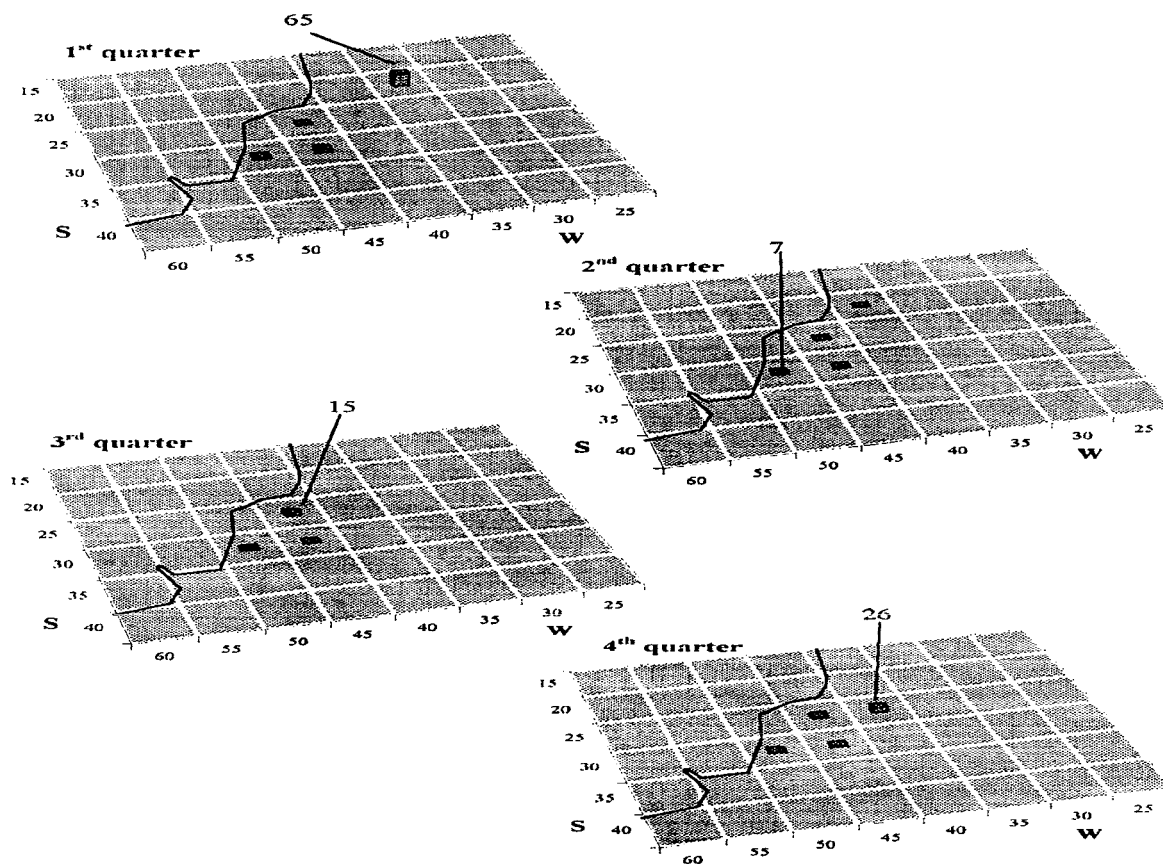


Fig. 15. Blue marlin quarterly nominal CPUE (total weight in kg / thousand hooks) by Japanese Fleet with regular longline, by 5 degrees area, 1986-1990.

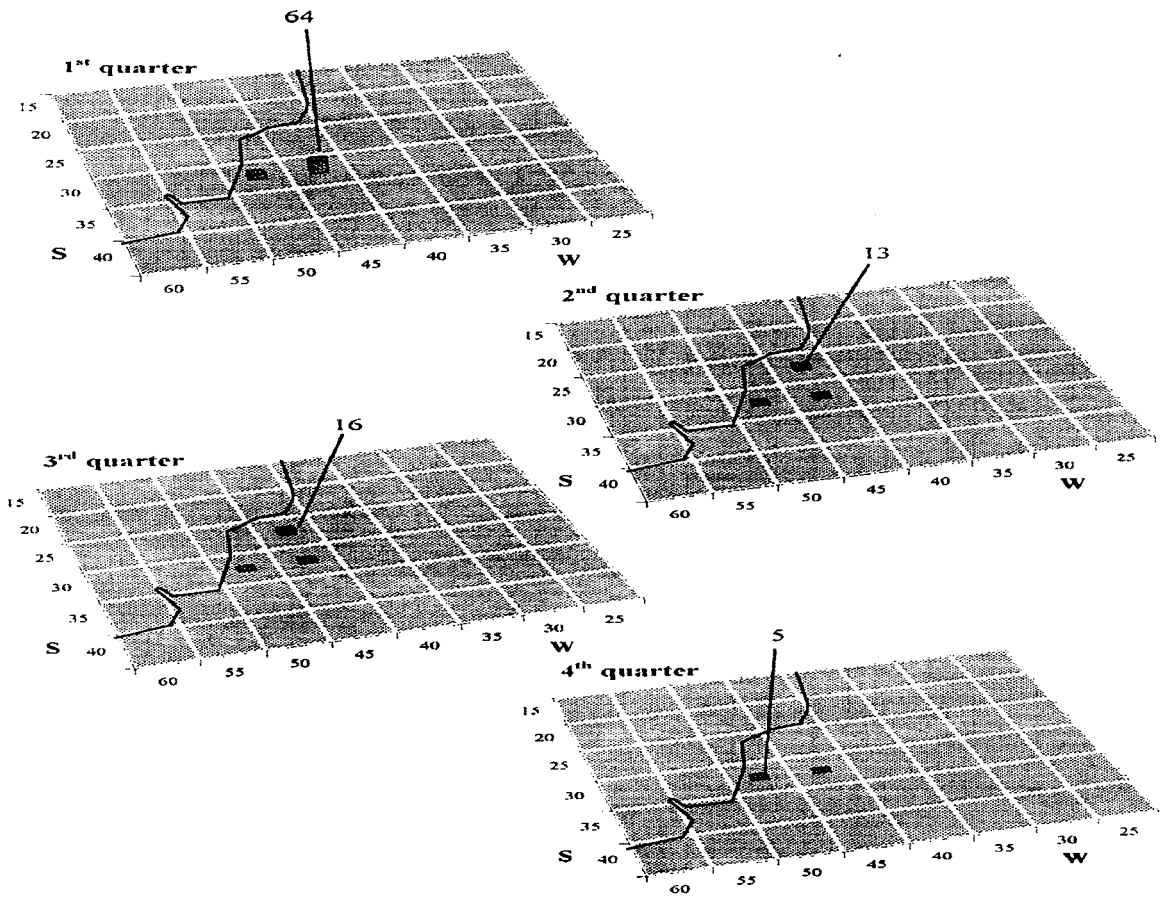


Fig. 16. Blue marlin quarterly nominal CPUE (total weight in kg / thousand hooks) by Japanese Fleet with regular longline, by 5 degrees area, 1991-1995.

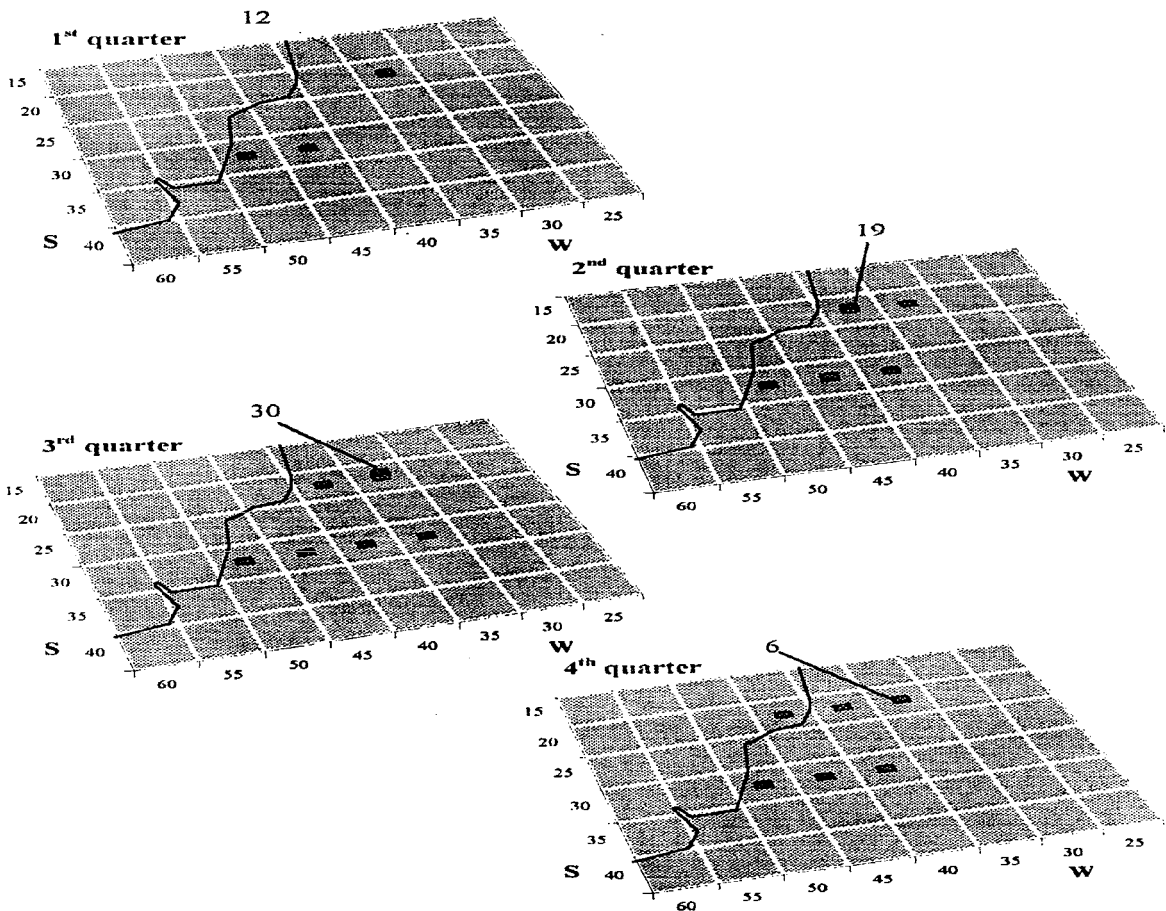


Fig. 17. Blue marlin quarterly nominal CPUE (total weight in kg / thousand hooks) by Taiwanese Fleet with regular longline, by 5 degrees area, 1991-1994.

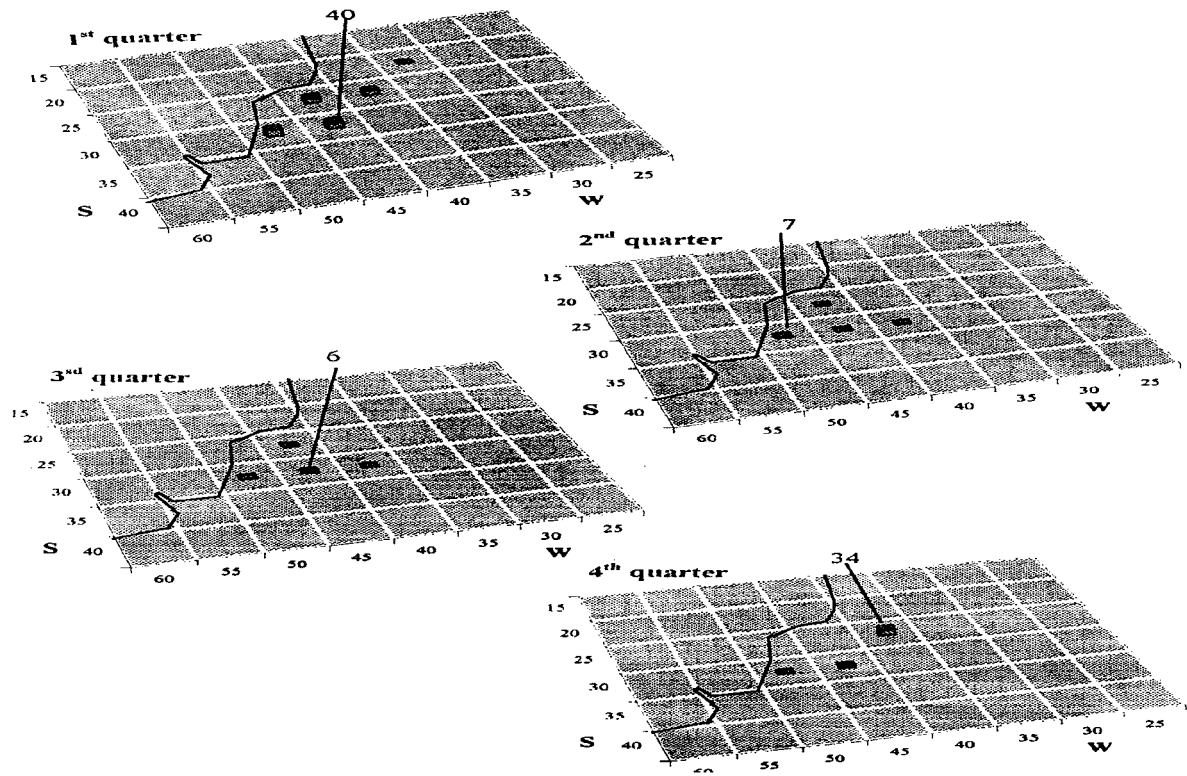


Fig. 18. Blue marlin quarterly nominal CPUE (total weight in kg/ thousand hooks) by Korean Fleet with regular longline, by 5 degrees area, 1994-1995.

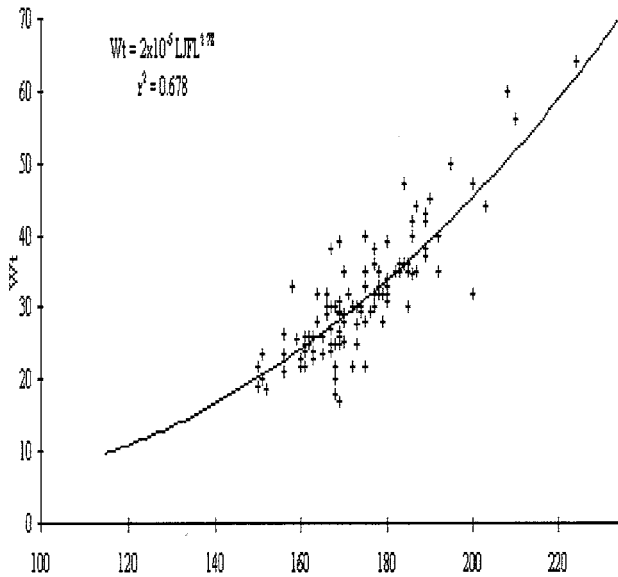


Fig. 19. Lower jaw fork-length / total weight relationship of white marlin caught off south and southeast Brazil.

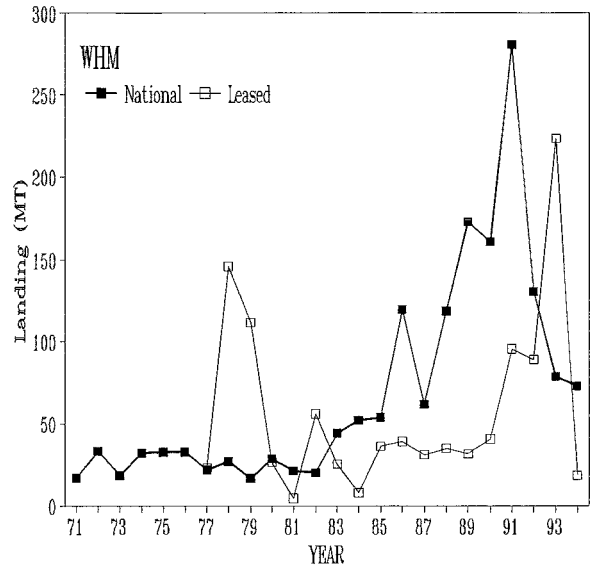


Fig. 22. White marlin landing (MT) by national and leased fleets from Brazil.

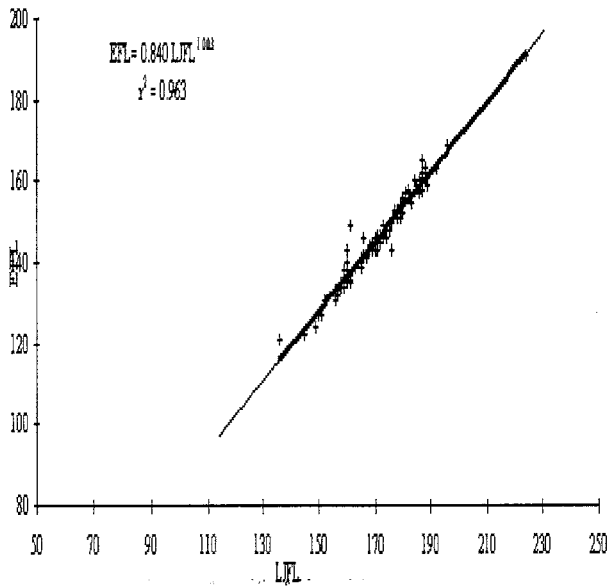


Fig. 20. Lower jaw fork length / eye fork length relationship of white marlin caught off south and southeast Brazil.

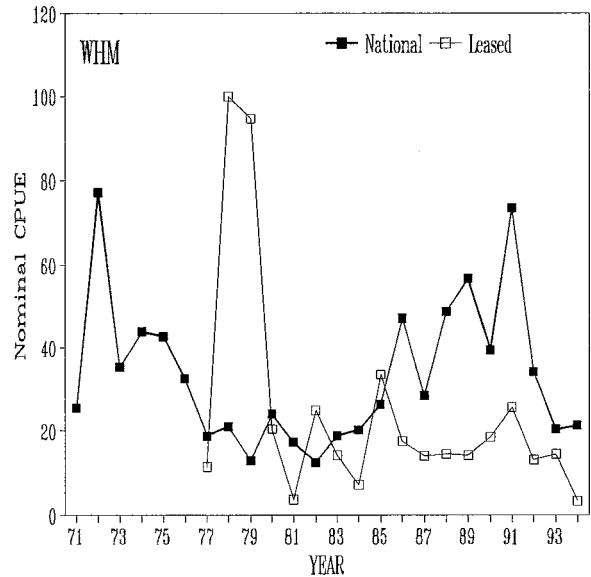


Fig. 23. White marlin nominal CPUE (total weight in kg / thousand hooks) by national and leased fleets from Brazil.

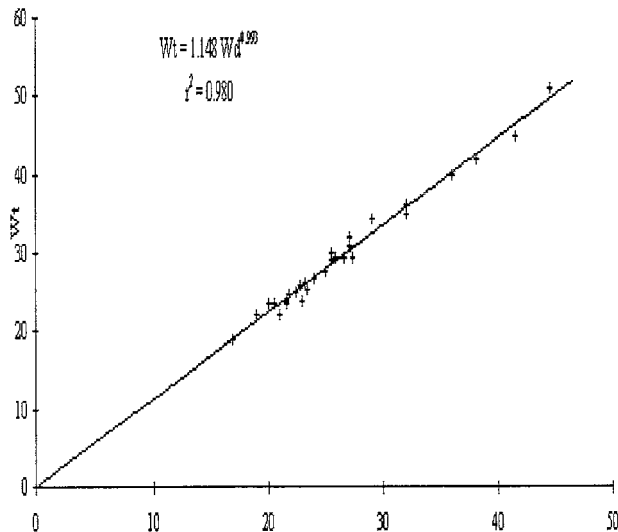


Fig. 21. Dressed weight / total weight relationship of white marlin caught off south and southeast Brazil.

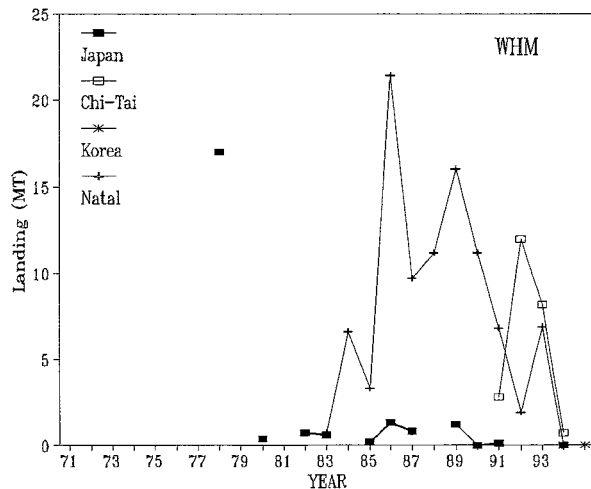


Fig. 24. White marlin landing (MT) from Area A by regular longline leased fleet from Rio Grande and Natal.

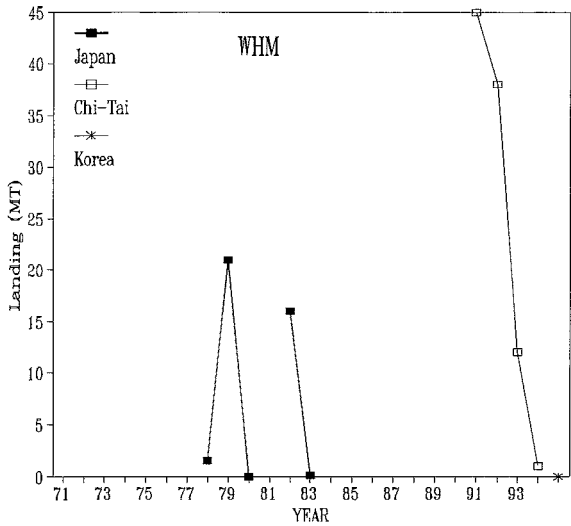


Fig. 25. White marlin landing (MT) from Area B by regular longline leased fleet of Rio Grande.

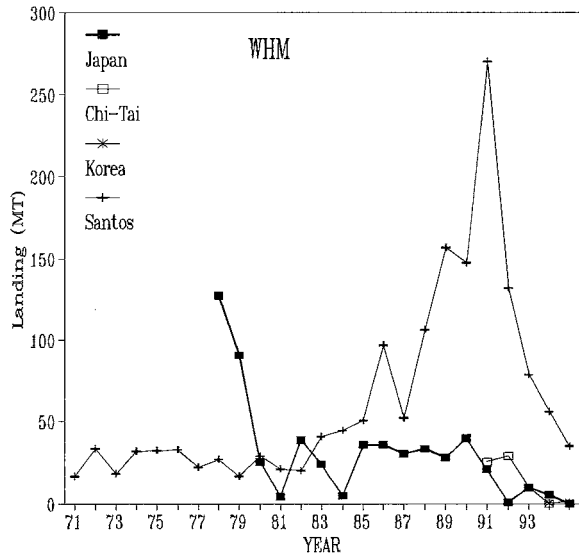


Fig. 26. White marlin landing (MT) from Area C by regular longline leased and national fleets of Rio Grande and Santos.

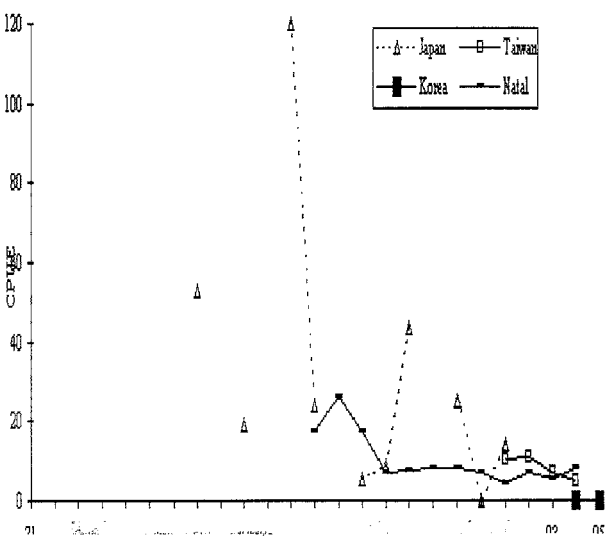


Fig. 27. White marlin nominal CPUE (total weight in kg / thousand hooks) from Area A by regular longline leased fleet of Rio Grande and Natal.

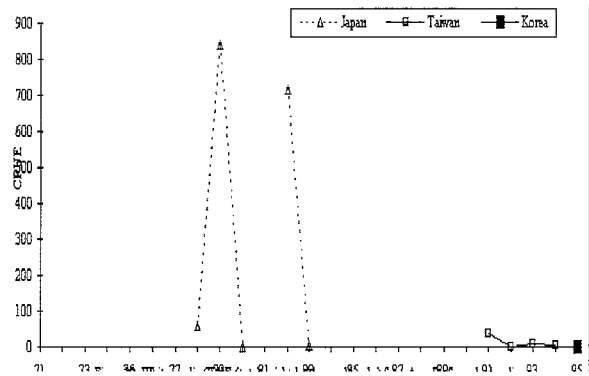


Fig. 28. White marlin nominal CPUE (total weight in kg / thousand hooks) from Area B by regular longline leased fleet of Rio Grande.

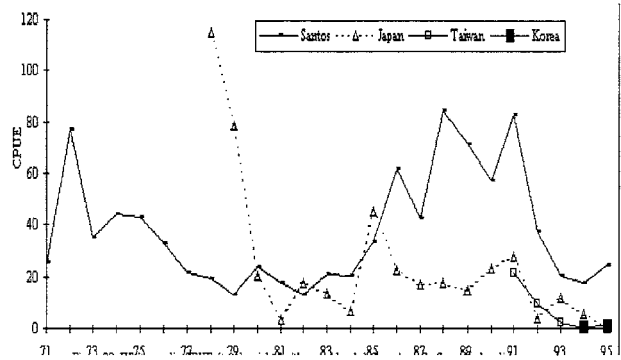


Fig. 29. White marlin nominal CPUE (total weight in kg / thousand hooks) from Area C by regular longline leased fleet of Rio Grande and Santos.

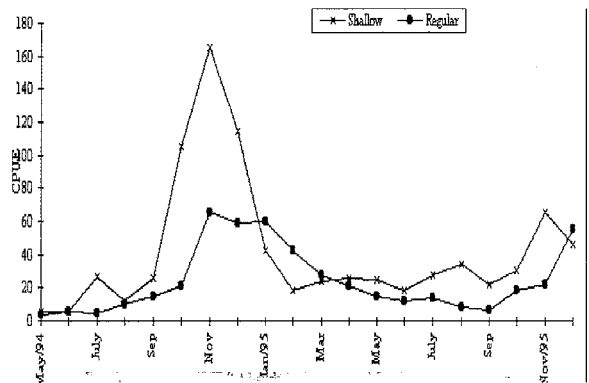


Fig. 30. White marlin nominal CPUE (total weight in kg / thousand hooks) regular and shallow longline fleet of Santos.

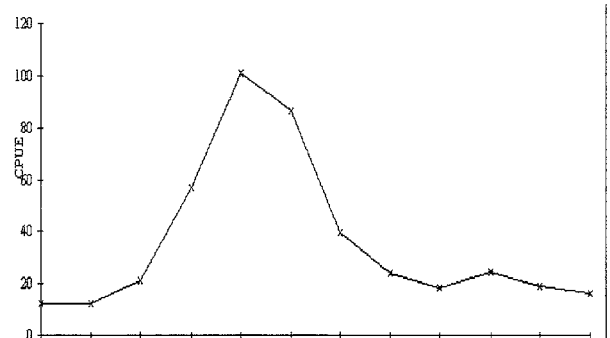


Fig. 31. White marlin monthly nominal CPUE (total weight in kg / thousand hooks) by regular longline fleet from Santos, 1971-1995.

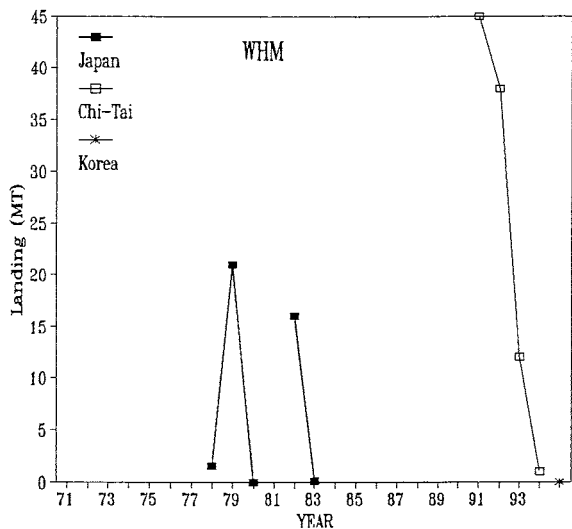


Fig. 25. White marlin landing (MT) from Area B by regular longline leased fleet of Rio Grande.

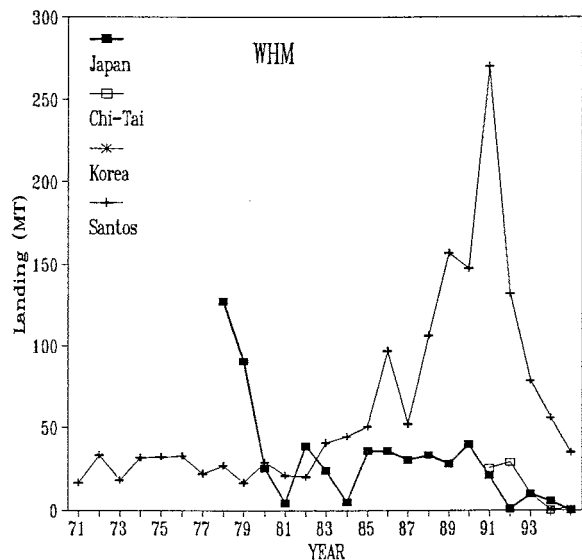


Fig. 26. White marlin landing (MT) from Area C by regular longline leased and national fleets of Rio Grande and Santos.

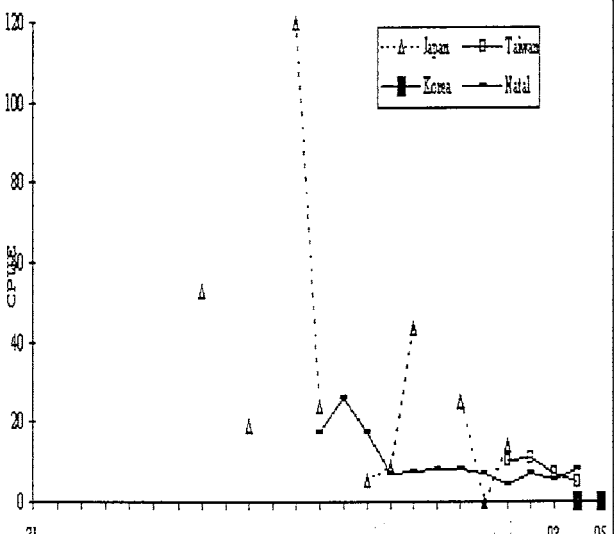


Fig. 27. White marlin nominal CPUE (total weight in kg / thousand hooks) from Area A by regular longline leased fleet of Rio Grande and Natal.

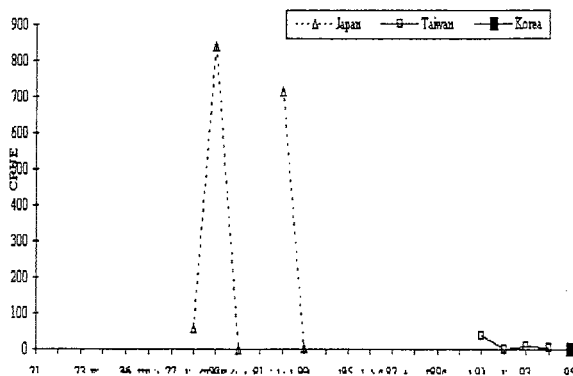


Fig. 28. White marlin nominal CPUE (total weight in kg / thousand hooks) from Area B by regular longline leased fleet of Rio Grande.

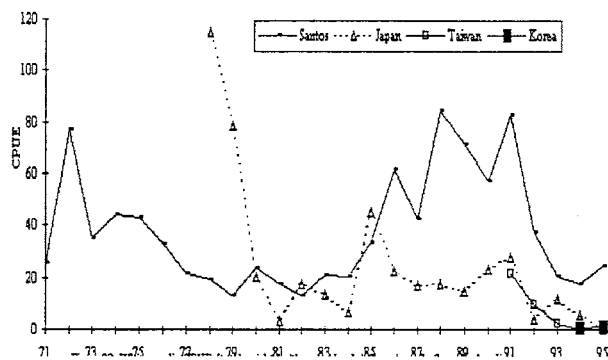


Fig. 29. White marlin nominal CPUE (total weight in kg / thousand hooks) from Area C by regular longline leased fleet of Rio Grande and Santos.

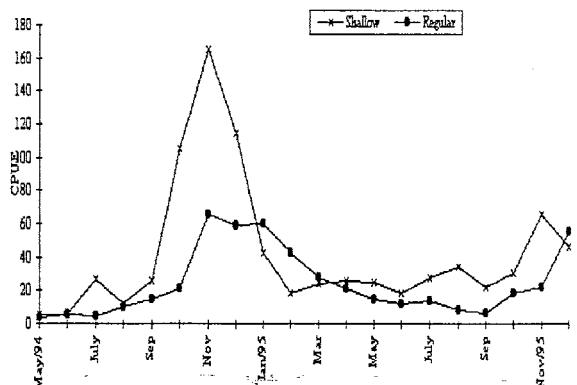


Fig. 30. White marlin nominal CPUE (total weight in kg / thousand hooks) regular and shallow longline fleet of Santos.

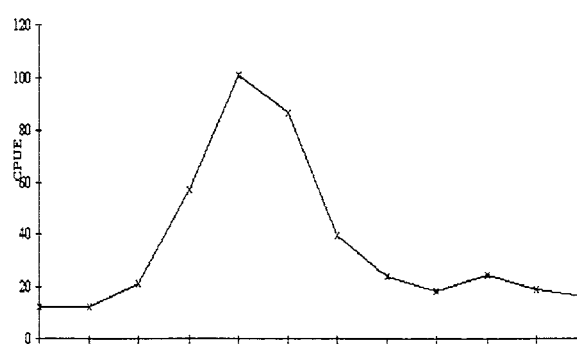


Fig. 31. White marlin monthly nominal CPUE (total weight in kg / thousand hooks) by regular longline fleet from Santos, 1971-1995.

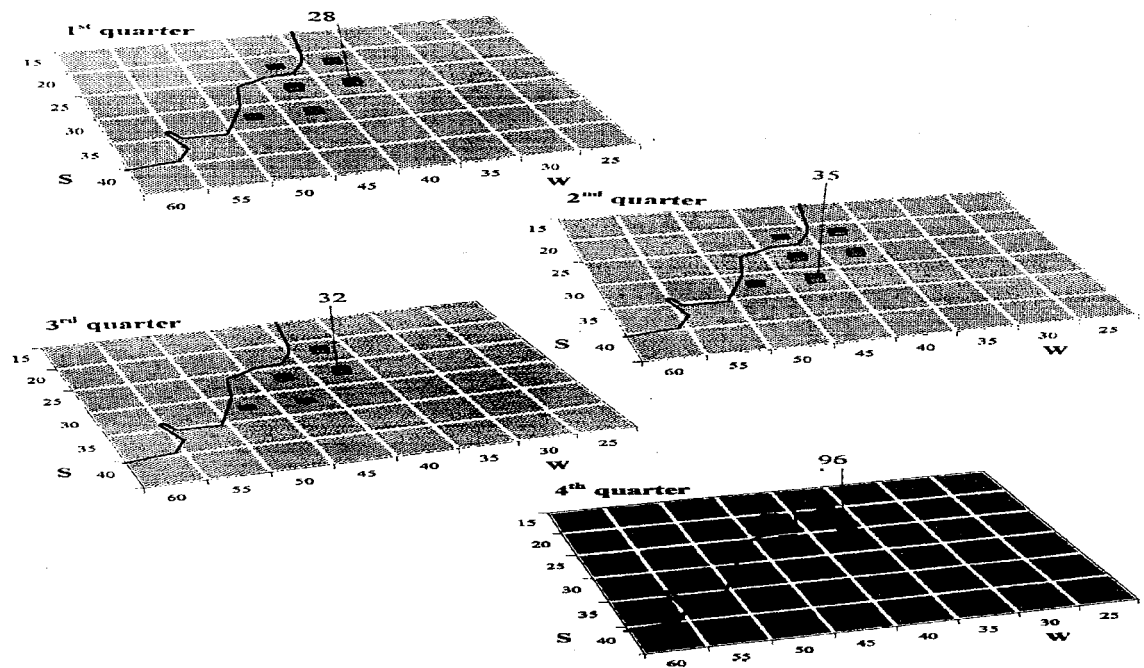


Fig. 32. White marlin quarterly nominal CPUE (total weight in kg / thousand hooks) by fleet from Santos with regular longline, by 5 degrees area and for the period of 1986-1989

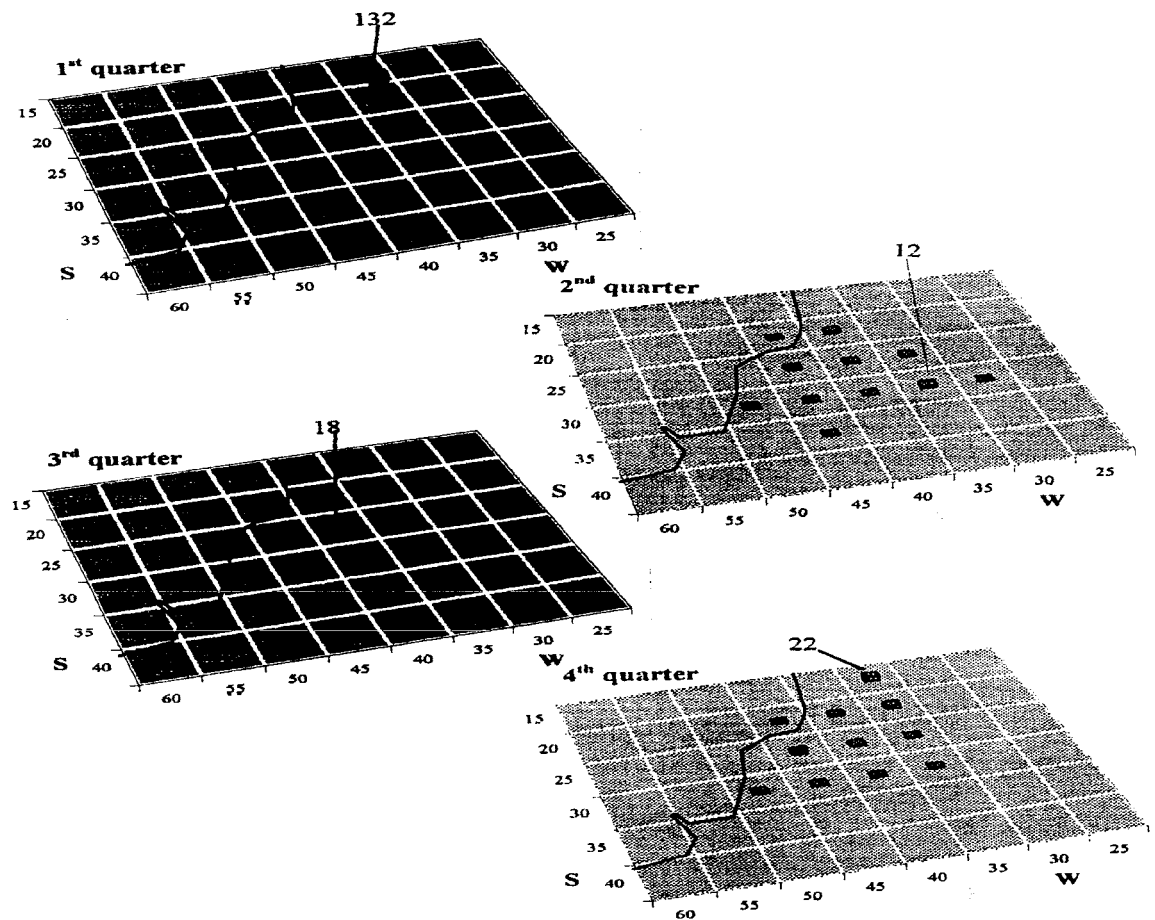


Fig. 33. White marlin quarterly nominal CPUE (total weight in kg / thousand hooks) by fleet from Santos with regular longline, by 5 degrees area and for the period of 1992-1995

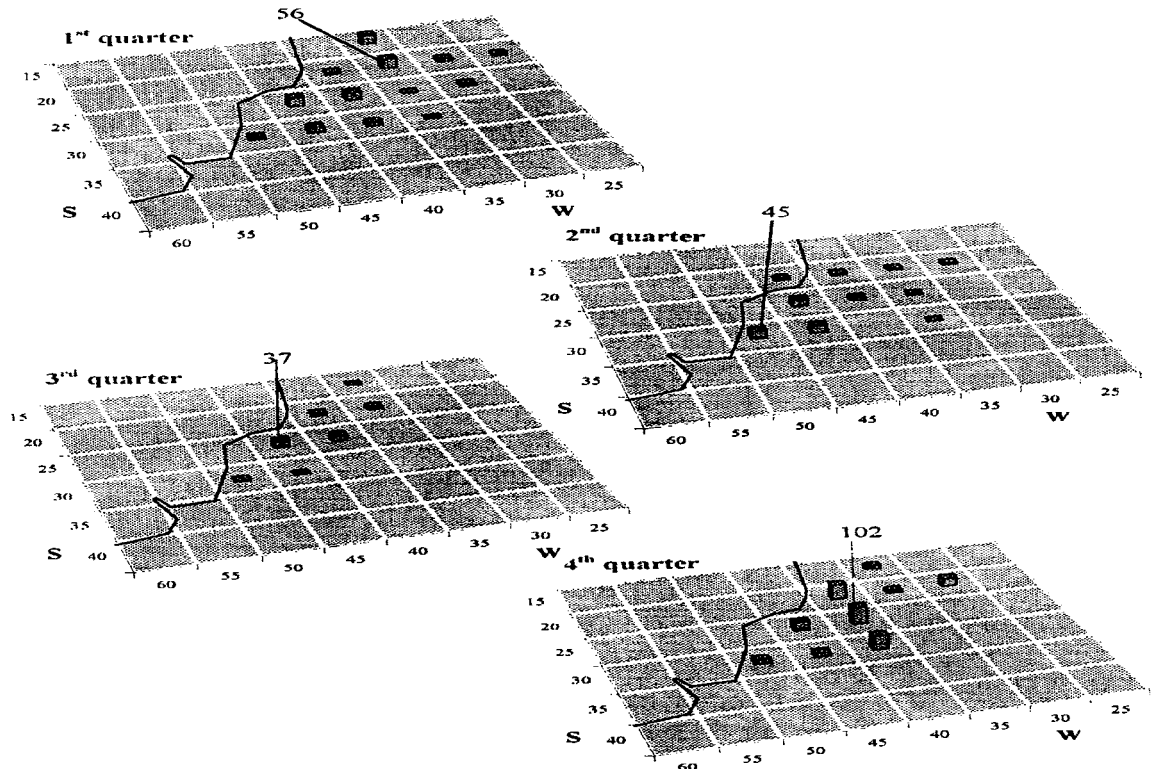


Fig. 34. White marlin quarterly nominal CPUE (total weight in kg / thousand hooks) by fleet from Santos with shallow longline, by 5 degrees area and for the period of 1994-1995

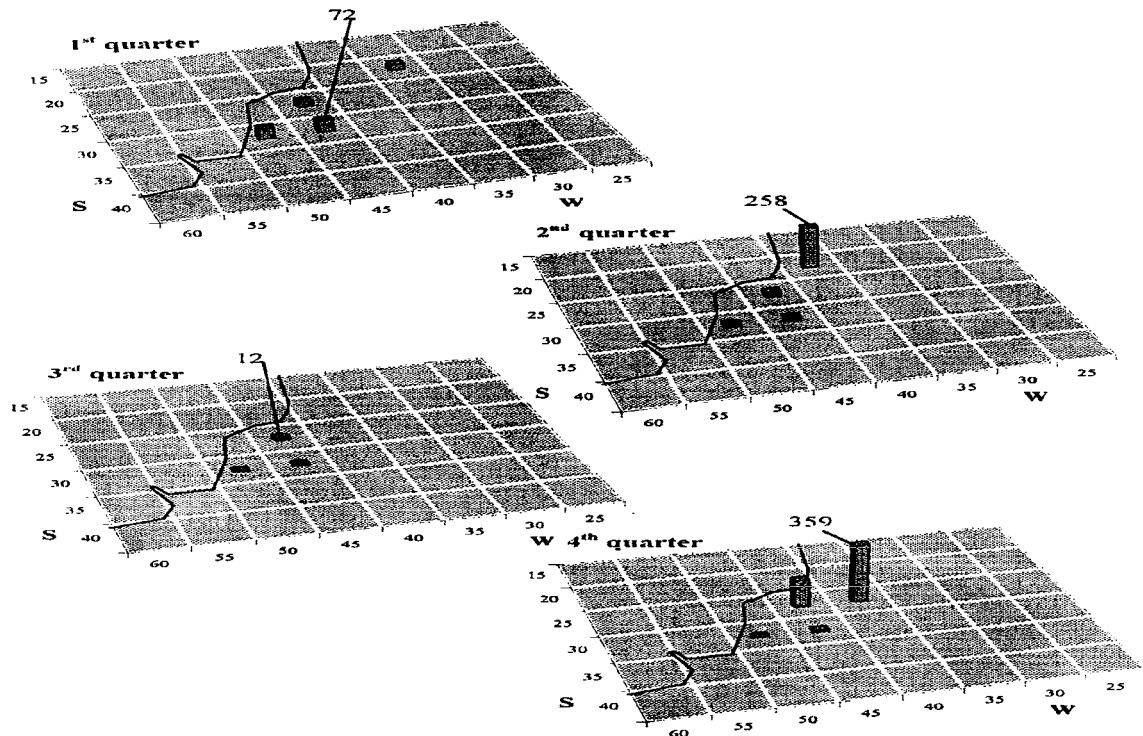


Fig. 35. White marlin quarterly nominal CPUE (total weight in kg / thousand hooks) by Japanese fleet with regular longline, by 5 degrees area and for the period of 1986-1990

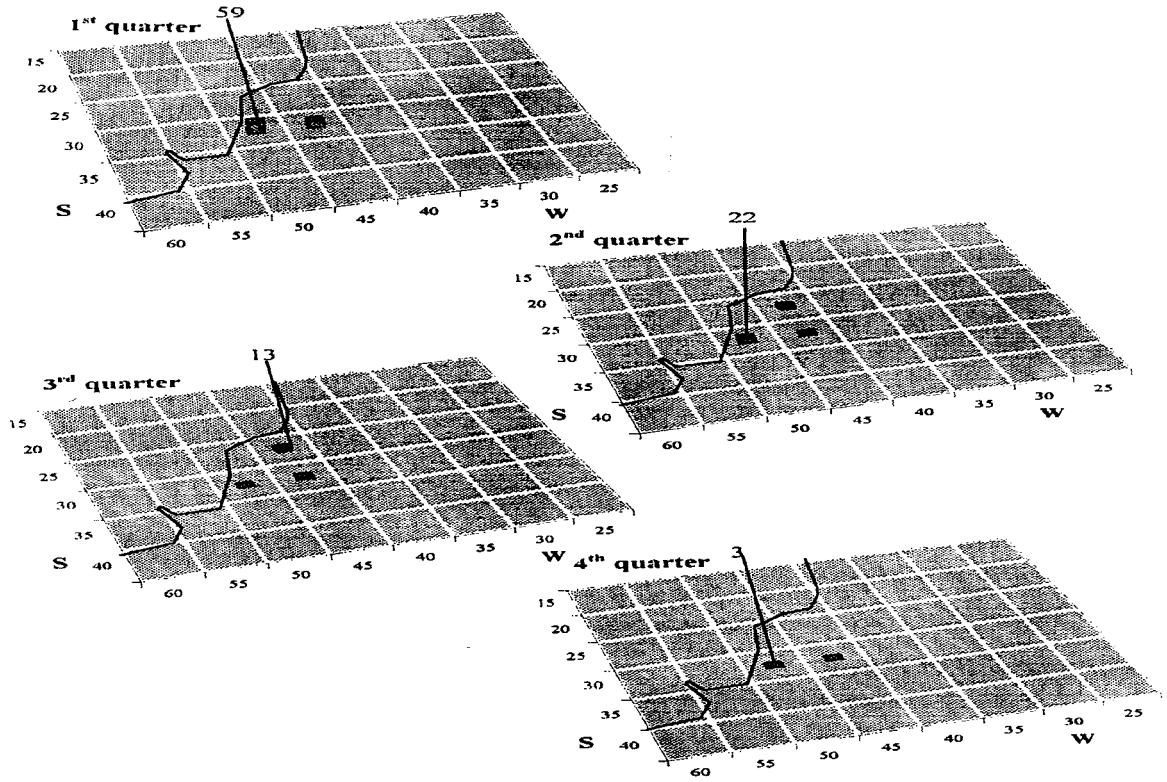


Fig. 36. White marlin quarterly nominal CPUE (total weight in kg / thousand hooks) by Japanese fleet with regular longline, by 5 degrees area and for the period of 1991-1995

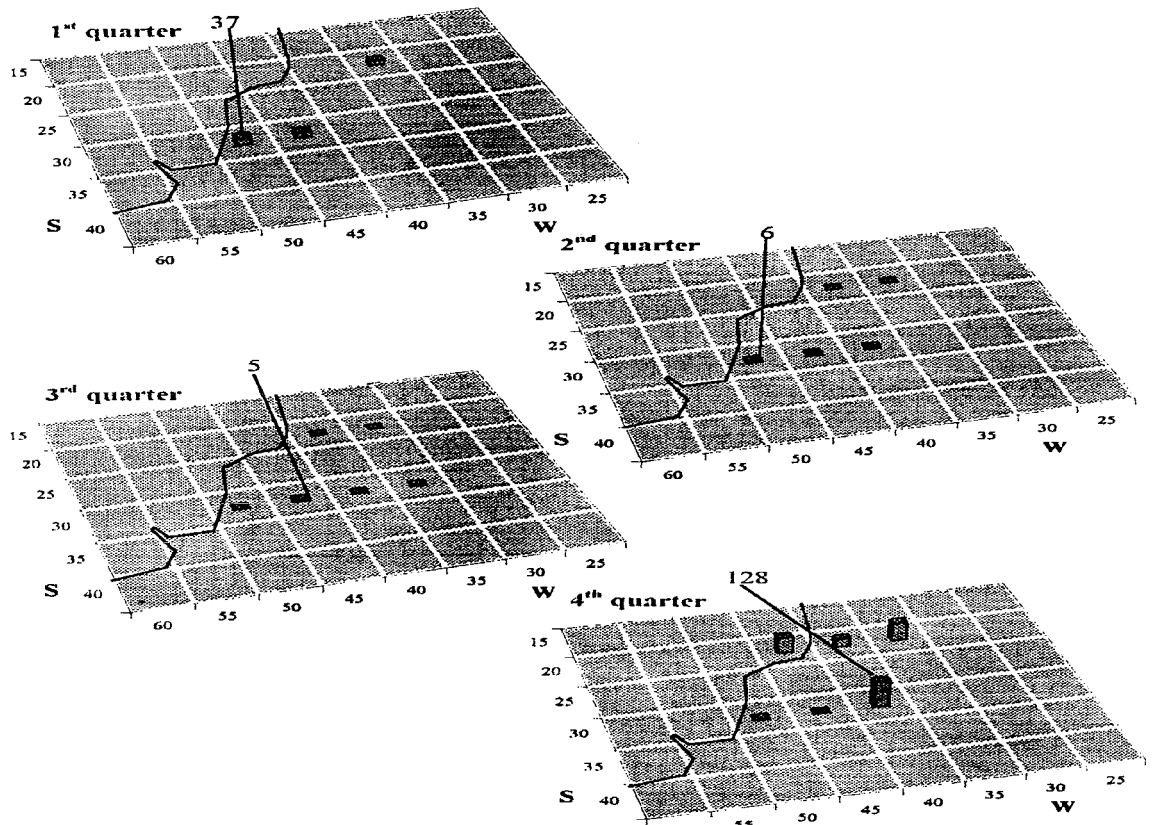


Fig. 37. White marlin quarterly nominal CPUE (total weight in kg / thousand hooks) by Taiwanese fleet with regular longline, by 5 degrees area and for the period of 1991-1994.

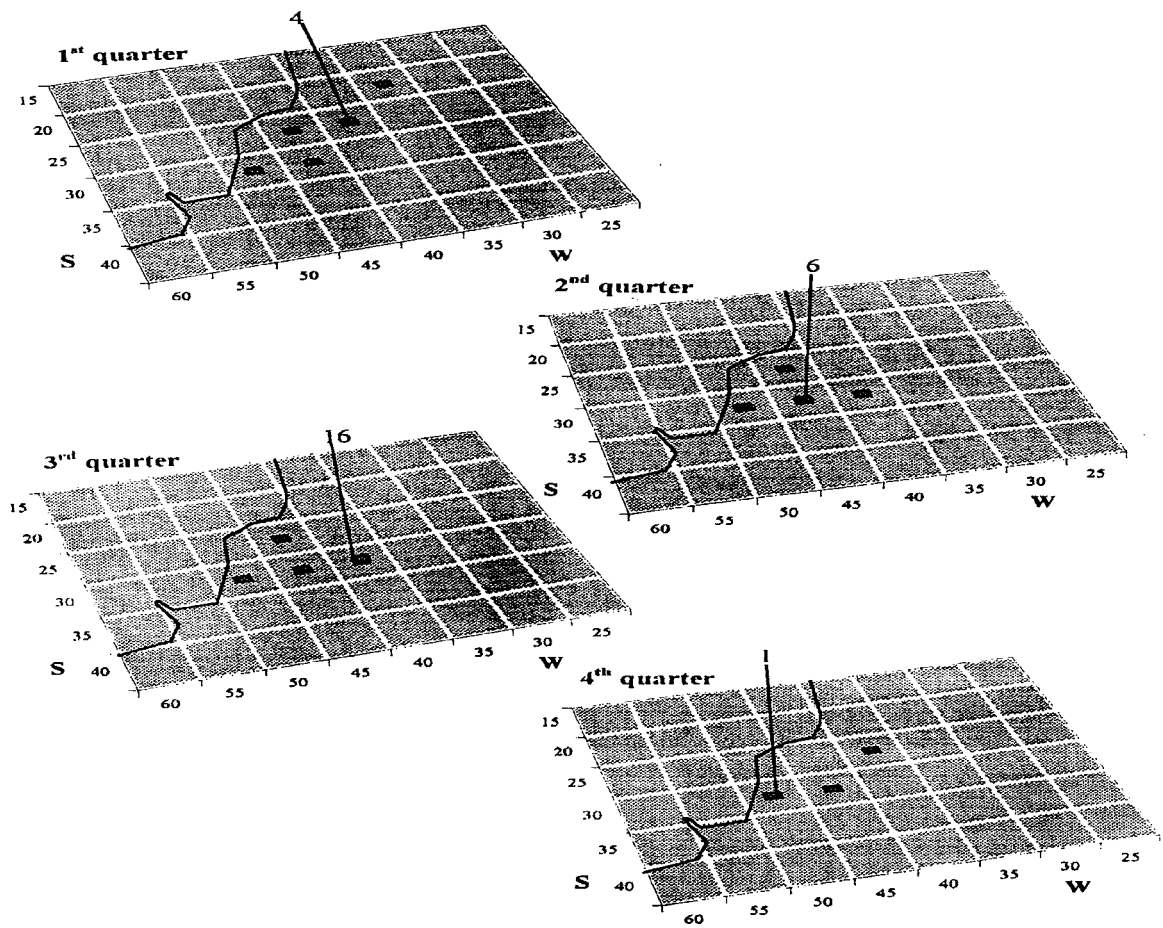


Fig. 38. White marlin quarterly nominal CPUE (total weight in kg / thousand hooks) by Korean fleet with regular longline, by 5 degrees area and for the period of 1994-1995.