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A HISTORICAL REVIEW OF THE BRAZILIAN LONGLINE FISHERY AND CATCH OF SWORDFISH (1972-1997)

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ABSTRACT

A descriptive analysis of the Brazilian longline fishery for tunas is presented, showing the evolution of the fishery since its beginning, in 1956, laying stress on changes in target species and fleet composition, the development of direct swordfish fishery and general catch trend of swordfish over the period 1972-1997. Four distinct time periods were considered. Up to 1976 tuna species were dominant in the catches of Brazilian longliners, which operated in more coastal waters of the South and Southeast region of Brazil. Since then, with the initiation of fishing operations by foreign flagged leased longliners, which were composed only by Japanese flagged longliners up to 1991 and, after then, by a number of vessels of other nationalities, with predominance of Taiwanese flagged vessels, significant changes occurred in the fishery with the expansion of the fishing grounds and periodic shifts in target species. The Japanese leased longliners started targeting yellowfin, using the conventional longline. After 1984 they developed fishing with deep longline in Brazilian waters targeting bigeye in the tropical area. Starting in 1991 the Japanese flagged vessels were gradually replaced by Taiwanese vessels and there was a shift in target species from bigeye to albacore, which dominated catches up to 1995 when bigeye catches increased again. Since 1992, the number of leased vessels from other nationalities has increased, specially after 1996, when fishing operations by Spanish flagged vessels targeting swordfish were initiated, and catches of this species have been showing an increasing trend.

RÉSUMÉ

Le présent document présente une analyse descriptive de la pêche palangrière brésilienne de thonidés, qui illustre l'évolution de la pêcherie depuis ses débuts en 1956, en mettant l'accent sur les changements d'espèce-cible et de la composition de la flottille, l'essor de la pêche dirigée d'espadon et la tendance générale des captures d'espadon pendant la période 1972-1997. Quatre périodes distinctes sont étudiées. Jusqu'en 1976, les thons prédominaient dans les prises des palangriers brésiliens, qui pêchaient dans les eaux côtières au sud et au sud-est du Brésil. Depuis lors, l'entrée en scène de palangriers en location arborant des pavillons étrangers, qui ne comptaient jusqu'en 1991 que des palangriers à pavillon japonais, et ont compris par la suite un certain nombre de bateaux d'autres nationalités parmi lesquels prédominaient ceux du Taïpei chinois, a entraîné des changements significatifs dans la pêcherie, qui a étendu ses zones de pêche et change périodiquement d'espèce-cible. Les palangriers japonais en location ont commencé à viser l'albacore au moyen des palangres traditionnelles. A partir de 1984, ils ont commencé à pêcher à la palangre de profondeur dans les eaux brésiliennes en visant le thon obèse dans le secteur tropical. A partir de

1991, les bateaux japonais en location ont été progressivement remplacés par des bateaux du Taïpei chinois, et il s'est produit un changement d'espèce-cible, du thon obèse au germon, qui a prédominé dans les prises jusqu'en 1995, lorsque les prises de thon obèse se mirent à remonter. Depuis 1992, le nombre de bateaux en location d'autres nationalités s'est accru, notamment à partir de 1996 lorsque débuta la pêche de bateaux à pavillon espagnol visant l'espadon et que les prises de cette espèce se mirent à montrer une tendance à la hausse.

RESUMEN

Se trata de un análisis descriptivo de la pesquería palangrera de túnidos brasileña, que muestra su evolución desde sus principios, en 1956, poniendo énfasis en los cambios de especie-objetivo y composición de la flota, el desarrollo de la pesquería dirigida al pez espada y las tendencias generales de la captura de pez espada en el periodo 1972-1997. Se consideraron cuatro períodos diferentes. Hasta 1976, las especies de túnidos predominaban en la captura de los palangreros brasileños que faenaban en aguas costeras de la región sur y sudeste de Brasil. Desde entonces, con el inicio de las operaciones de pesca con palangreros alquilados, de bandera extranjera - que eran palangreros de bandera japonesa hasta 1991 y a partir de entonces se trataba de un cierto número de barcos de otras banderas, sobre todo taiwanesa - la pesquería experimentó cambios importantes, con ampliación de los caladeros y cambios periódicos en las especies-objetivo. Los palangreros japoneses alquilados empezaron a dirigirse al rabil, con palangre convencional. A partir de 1984, iniciaron la pesca con palangre profundo en aguas de Brasil, dirigida al patudo en la zona tropical. A partir de 1991, los palangreros de bandera japonesa fueron paulatinamente remplazados por barcos taiwaneses y la especie-objetivo cambió del patudo al atún blanco, que predominaba en las capturas hasta 1995 cuando aumentaron de nuevo las de patudo. Desde 1992, ha aumentado el número de barcos alquilados de otras nacionalidades, sobre todo a partir de 1996, con el inicio de las operaciones de barcos de bandera española dirigidas al pez espada, presentando la captura de esta especie una tendencia al alza.

1. INTRODUCTION

Longline fishery for tunas off Brazilian waters has a relatively long history. It was initiated in 1956, by Japanese leased longliners based at Recife (State of Pernambuco) in the Northeast region of Brazil, at the same time when there was the expansion of Japanese longline fishery in the Atlantic ocean, which rapidly covered the whole distribution range of tropical tunas in the mid-1960s.

Fishing operations by these leased vessels were interrupted by 1964 and, two years later (in 1966), a longline fishery was initiated by Brazilian longliners based at Santos (State of São Paulo) in the Southeast region of Brazil. For a long time this was the only industrial fleet fishing for tunas in Brazilian waters. In the northeast region of Brazil longline fishery for tunas was resumed only in 1983 by small sized vessels from the lobster fishery that were modified to operate as longliners and were based at Natal (Rio Grande do Norte State). This longline fleet is composed of small and medium sized iced well vessels with a relatively short operational range. For this reason their fishing area is restricted to more coastal waters, ranging from $20^{o} – 33^{o}$ S and $39^{o} – 50^{o}$ W for the Santos based fleet and from 02^{o} N - 8^{o} S and $29^{o} –39^{o}$ W for the fleet based at Natal.

By the end of 1976 fishing operations by foreign flagged leased longliners were resumed, from the port of Recife and one year later from the port of Rio Grande (Rio G. do Sul State) in the South region of Brazil. A small fleet of 3 Brazilian longliners operated in this port from 1982 to 1987,

fishing mainly in the area south of 30º S of latitude. The foreign flagged leased longliners stopped operations from the port of Rio Grande in 1995 but tuna fishing by foreign longliners continued from other ports, mainly in the Northeast region of Brazil where Cabedelo, in the State of Paraiba, is nowadays the main fishing port for leased longliners. The foreign leased fleet is comprised of large and medium sized vessels with average length of 50 m and 30 m respectively,.

During the first phase of development of the fishery, tunas were the target species. By the middle of the eighties, there was an increase in market price for shark species, and the catches taken by Brazilian longliners started showing a great increase in percentage composition of sharks in relation to total catch in weight. In the mid-1990s shark catches represented more than 50% of the total weight of catches. It seems that the marked increase in shark catches was not only the result of directed fishing for sharks but also from reduction in discards at sea of some unwanted species, which used to have small economic value and became more valuable by the end of the eighties.

Since the start of the fishery by leased longliners, species composition of catches has showed marked changes, which reflect in part the changes observed in fleet composition over the time.The Japanese leased vessels started targeting yellowfin and moved to bigeye tuna after 1984. In 1991 albacore replaced bigeye as target species and remained as the most important species caught up to 1995 when bigeye catches increased again. This changes in target species seems to be associated with changes in fishing strategy as a result of the introduction of deep longline and shifts in the fishing grounds.

Since 1994 one important change has occurred in the longline fishery with the starting of fishing with the nylon monofilament longline directed to catch swordfish. This change was in line with the expansion of direct swordfish fishery in the South Atlantic by distant water fishing countries which was caused by increased exploitation of the north Atlantic swordfish stock, which resulted in the adoption of catch limits for this stock. As a result of the relocation of fishing effort from the North to the South Atlantic, swordfish catches of the main countries in the north increased dramatically in the South Atlantic area, reaching in 1995 more than 50% of the total catch in weight.

In 1997, the total Brazilian longline catch was 9389 MT. In the catches of the national fleet swordfish represented 47.4 %, and sharks 34.7 % of the total catch in weight . For the foreign leased fleet, during the same period, swordfish represented 41.4 %, and sharks 14.5 % of the total catch in weight.

2. MATERIALS AND METHODS

The basic data used in this analysis were obtained from ICCAT CATDIS data base and comprised total swordfish catch (in MT) distributed geographically (5º x 5º) and temporarilly (quarter of a year), covering the period 1972 to 1990. Catch and effort data assembled into 5º x 5º area by gear, flag and month were taken from ICCAT Task II data base. For the most recent years ICCAT task II data was complemented by Brazilian longline fishery statistics compiled at IBAMA and Instituto de Pesca of São Paulo State, in a similar way as Task II data.

As the historical data on catches, covering the period 1972 to 1997, indicate distinct time periods over which significant changes in Brazilian longline fishery have occurred, in order to describe these changes four time periods were considered. First period corresponds to years 1972-76, in which only Brazilian longliners operated in the fishery; the second period, from 1977 to 1982, was marked by starting of first operations by foreign flagged longliners leased by Brazilian companies; the third period (1983 to 1990) starts with development of fishery in the Northeast region of Brazil, by small Brazilian longliners and finishes with replacement of Japanese flagged leased longliners by Taiwanese longliners; the last period from 1991 to 1997, corresponds to a phase of transition in fishing pattern of Brazilian longliners, which started direct swordfish fishery, and the initiation of fishing by foreign flagged longliners targeting swordfish.

Catch and effort data by area and time strata were used to depict the geographical distribution of fishing effort, as well as the distribution of catches and catch rates of swordfish to show changes in fishing pattern which have occurred in these distinct time periods.

Swordfish catch data contained in CATDIS data base covers only the period 1972-to 1994. Starting in 1992, all Task II catch statistics for the Santos based longliners were expressed in numbers rather than in weight. Due to time limitations it was not possible to convert these catch in numbers to catch in weight in order to raise Task II catch data to the Task I nominal catches. For this reason geographical distribution of average annual catches of swordfish are shown only for the period 1972 to 1990. For the same reason swordfsih catch rates for years 1996 and 1997 are shown in different units: catch rates are expressed in kg/ 100 hooks for leased longliners and in number of fish by a thousand hooks for Brazilian longliners.

As Task II data base presents fishing effort data for all years and fleets over the period 1972 through 1997, geographical distribution of fishing effort in number of hooks is shown for all time periods considered in this analysis.

The main intent in developing maps of geographical distribution of nominal fishing effort and swordfish catch rates was to find out evidence of seasonality in direct swordfish fisheries developed in Brazilian waters, as it has been previously suggested (Meneses de Lima, 1998), for this reason the only catch and effort data used were obtained from vessels engaged in direct swordfish fishery, and covers years 1996 and 1997.

3. FLEET DEVELOPMENT

The industrial tuna longline fishery began in 1956/57, in Recife (Anonymous, 1996). From December 1976, 3 Korean longliners based at the same place began to operate throughout the Brazilian Northeast region and reaching the Espirito Santo state in the southeast region (Aragão & Lima, 1985). These boats had between 35 and 40 m total length. In September 1977, 3 Japanese longliners entered the fishery, operating from Rio Grande (Antero-Silva, 1982). The Japanese longliners were big size boats, with an average length of 48,5 m and could stay at sea for over 90 days in a single trip. They operated throughout the Brazilian coast, mainly in the southeast-south region. In 1978, another two Japanese vessels began fishing activities in São Sebastião, state of São Paulo, however, due to operational problems, they were transferred in September 1979 to Rio Grande. The number of Japanese leased longliners operating along the Brazilian coast ranged from 3 in the years 1977/78 to 6 in 1986.

During the period 1985 – 1997, foreign leased vessels were based in Santos, Rio Grande, Cabedelo and Itajaí. The fleet based in Rio Grande operated until 1995, and was composed of Japanese, Korean and Taiwanese boats. Japanese boats were the first in operation, reaching a maximum of 6 units in 1986 and only 2 in 1995. The biggest number of leased vessels were from Taiwan, which reached a maximum of 18 units in 1993. Korean vessels operated only for the period 1994-95. In Itajaí there was only one Hondurian flagged vessel in operation during the period 1990-91. In Santos, there were leased vessels in operation from the following nations: Portugal (2 boats for the period 1991-92), Panama (1 boat for the period 1993-96), Honduras (2 boats for the period 1992-1997) and Barbados (2 vessels for period 1995-1997). The leased fleet based at Cabedelo has been comprised mainly of Taiwanese and Spanish flagged vessels

The national fleet is nowadays based at Itajaí, Santos, Recife and Natal. Tuna longline fishery from Santos, which had begun their operations in 1958, with Japanese leased vessels, interrupted their activities in 1961 and restarted in 1965-66, with 2 national fishing boats. This fishery gradually increased, reaching a maximum of 9 national vessels in 1984. In 1985, there was a decrease to 7 units.

The national fleet based at Santos, restarted its development from 1988 onwards, reaching a peak of 15 boats in 1996. Nowadays the fleet is composed of 11 units, most of them using the monofilament longline gear introduced in 1994, and operating in directed swordfish fishery (Arfelli, 1996). The national fleet based in Rio Grande operated only until 1987, with 2 fishing boats, using the traditional Japanese longline system (i.e., multifilament). In 1996 a longline fleet started operations in the south region of Brazil, based at Itajaí, Santa Catarina State, using the monofilament longline in directed swordfish fishery. Starting with only one vessel, in 1996, it increased to 6 vessels by the end of 1997.

For the whole south-southeast national longline fleet an increment in number of vessels was observed during the period 1985 – 1998, from 8 units in 1986/87 to a maximum of 19 vessels in 1997/98.

The longline fishery in the northeast region, whose activities were interrupted at the beginning of the 60's were resumed in 1983, by national vessels, initially operating from Recife, and later based also in Natal. In 1983, the fleet was composed of only one vessel, reaching a peak of 10 units in 1990. Between 1991 and 1994, there was a decrease in the number of longline vessels, being restricted to only 3 – 5 boats. From 1995 onwards, the fleet increased again, reaching a total of 7 vessels this year. The fleet continued to develop, reaching a level of 14 units in 1998.

For the north region, there was a leased fleet from Taiwan, based at Belém (State of Pará), which operated during the period 1992-1994, reaching a peak of 14 vessels in 1993. In 1995 this fleet was transferred to Cabedelo (Paraíba State).

Figure 1 shows the evolution in size of the longline fleet over the period 1979 to 1997. For the whole longline fleet (national and leased vessels) it is observed a quick growth from 1988 onwards, reaching a peak of 55 boats in 1993. The leased fleet showed a marked increase from 6 units in 1990 to a total of 36 vessels in 1993. In 1994, there was a decline in foreign fleet's size, mainly due to the interruption of fishing by the leased fleet from Rio Grande do Sul State. Large oscillations occurred for this fleet onwards, i.e., 21 units in 1995, 27 in 1996 and 18 boats in 1997. During this last period there was an entrance of new leased vessels in the northeast region, mainly in Natal and Cabedelo, i.e., leased vessels from USA, Panamá, Barbados, Belize, Spain and Taiwan. The national fleet increased since 1983, reaching a peak of 21 boats in 1990. From 1995, there was again a new growth in size of the national fleet due to entrance of new vessels in the northeast region and development of longline fishery in Itajaí.

4.FISHING EFFORT

4.1 NATIONAL FLEET

Total fishing effort by the national longline fleet based in the south-southeast and northeast regions, was 1,150,335 hooks, in 1977, and reached a peak of 2,588,037 hooks in 1984 (figure 2). This growth was due to the increase in size of the national fleet, from only 5 longline vessels based in Santos in 1979 to a total of 12 units along all the Brazilian coast in 1984. The increment occurred due to entrance of fishing boats from other modalities (i.e., trawlers, purse-seiners), i.e., 4 units in São Paulo State, 2 in Rio Grande do Sul State, and 1 vessel in the northeast. Between 1985 and 1990 fishing effort increased again, however with fluctuations, between a minimum of 2,153,041 hooks in 1985 to a maximum of 4,109,846 hooks in 1990. The increment was due to entrance of 4 vessels in Santos and 8 units in the northeast region (Pernambuco and Rio Grande do Norte States). From 1991 to 1995, there was a decline in the fishing effort, reaching a minimum of 2,125,050 hooks in 1995, a similar effort level found during the 80's. During this period, the fleet based in Santos remained at a level between 13–14 vessels, while the northeast fleet fluctuate from 3 boats in 1991 to 7 units in 1995.

4.2 FOREIGN LEASED FLEET

Until 1990, the fishing effort by the leased fleet fluctuated between 1,081,479 hooks in 1985 to 2,426,915 hooks in 1988. During this period, the average number of foreign vessels throughout the Brazilian coast was 5, i.e., Japanese longliners. From 1991 onwards, there was a sharp increase in the leased fleet effort levels. The effort increased from a minimum of 3,693,511 hooks in 1991 to a peak of 15,605,650 hooks in 1993, due to the massive entrance of foreign vessels from Taiwan, Honduras, Korea, Portugal and Panama. In 1991, there were 16 leased vessels, but in 1992 the fleet almost doubled reaching a total of 30 units. In 1993 the number of foreign leased vessels reached a maximum of 36 units. In 1994 the fishing effort declined again, reaching a total of 5,524,070 hooks. This sharp decrease occurred due to the interruption of fishing activities by 8 longliners from Taiwan based at the Port of Rio Grande.

5.CATCH TRENDS

5.1 LONGLINE NATIONAL FLEET

The proportion of tuna species catch (*Thunnus spp*) relative to the total longline catch in weight (%), considering all the national fleet (south-southeast and northeast regions), has decreased since the 70's, when the catches of yellowfin (*Thunnus albacares*) represented over 30 % of the total catches. Since 1995, catches of the main tuna species (*T. albacares, T. alalunga, T. obesus, T. thynnus)*, have been very low in comparison with catches obtained during the 70's and 80's decades, i.e., the proportions remained in a level between 8.9 and 10.9 % of the total catch (figure 3).

The yellowfin (*Thunnus albacares*), was the most important species caught in the Brazilian longline fishery. In 1979 its catch represented 33 % of the total national catch, dropped to only 9.4 %, in 1980, but in 1981 increased again reaching 21.6 %. Since then it has been gradually decreasing, reaching a minimum of 5.9 % in 1991. In 1993, the relative proportion of this species catch showed a small recovery to 10.9 % of the total catch, but during the last years it has been kept at levels between 3.1 %, in 1995, and 5.1 %, in 1997.

The bigeye (*Thunnus obesus*), which was the second most important species in catches of the longline fishery during the 70's and beginning of 80's, also presented a declining trend. In 1978 reached a peak of 16.6 % of the total catch, dropping to a minimum of 5.7 % in 1981. For the next year, there was a recovery to a value of 10.1%. Afterwards there was a gradual decline with a minimum of 0.9 % in 1989 and 1992. In 1997, catch of this species was only 3.6 % of the total catch.

At the end of the 70's, catches of albacore (*Thunnus alalunga*) represented 9.9 % of the total catch (i.e., 1977 year). Subsequently, there was a decrease, with oscillations, reaching a minimum of 3.2 % in 1981. Between 1982 and 1984, there was a recovery to levels between 7 and 8 % of the total catch. From 1985 until 1997, the proportion went down a little bit more staying at the 1.4 and 3.4 % values.

Swordfish catches showed a great increment on its percentage composition at the end of the 70's, reaching a peak of 45.1 % of the total catch in 1980. Afterwards there was a sharp decline attaining a minimum of 13.3 % in 1984. Between 1987 – 1996, the swordfish catch proportion reached a peak of 37%, in 1995, surpassing the total catch of the main tuna species, however it was inferior to the percentage composition of sharks (47.0). In 1997, swordfish was the main target species, representing 51 % of the total national longline catch in weight (figure 3).

Since 1980, except for 1982, catches of shark species have exceeded the combined catches of swordfish and the main tuna species, attaining a peak of 60.8 % in 1992. Subsequently, there was a

sharp decrease in the shark proportions, reaching a minimum of 32 % of the longline catch in 1997 (figure 3).

5.2 FOREIGN LEASED FLEET.

In general, the catch proportion (%) of the different tuna species showed big fluctuations during the period considered (figure 4). Probably this can be explained by the fact that the different leased fleets (i.e, Japanese, Taiwanese, Spanish, Korean longliners) have different target species, using the longline in different depths and areas, by seasonality in abundance of tuna species, and by variability in demand for tuna species to supply the Japanese "sashimi" market.

Until 1989, the leased fleet was comprised only by Japanese flagged vessels. This fact was responsible for the fluctuations in catch proportions of the main tuna species, managed by the Asian market demand. Confirming this behaviour, it can be observed that in 1981 the yellowfin reached a peak of 38.2 %, while the albacore and bigeye performed only 9.8 and 18 % respectively. In 1984 the situation was reversed, i.e., the bigeye attained a peak of 39.8 %, while the yellowfin went down to only 10 % and the albacore showed an increment reaching 21.4 %. In 1988 the bigeye continued to be the dominant species, representing 32.4% , while the relative proportion of yellowfin and albacore reversed, i.e., yellowfin with a level of 17.5 % and albacore with only 12 % of the total catch. In 1989 the yellowfin was again the target species, representing 31.7 %, followed by bigeye with 23.6 % and albacore with 18.6 % of the total catch.

For the period 1991-1993, the situation changed. Albacore was highly fished, reaching peaks of 36 and 39.5 %, caused by the entrance of 11 leased boats from Taiwan, in 1991. This fleet amounted to 18 units in 1993. The other two species remained at a lower level, i.e., between 10 and 13 %. Fishing activities by the Taiwanese boats were interrupted after 1994, and the remaining leased longline fleet targeted again yellowfin (25.4%) in 1994 and bigeye (33.5 %) in 1995. In 1997 the bigeye was again the main target species, with 19.5 %, while albacore and yellowfin performed only 8.4 and 11.7 %, respectively.

6. TRENDS OF CATCH PER UNIT OF EFFORT (CPUE)

6.1 NATIONAL LONGLINE FLEET (SOUTHEAST-SOUTH REGION)

Figure 5 shows the nominal CPUE for tuna species, swordfish and sharks caught by the national longline fleet in the southeast-south region, during the period 1977-1994.

The CPUE of the main tuna species was at a high level during the 70's reaching a peak in 1979 of 842 kg/1000 hooks. Since then it started to decrease sharply with a minimum of 61 kg/1000 hooks being observed in 1991. Afterwards there was not any recovery in the yields of this species, whose CPUE has remained between 71 and 86 kg/1000 hooks. In relation with sharks, since 1980, with exception of 1982, shark's CPUE has continuously surpassed the CPUE of tuna species and swordfish, attaining a peak of 889 kg/1000 hooks in 1989. Subsequently, it is observed an accelerated decline, stabilizing in a level between 501-546 kg/1000 hooks for the period 1992-1994. The swordfish CPUE showed a marked increase at the end of the 70's, reaching a peak of 956 kg/1000 hooks in 1980. Posteriorly went down, reaching only 134 kg/1000 hooks in 1984. Since 1985, the CPUE for this species kept fluctuating between 172 and 335 kg/1000 hooks, above the tuna species levels.

As a whole, it can be observed that until the end of the 70's the main fishing effort was directed to catch the main tuna species, using the traditional Japanese longline, which operated between 60 – 120 m. Afterwards, the effort was targeted to sharks and swordfish, due to the increase

in international market demand for shark fins and swordfish meat. In 1994 the monofilament longline fishery was developed in Santos and later in 1996 in Itajaí. This fishing gear was mainly directed to adult swordfish between 15 – 40 m depth (Arfelli, 1996, Amorim, Arfelli and Fagundes, 1998). Nowadays, swordfish followed by sharks are the main species caught by the national fleet operating in the southeast-south region of Brazil.

6.2 NATIONAL LONGLINE FLEET (NORTHEAST REGION).

For the national longline fleet operating in the northeast region (figure 6), it can be observed an accelerated increase in CPUE for shark species, with big fluctuations. The CPUE values increased from a minimum of 161 kg/1000 hooks in 1983, to a maximum of 1219 kg/1000 hooks in 1993. Afterwards there was a sharp fall, reaching values of only 210 kg/1000 hooks in 1995. The CPUE of the main tuna species showed fluctuations, i.e., between a minimum of 207 kg/1000 hooks in 1987 and a maximum of 480 kg/1000 hooks in 1990. The fishery was mainly directed to catch for tuna species during the periods 1983-84, 1986 and 1990. On the other hand, swordfish was fished in lower quantities than sharks and tunas, i.e., with CPUE remaining at a low level between 23 and 107 kg/1000 hooks. During the period, 1983–1995, the national northeast fleet operated with the traditional Japanese longline (Evangelista et. al. , 1998), and catches were dominated by sharks and tuna species. The fishery with nylon monofilament longline directed to swordfish began to operate only from 1996 onwards.

6.3 FOREIGN LEASED FLEET

The CPUE of the main tuna species showed a sharp increase (figure 7), reaching a peak of 344 kg/1000 hooks, in 1979, when the fishery was directed to these species, using the traditional Japanese longline. However, during the period 1981 – 1983, sharks' catches increased, due to the increased demand of the international fin market. The selaceans' CPUE ranged between 337 and 371 kg/1000 hooks. The effort again was directed to the tuna species during the period 1984 and 1989, with the fleet still continuing to use the traditional Japanese longline. During this period, tuna specie's CPUE showed a declining trend, i.e., from a peak of 482 kg/1000 hooks in 1984 to a minimum of 212 kg/1000 hooks in 1989. Sharks and swordfish catches were always lower than catches of the main tuna species during this period. From 1990 onwards, tuna species CPUE continued to decline, reaching a minimum of 63 kg/1000 hooks in 1992, subsequently there was a small recovery to 101 kg/1000 hooks in 1994. Sharks also declined reaching a minimum of 47 kg/1000 hooks in 1992. Swordfish led the catches in the 90's, with a peak of 310 kg/1000 hooks in 1990. However, for the following years it showed a declining trend, with a minimum of 86 kg/1000 hooks in 1993. Recovery signs were detected from 1993 for tuna species and sharks, and from 1994 for swordfish.

7. THE BRAZILIAN SWORDFISH FISHERY

Swordfish are taken throughout the Brazilian waters, all year round, by directed fisheries and as by-catch of tuna longline fisheries. Brazilian fisheries for swordfish are carried out by national longliners and by foreign flagged longliners, leased by Brazilian companies and licensed to operate in Brazilian waters.

Traditionally, swordfish were taken as by-catch in the tuna fisheries carried out by Brazilian longliners. Only sporadically these vessel used to conduct fishing operations targeting for swordfish, which were concentrated in certain seasons of the year. The first experiences of directed swordfish fisheries were carried out in the years 1980-81, with the vessels still using the traditional nylon multifilament longline, which was set early in the night, and used squid as bait (Amorim & Arfelli, 1984).

In 1994 longliners with Panamanian and Hondurian flag leased by Brazilian companies started direct swordfish fishery, based at Santos, and in a short time period almost all of the Brazilian longliners started replacing the conventional longline by the monofilament longline and were targeting swordfish.

In 1996, American and Spanish flagged longliners were leased by Brazilian companies from the Northeast of Brazil and started fishing for swordfish along all the Brazilian coast. Some of these vessels were equipped with freezer and could stay longer at sea and they started to fish to the north of the traditional area fished by the Brazilian longliner expanding the traditional fishing area of this species which now cover all the Brazilian coast.

The process of adaptation of Brazilian longliners to fish for swordfish involved several adaptations in gear structure and operational pattern of fishing, including replacement of regular longline by the monofilament longline; use of squid as bait together with a one way light stick attached to each branch line. Shortening of buoys cord and reduction in the number of branch lines attached to each section of the main line. According to Amorim (1997), in October 1995 a total of 7 Santos-based longliners were operating in directed swordfish fisheries.

As a result, the Brazilian longliners modified to operate in directed swordfish fishery reached highest catch rates, in comparison with catch rates obtained in the longline fishery using the conventional longline, and more vessels entered into the fishery, which started being developed even in States where no longline fishery had previously been reported, such as in Santa Catarina State, in the South of Brazil.

In the Northeast region of Brazil some vessels from the small scale fishery were adapted, in 1997, to fish for swordfish and some experimental directed swordfish fishery was carried out, during the period August to December, reaching very successful results. After this experiments a number of small vessels, ranging from 9 to 13 meters long and with less than 20 gross registered tonnage (GRT), entered into the swordfish fishery based at Natal (Rio G. do Norte state).

It is still uncertain if these small sized vessels will have chances to continue fishing for swordfish all year round. The operational pattern of the fishery developed by the leased longliners shows that from May to October fishing concentrates in the Southeast and South regions of Brazil while from November to April it concentrates in the Northeast of Brazil. this seems to indicate that the leased fleet is concentrating their fishing operations in that areas of highest abundance of swordfish, which is reflected by higher catch rates of these vessels compared with the ones taken by the Brazilian vessels, which use to operate in fishing grounds closer to their port base.

It has been reported that some of the small sized vessels which started fishing for swordfish in the Northeast of Brazil, in 1997, have been withdrawn from the fishery during 1998, as a result of decreases in swordfish catch rates during the first half of 1998 in the northeast region of Brazil.

There are also indications that some vessels have been experiencing difficulties to continue operating in directed swordfish fishery due to a drop in the price paid for swordfish in the international market as a result of a campaign initiated in the USA to reduce consumption of Atlantic swordfish, sponsored by a group of marine conservation organizations.

As the majority of the catches are exported to the great consumers of swordfish (USA and Spain), the high devaluation of the Brazilian currency in relation to the US dollar, in the beginning of 1999 can be a factor external to the fishery which may contribute to increase the rent of the Brazilian longliners engaged in the swordfish fishery and will have the effect of maintaining even the less efficient vessels in the fishery.

7.1 GEOGRAPHICAL DISTRIBUTION OF FISHING EFFORT, CATCH AND CPUE

a) FISHING EFFORT

Figure 8 shows the geographical distribution of nominal fishing effort by foreign leased longliners operating in Brazilian waters, in three distinct time periods over the years 1977 – 1997.

For the first period, i.e., 1977 – 1982, fishing effort was restricted between latitudes 5º N (northeast Brazil) and 40°S (Rio de la Plata), longitudes 30º W (east of Fernando de Noronha Archipelago) and 55º W (Maldonado, Uruguay). During this period, fishing effort was concentrated in the south-southeast region (i.e., lat. 20°S - 35°S), mainly between 25°-35°S. Another area with high concentration of fishing effort was located between 20° S and 25° S, which seems to be associated with the presence of the Trindade –Vitória seamount system in this area.

For the period 1983 – 1990 , the fishing operations expanded throughout south and part of the north Atlantic, i.e., between latitudes 15° N and 45 °S, longitudes 55° W and 5°W, including south American and African coasts. The fishing operations continued to be concentrated in the southern Brazilian and Uruguayan waters, i.e., mainly between 25° S and 35°S latitude. There was another fishing effort concentration, i.e., in the middle of Atlantic ocean (around Ascension island, 5°-10°S lat./25°- 15°W long.), in waters off the west coast of Africa, where is located the fishing ground for bigeye tuna.

During 1991 – 1997 fishing effort was concentrated in two main fishing areas: in front of southern Brazilian and Uruguayan coasts, and in the northeast Brazilian region. The overall longline fishery was distributed between 10° N - 50° S latitude, 50° W - 5° W longitude, during this period.

Figure 9 shows the distribution of nominal fishing effort (hook number), by national longliners, in four distinct time periods, over the years 1972 – 1997.

During the period 1972 – 1976, fishing effort was concentrated along the coastal waters of the southeast-south region of Brazil. The fishing effort was more intense in front of Espirito Santo, Rio de Janeiro and São Paulo States (latitudes 20°- 25°S / longitudes 40° - 45°W) and in coastal waters of Santa Catarina and Rio Grande do Sul states (25° - 30°S latitude and 45° - 50°W longitude).

During the period 1977 – 1982, the fishing area was expanded ranging from 15°S (Ilhéus, Brazil) to 40°S (Bahia Blanca, Argentina) latitudes, going offshore until 35°W longitude. However, the distribution pattern of fishing effort remained unchanged, with high concentrations in the area between 20° S (Vitória, Brazil) - 30° S (Porto Alegre, Brazil) latitude.

Between 1983–1990, with development of longline fishery in the northeast region, fishing effort was concentrated in two restricted areas, between 0º S and 10º S in the northeast and 20 º S and 40 º S in the South-southeast region. The most important fishing area continued to be between 20°S (Vitória, Brazil) and 35°S (Maldonado, Uruguay)

During the period 1991 – 1997, the fishing area was further expanded shifting to the north and to offshore waters. However the distribution pattern of fishing effort was the same, concentrating along the southern Brazilian – Uruguayan adjacent waters

b) SWORDFISH CATCH

The distribution of swordfish catches by national longliners, during the period 1972 – 1990, is shown in figure 10. As a whole, swordfish catch was mainly concentrated between 20°S (Vitória) and 30°S latitudes (Porto Alegre), and 40° - 50° W longitudes. For the period 1972 – 1976, swordfish catch was mainly obtained from the area between 25° -30°S latitudes and 45° - 50°W. Between 1977 – 1982, the highest catches again occurred along Rio Grande do Sul and Santa Catarina states (i.e.,

25°- 30°S latitudes). During the period 1983 – 1990, the distribution pattern of swordfish catch has remained unchanged. The distribution of fishing effort covered also the northeast region, however, because swordfish was caught as by-catch, by the longline fleet from the northeast region, there is a discrepancy between the distribution of catch (fig 10) and fishing effort (fig 9).

Figure 11 shows the geographical distribution of swordfish average catches (in tonnes), by foreign flagged leased longliners, in distinct time periods, over the years 1977 – 1990.

During the period 1977 –1982 swordfish catches were obtained throughout the northeast region and southern Brazilian – Uruguayan waters. During this period, in the northeast region, swordfish catches were low. The swordfish catches were mainly concentrated in the southern Brazilian region and Uruguayan adjacent waters, between 25° - 35° S latitudes, and 55° - 45° W longitudes. During 1983 – 1990, swordfish catches occurred throughout the south-atlantic, with best yields again in southern Brazilian-Uruguayan adjacent waters, mainly in the block 30° S lat./50 ° W long. Catches occurring along the northeast Brazilian coast, the middle of the Atlantic ocean and African coast, shown low average values.

c) NOMINAL SWORDFISH CPUE

Figure 12 shows average CPUE of swordfish (kg/100 hooks), in each quarter, for the national fleet operating along the southern Brazilian and Uruguayan adjacent waters, for the period 1972 – 1990. As a whole, the best swordfish CPUE were obtained during the 3rd trimester, mainly between 30°S and 35°S latitude, and 55°W and 35°W longitude. During this season (winter), there are huge squid concentrations, associated with the presence of the subtropical convergence system, which are preyed by swordfish. The lowest swordfish CPUEs were observed during the first and fourth quarters.

Figure 13 shows the CPUE distribution of swordfish by foreign flagged leased longliners, during the period 1983 - 1990. The high CPUE were obtained during the third quarter, in the area south of 25^{o} S. During 1983-1990, the leased fleet was comprised only by Japanese flagged vessels, which have been targeting either yellowfin or bigeye tuna in Brazilian waters and swordfish was caught as by-catch.

7.2 FISHING EFFORT AND CPUE IN DIRECT SWORDFISH FISHERIES

Figures 14 and 15 show the geographical distribution of fishing effort by Brazilian and foreign flagged leased longliners, operating in direct swordfish fishery, during the years 1996 and 1997. While fishing effort for the Brazilian longline fleet is concentrated in a restricted area, between 15 ^{o} S and 35 ^{o} S, specially within coastal waters, fishing effort by leased longliners shows a wide distribution, ranging from 5 ^{o} N to 40 ^{o} S , with relatively large amount of effort being spent in offshore waters. In the first quarter, the distribution pattern of fishing effort seems to be similar for both fleets, being restricted in the area south of 15 ^{o} S. For the second and third quarters, fishing effort is distributed widely by the leased fleet, while shows a high concentration in the area between 25^{o} S and 30^{o} S, for the Brazilian fleet. During the fourth quarter, fishing effort by the leased fleet is still widespread but shifting to the north, with a high concentration in the area between 5^{o} N and 10 ^{o} S.

Figures 16 and 17 show the geographical distribuiton of nominal CPUE of swordfish for Brazilian longliners (catch in number / 1000 hooks) and foreign flagged longliners (catch in weight / 100 hooks), respectively, during the period 1996 and 1997. The high CPUE were obtained during the second and third quarter for both fleets, specially in the southern coast of Brazil.

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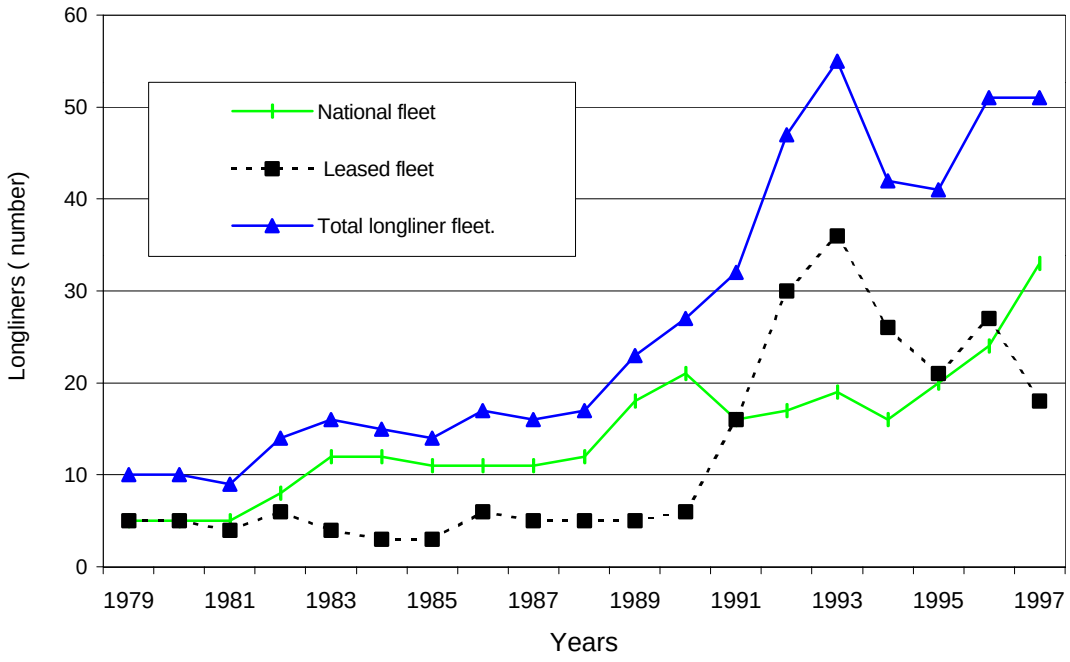


Figure 1 - Historical trend of longline fleet (number of vessels) throughout the Brazilian coast, period 1979-1997, national and foreign flagged leased fleet.

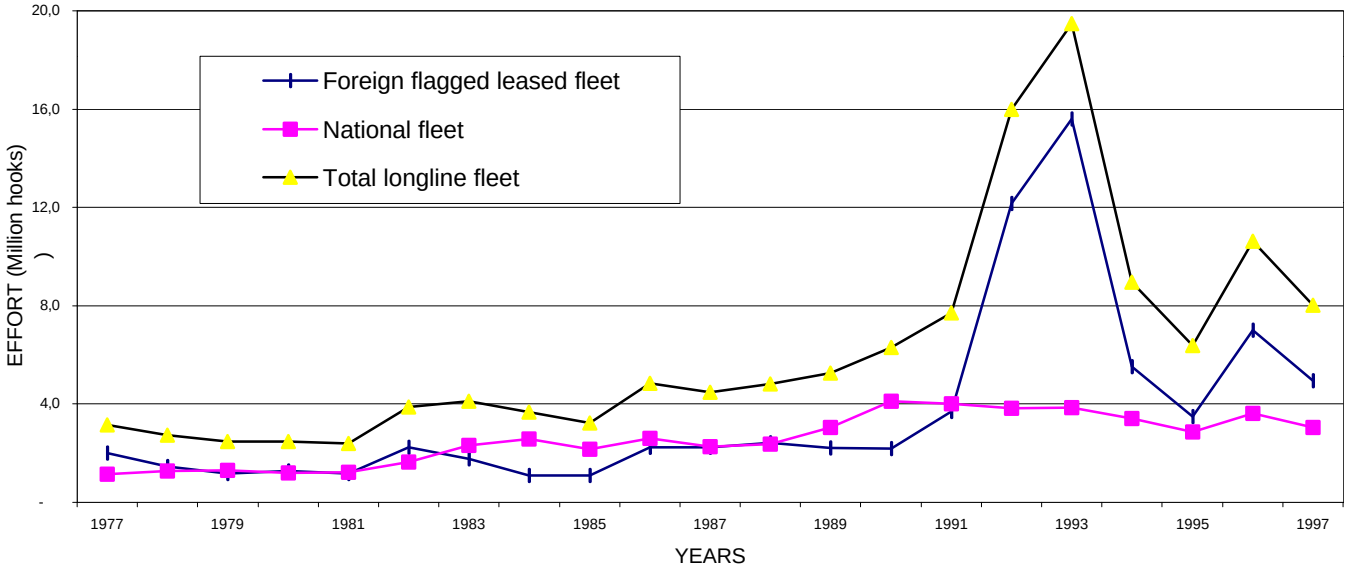


Figure 2 - Historical development of fishing effort (hook number) by fleet type (national and foreign flagged leased fleet, period 1977-1997.

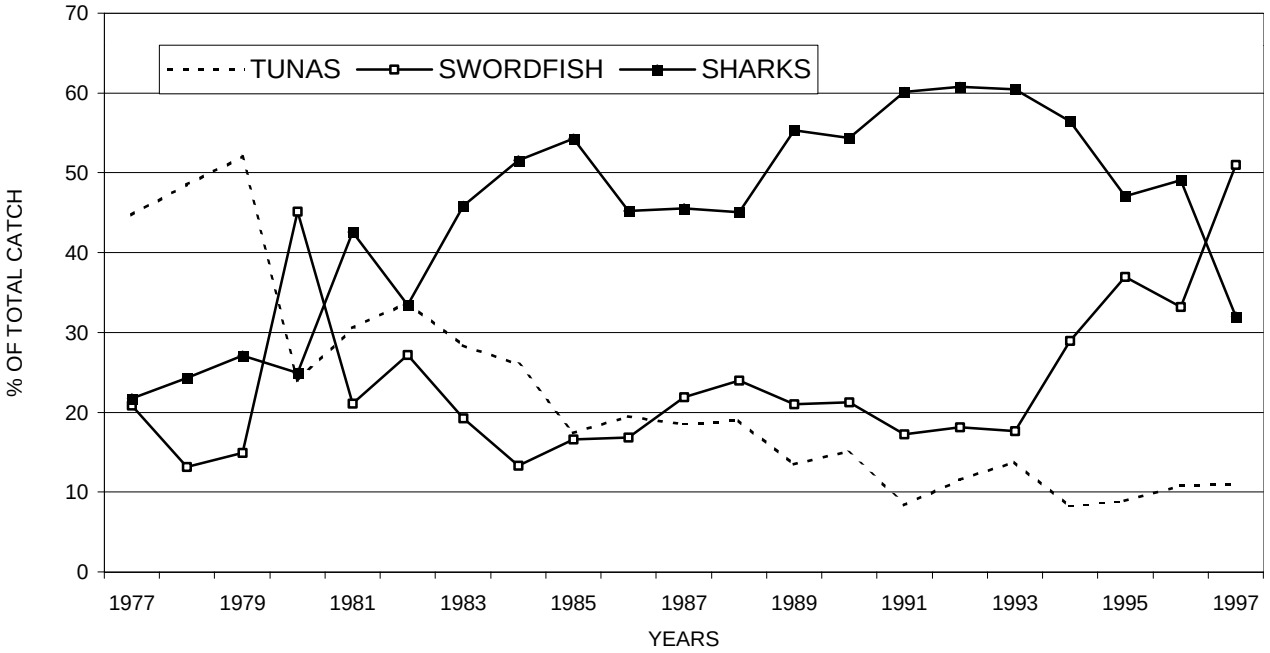


Figure 3 - Development of catch composition, national longline fleet, period 1977 - 1997

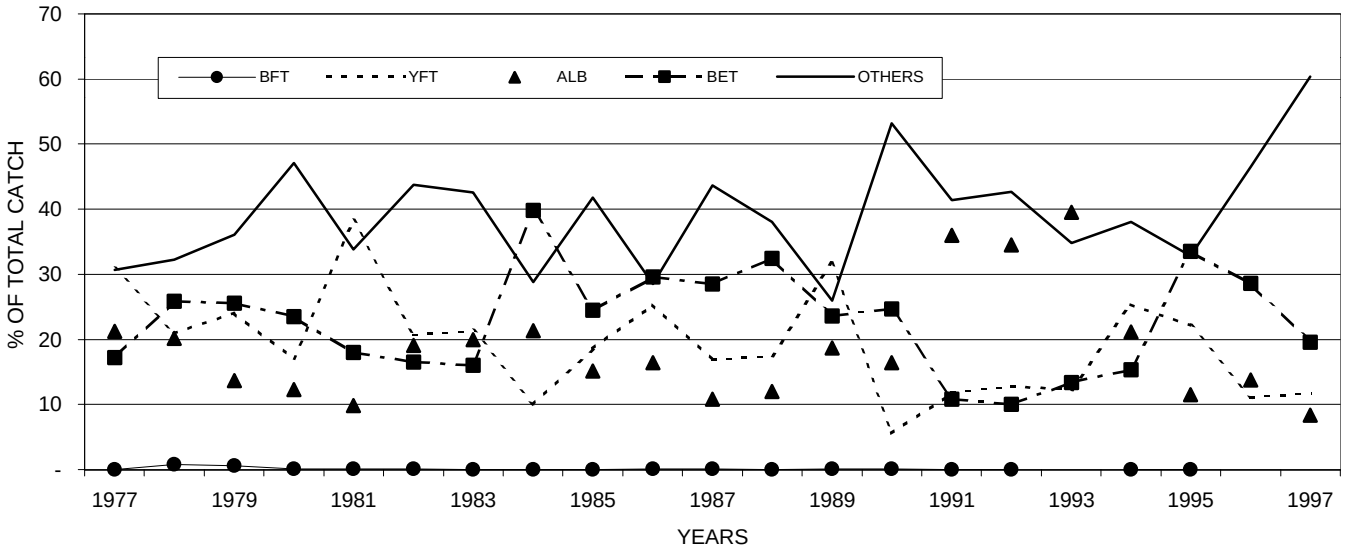


Figure 4 - Historical changes of tuna species catch (%) by foreign flagged leased longliners during the período 1977 - 1997.

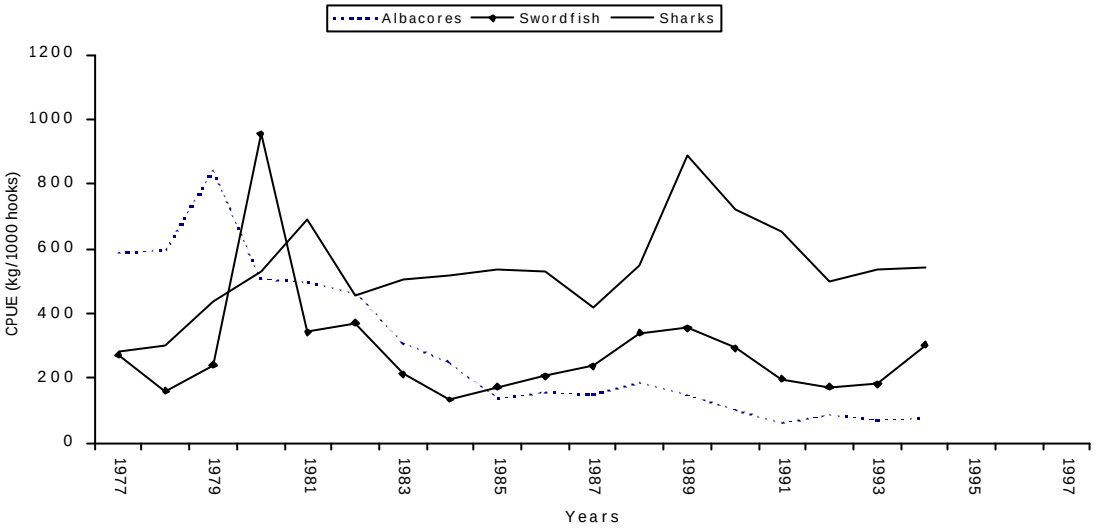


Figure 5 – Historical CPUE trends for tunas, sharks and swordfish (kg/1000 hooks). Brazilian national longliner fleet (south-southeast region) . Period 1977 – 1994

Figure 6 – Historical CPUE trends (kg/1000 hooks) for tunas, swordfish and sharks. National northeast fleet. Period 1983 – 1995.

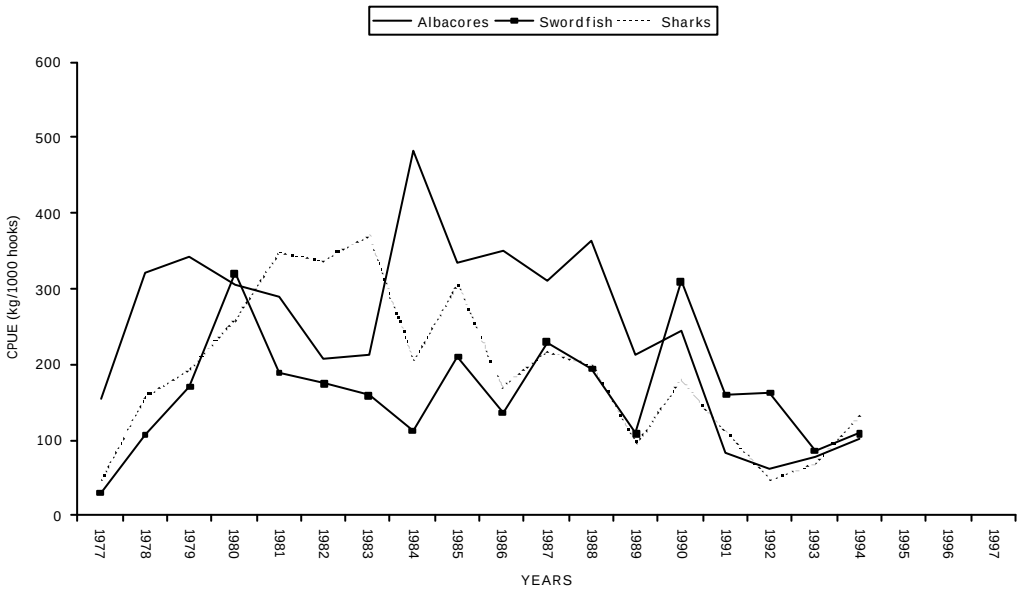
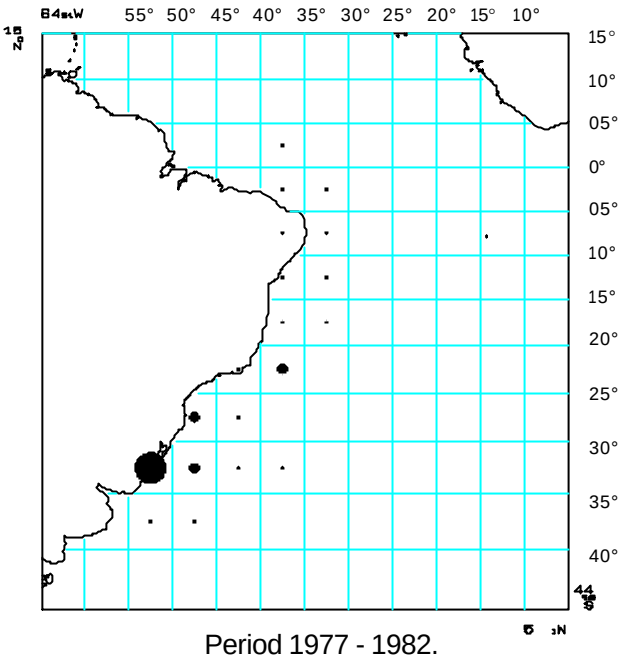
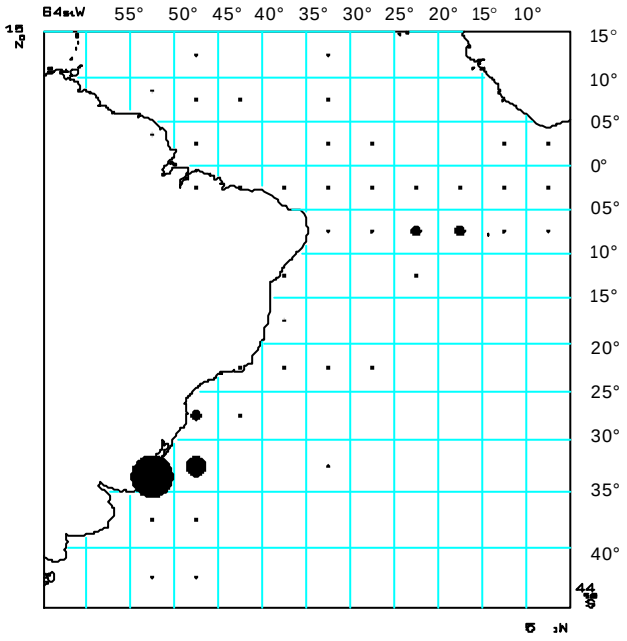


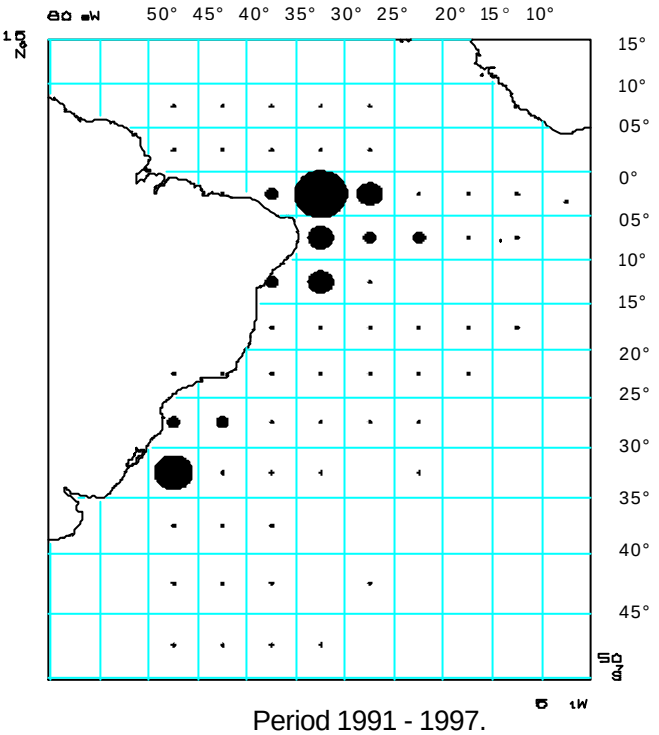
Figure 7 – Historical CPUE trends (kg/1000 hooks) for tunas, sharks and swordfish. Foreign flagged leased fleet. Period 1977 – 1995.



Period 1977 - 1982.



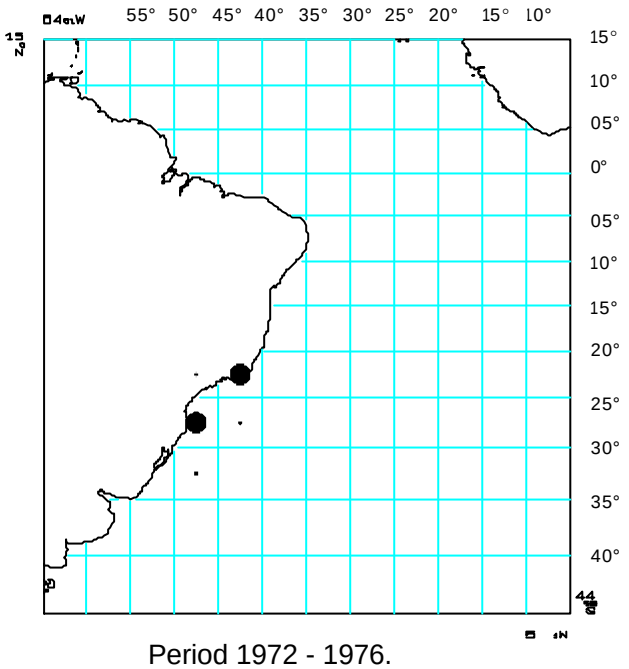
Period 1983 - 1990.



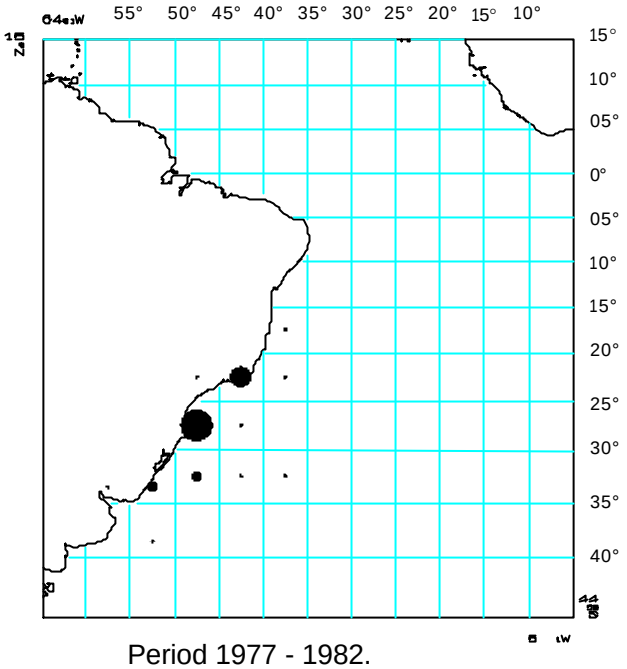
Period 1991 - 1997.

e < 50.000 | 50.000 ≥ e < 250.000 | 250.000 ≥ e < 500.000 | 500.000 ≥ e < 750.000 | e ≥ 750.000

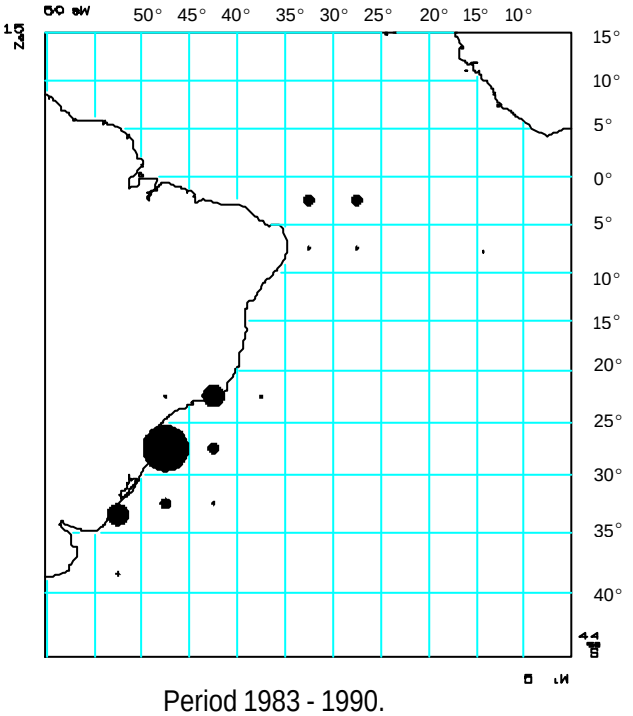
Figure 8 - Distribution of nominal fishing effort (e=hooks number) by foreign flagged leased longliners in Brazilian waters, over the period 1977 - 1997.



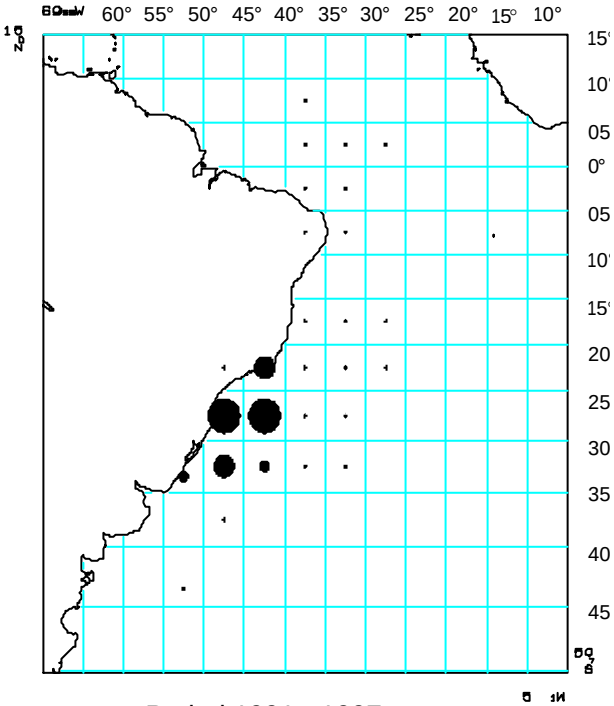
Period 1972 - 1976.



Period 1977 - 1982.



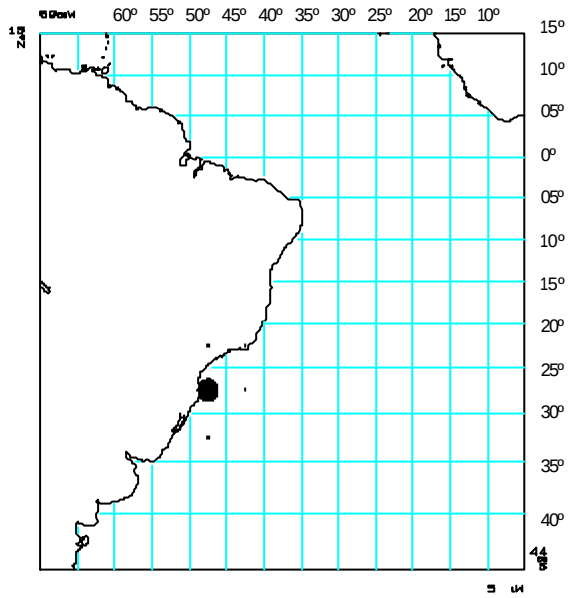
Period 1983 - 1990.



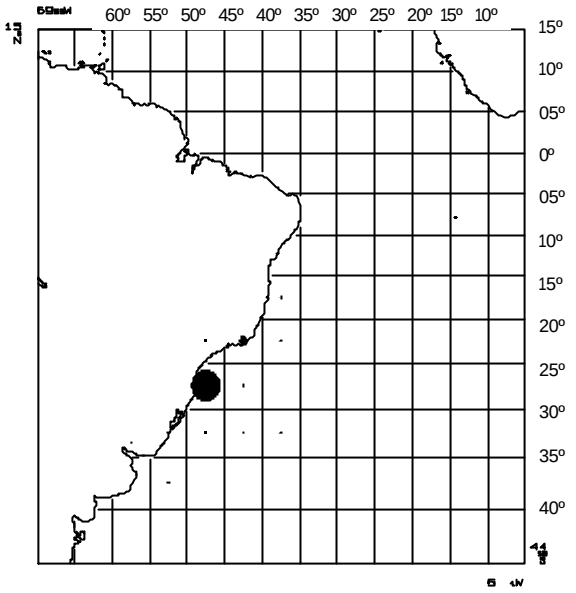
Period 1991 - 1997.

e< 50.000 50,000 ≤ e < 250,000 250.000 ≤ e < 500.000 500,000 ≤ e < 750,000 e ≥ 750,000

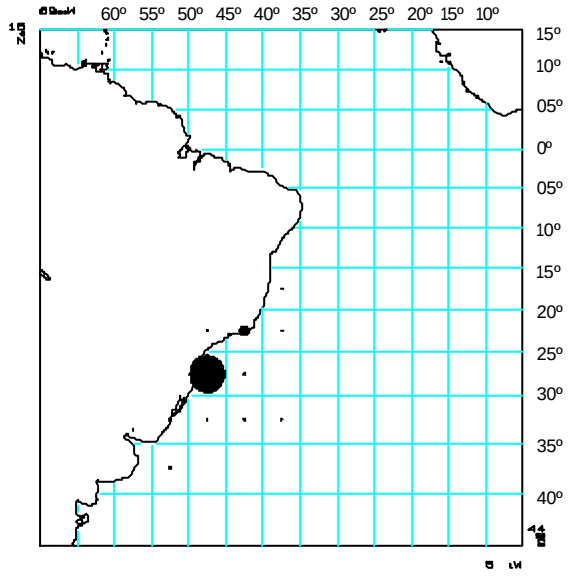
Figure 9 - Distribution of nominal fishing effort (e=hooks number) by national longliners in Brazilian waters, over the period 1972 - 1997.



Period 1972 - 1976.



Period 1977 - 1982.



Period 1983 - 1990.

Figure 10 - Distribution of swordfish average catch (C= M T) by national longline fleet, during the period 1972 – 1990.

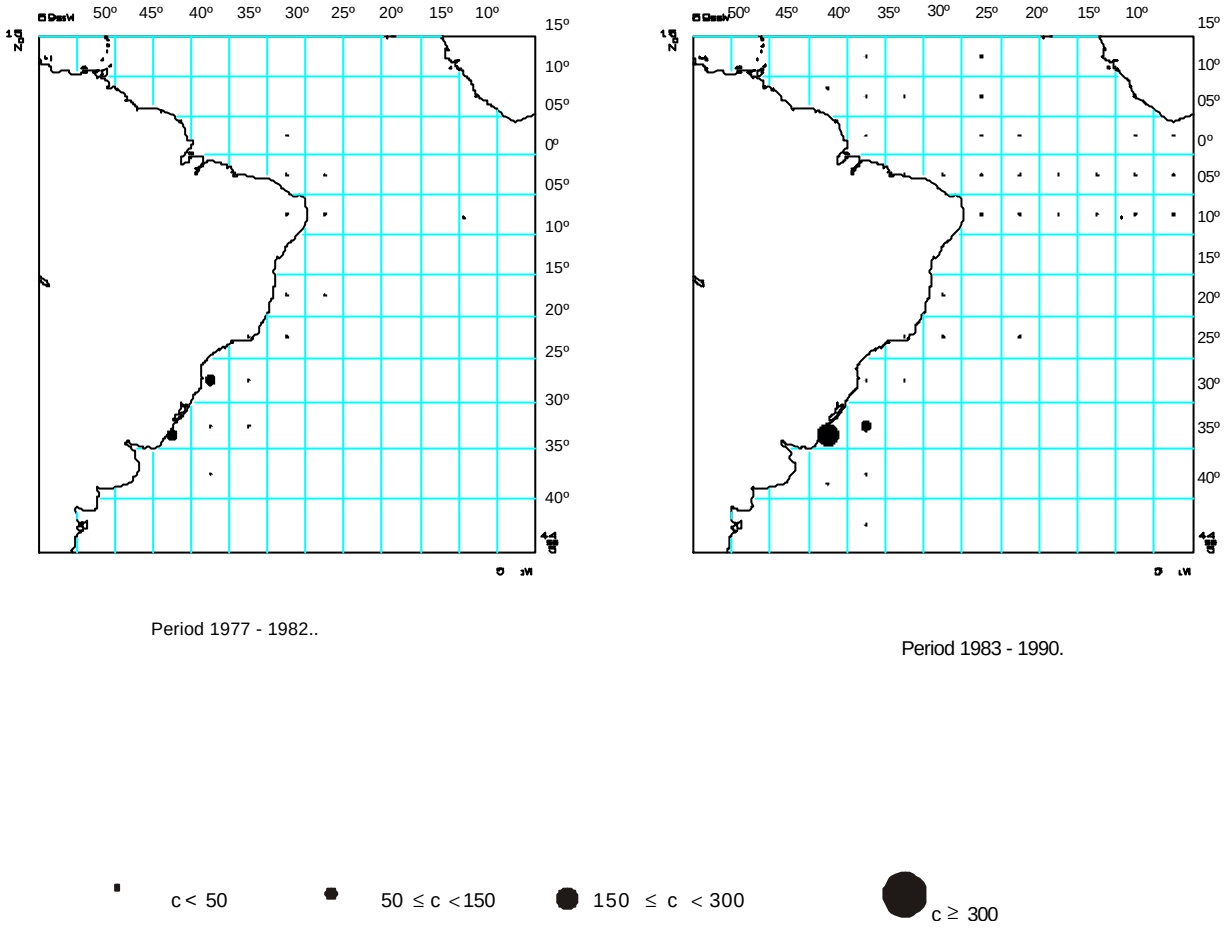


Figure 11 - Distribution of swordfish average catch (C=MT) by foreign flagged leasedlongline fleet, during the period 1977-1990.

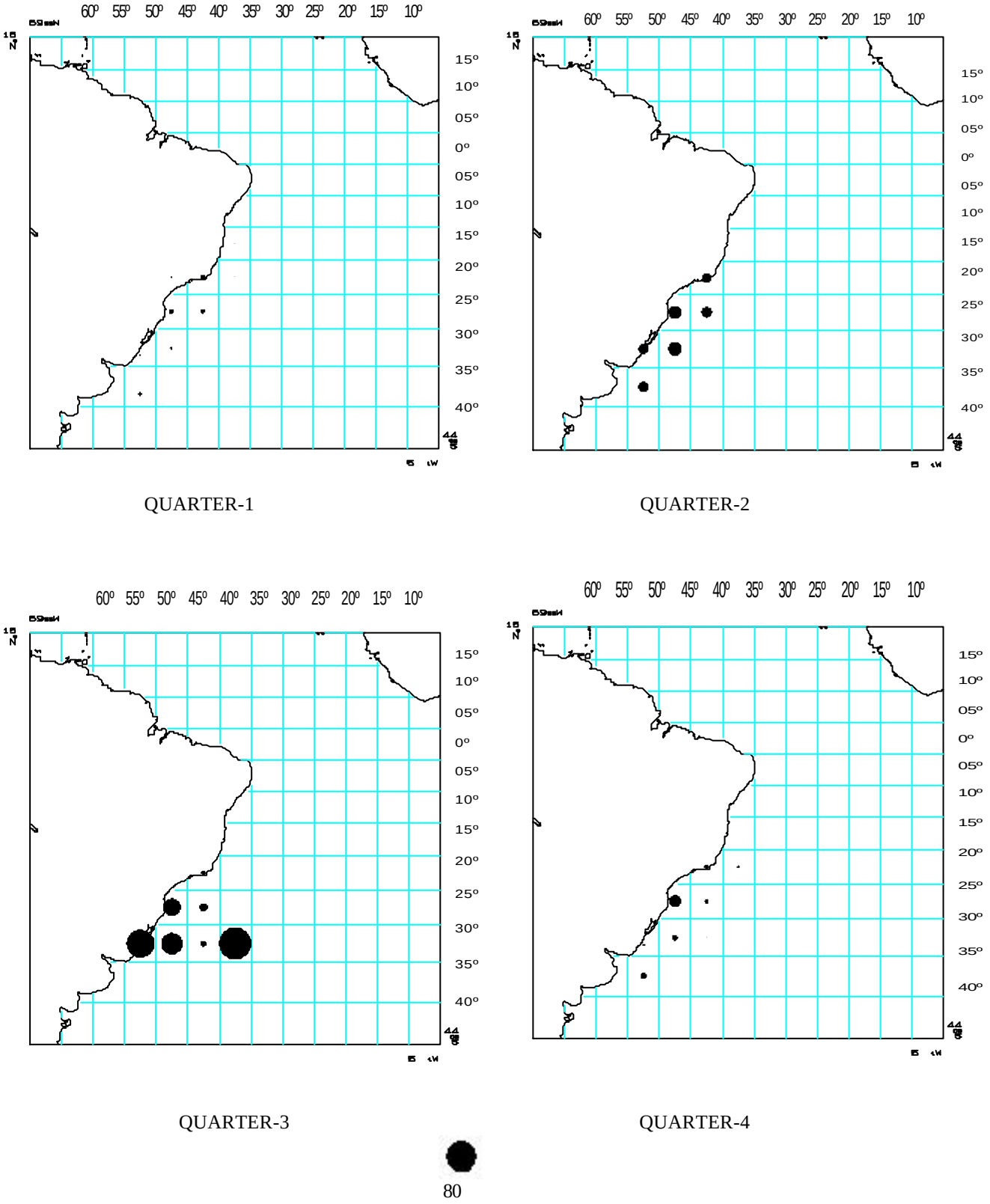
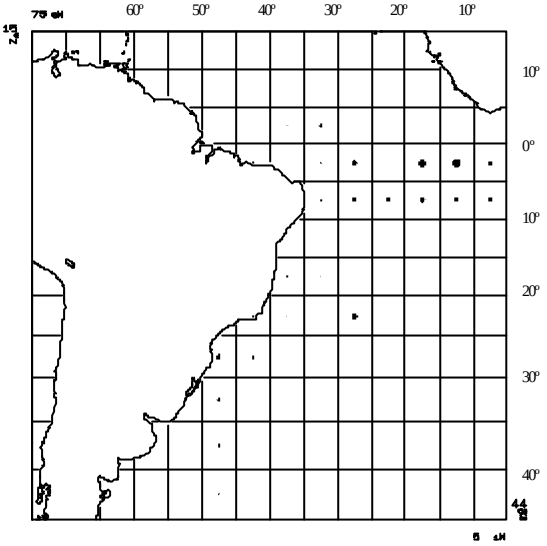


Figure 12 - Geographical distribution of nominal swordfish CPUE (kg/100 hooks) by national longline fleet, during the period 1972 - 1990.



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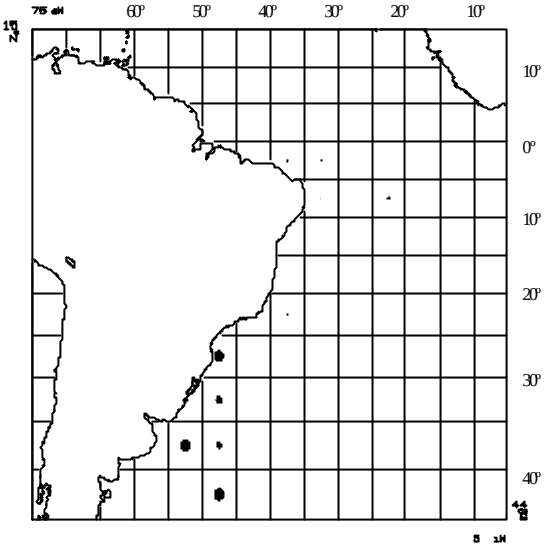

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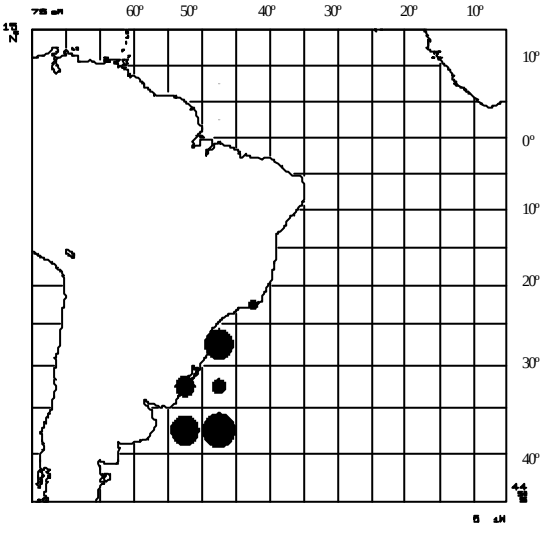

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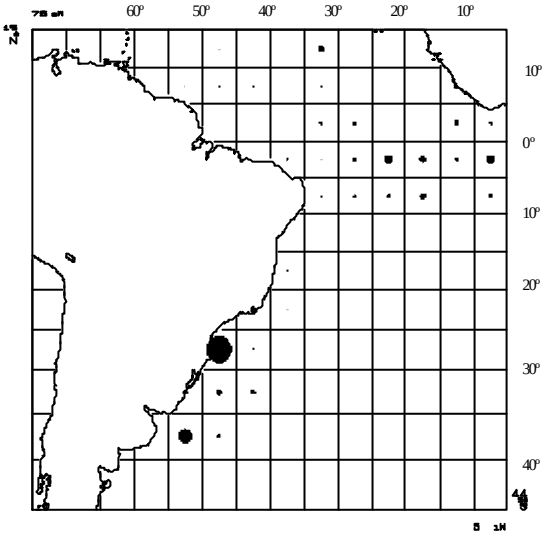
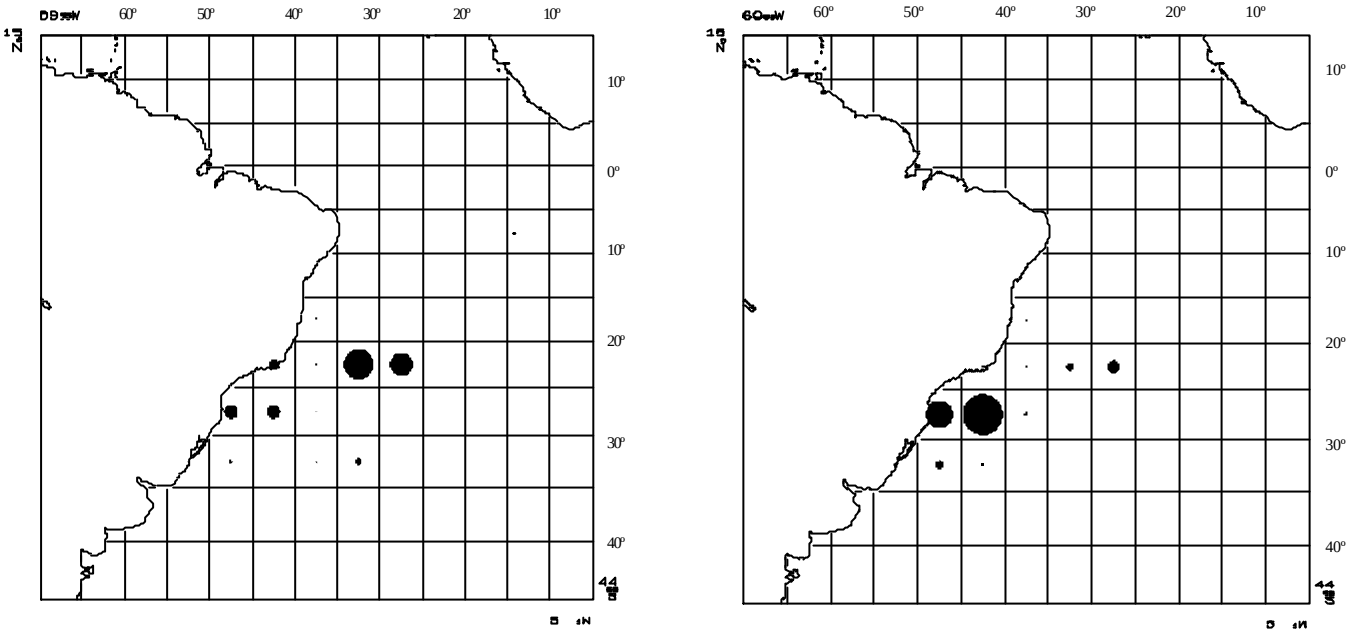


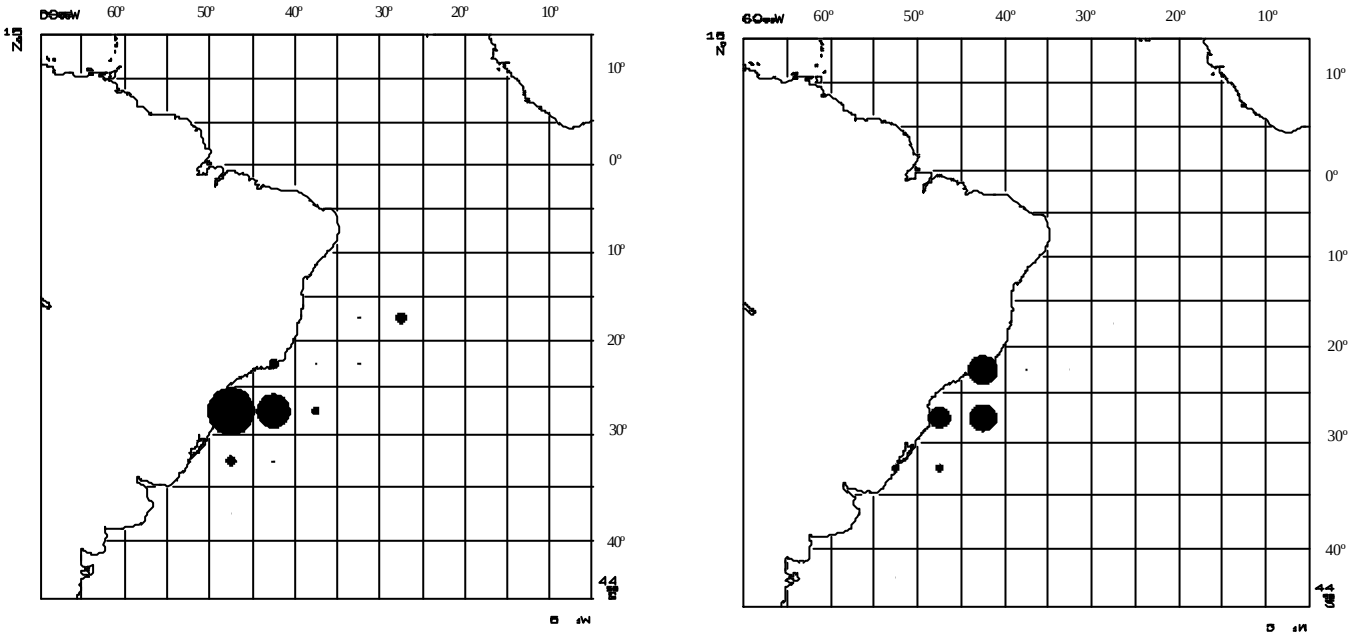
QUARTER-4

FIGURE 13 - Geographical distribution of nominal swordfish CPUE (kg / 100 hooks) by foreign flagged leased longliners operating in Brazilian waters, during the period 1983 - 1990



QUARTER-1

QUARTER-2

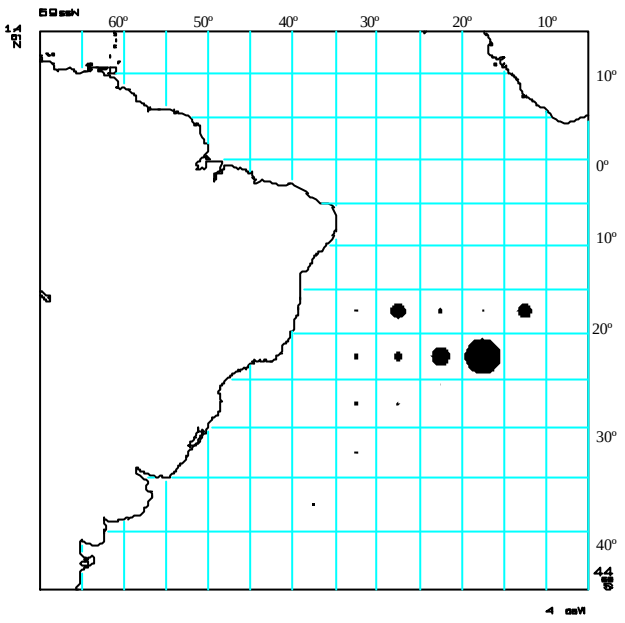


QUARTER-3

QUARTER-4

100,000

Figure 14 - Geographical distribution of nominal fishing effort (number of hooks) by national longliners operating in direct swordfish fishery in south and southeast regions of Brazil during the period 1996 - 1997



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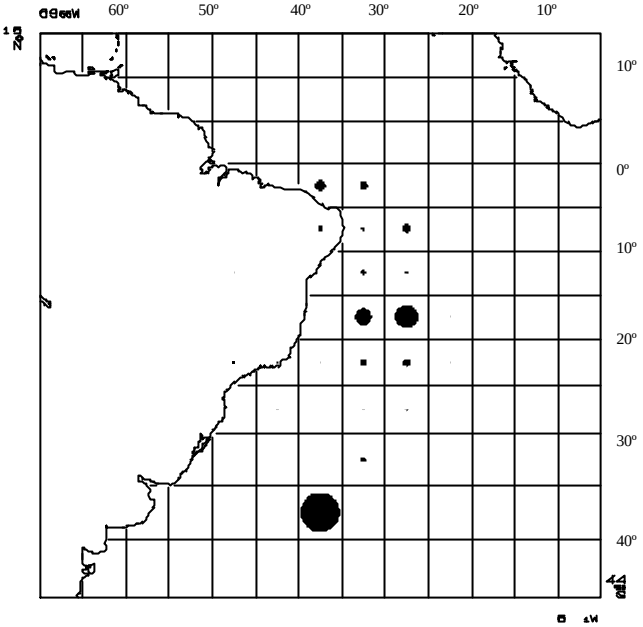

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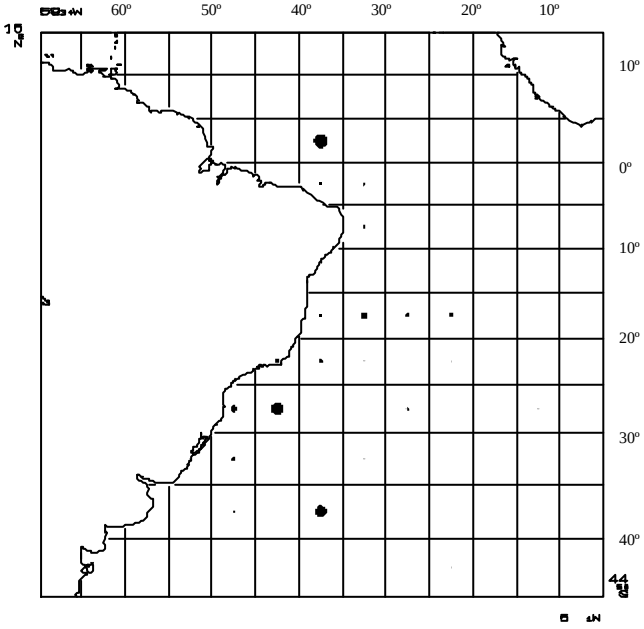

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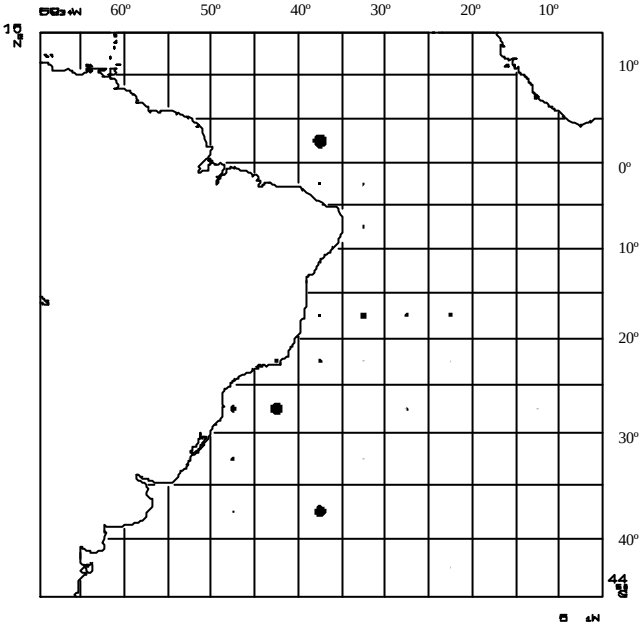
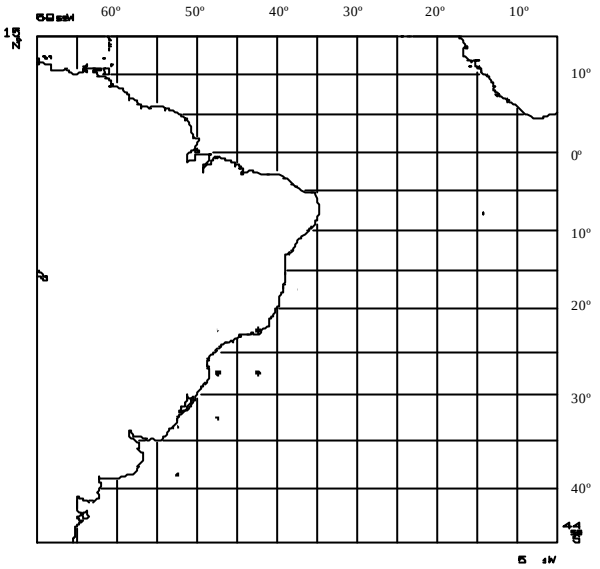


QUARTER- 4

81,000

Figure 15 - Geographical distribution of nominal fishing effort (number of hooks) by foreign flagged leased longliners operating in direct swordfish fishery in Brazilian waters, during the period 1996 - 1997.



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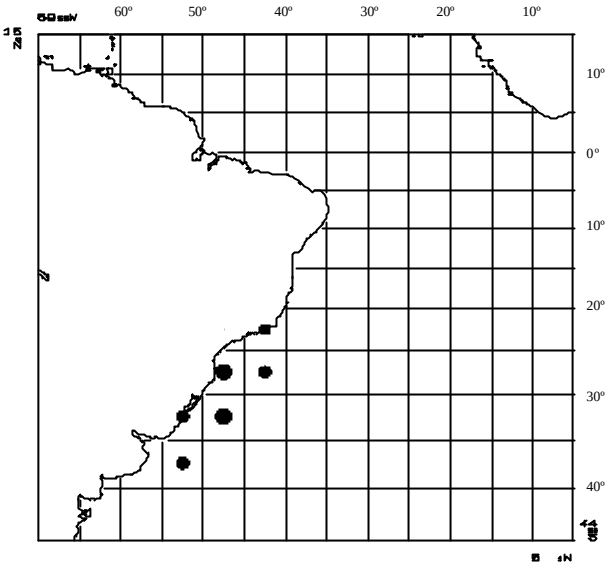

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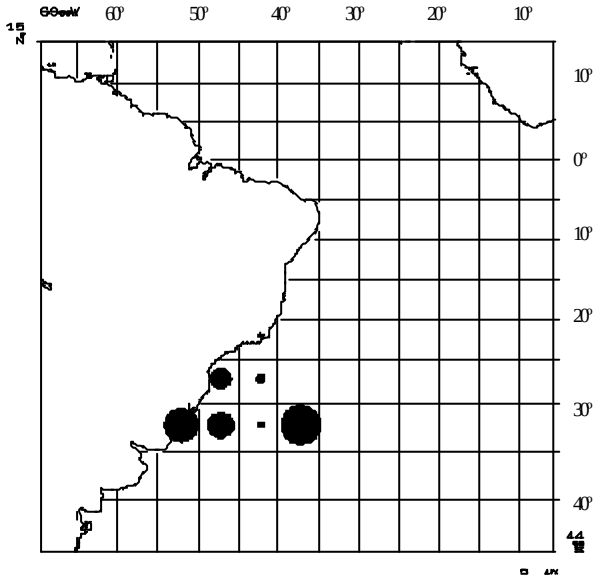
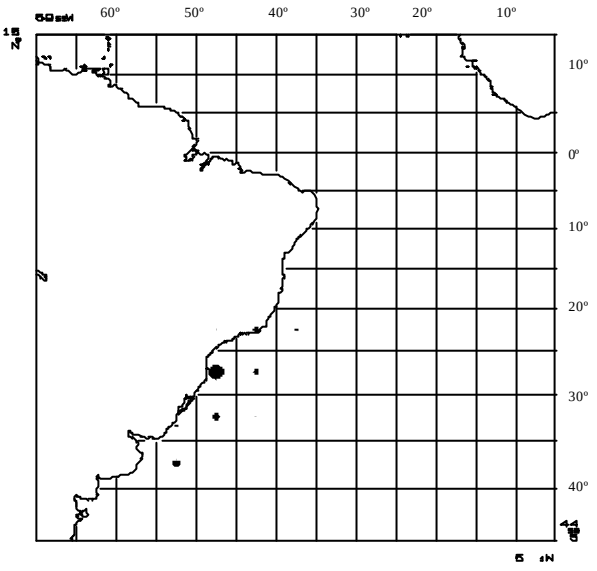
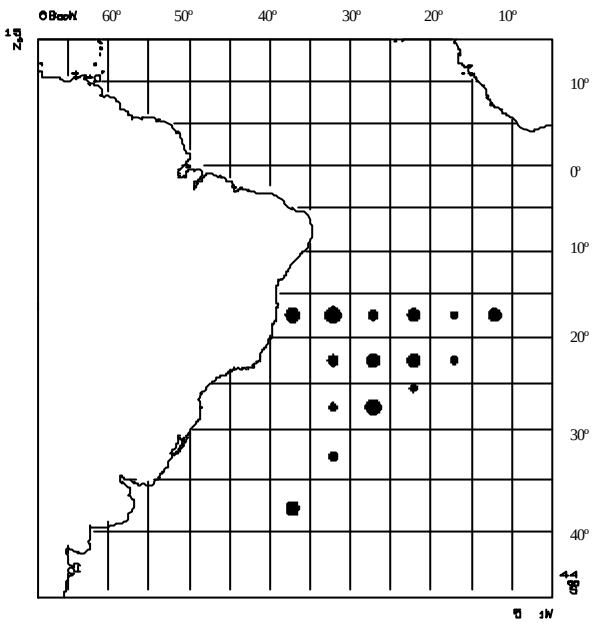


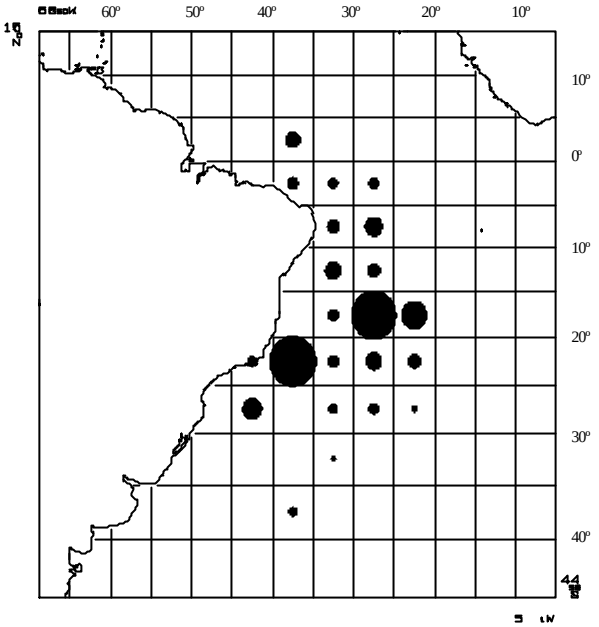


80

Figure 16 - Geographical distribution of nominal swordfish CPUE (number fish /1000 hooks) by Brazilian longliners operating in direct swordfish fishery in the south and southeast regions of Brazil, during the period 1996 - 1997



QUARTER-1



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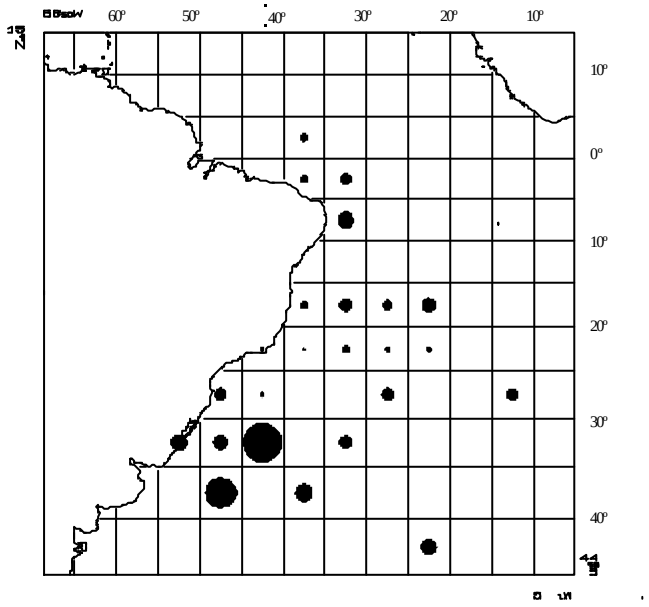
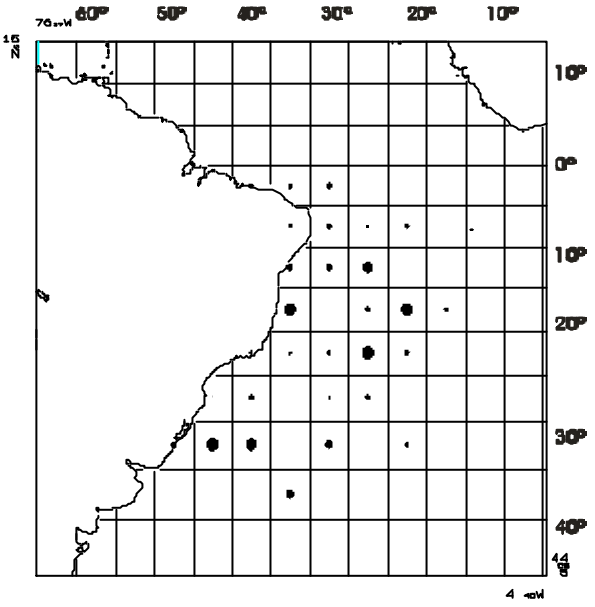


QUARTER-3



QUARTER-4

450

FIGURE 17 - Geographical distribution of nominal swordfish CPUE (kg / 100 kooks) by foreign flagged leased longliners operating in direct swodfish fishery in Brazilian waters, during the period 1996 - 1997