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Indian Ocean Tuna Commission
Commission des Thons de l'Océan Indien

Report of the 3rd Session of the IOTC Working Party on Billfish

Perth, Australia, November 10-12, 2003

1. OPENING OF THE MEETING

The Working Party on Billfish (WPB) was convened in Perth on November 10th, 2003.. The meeting, attended by 13 participants (list given as Appendix 1), was chaired by John Gunn (CSIRO, Australia). The draft agenda was approved (Appendix 2) after allocating the papers presented to the meeting to the appropriate agenda items. The list of documents presented to the WPB is given in Appendix 3.

A. Anganuzzi (IOTC Secretariat), M Basson (CSIRO), D. Bromhead (Bureau of Rural Sciences, Australia) and F. Poisson (IOTC Secretariat) acted as rapporteurs. As instructed by the Scientific Committee in its Third Session, the WPB concentrated its efforts in assessing the status of the swordfish, and briefly reviewed the new information available for the other species.

2. REPORTS ON CATCH STATISTICS

Status of IOTC databases

The catches of swordfish dramatically increased by over 800% in the 1990's , reaching a peak of 40,000 t in 1998, (Figure 1). Current catch levels are around 30,000 t. The change in target species from tunas to swordfish by part of the Taiwanese fleet, along with the development of longline fisheries in the region (Australia, Mauritius, Seychelles, Reunion) and the arrival of longline fleets from the Atlantic Ocean (Portugal, Spain), all targeting swordfish, are the main reasons for this dramatic increase.

The trends shown by the catches of each species are given in Figure 2 and catches of swordfish in the Indian Ocean for the period 1963-2002, in thousands of metric tons by gear and country/fleet in Figure 3.

A number of problem areas were identified in the data situation for billfishes:

- Poor knowledge of the catches, effort and size-frequency from fresh tuna and deep-freezing longline vessels, especially from non-reporting fleets.
- Lack of accurate catch, effort and size-frequency data for the Indonesian longline fishery in recent years.
- Poor knowledge of the catches, effort and size-frequency data for gillnet and other artisanal fisheries, especially the gillnet/longline fishery in Sri Lanka.

Improvements have taken place in a number of areas. These include:

A better level of reporting: New NC, CE and SF datasets have been obtained from several countries as for South Africa and Seychelles longline fisheries.

Revision of the IOTC databases: Several revisions have been conducted during the last year on the IOTC databases. This has led to new datasets being input, especially regarding CE and SF statistics (Indonesia, Sri Lanka) and to new series of NC data for some countries.

An improved Vessel Record: More information has been obtained on the number and type of vessels operating under flags of non-reporting parties. This information comes mostly from various licensing schemes in the Indian Ocean and has become an important element in the estimation of the catches of non reporting fleets.

Improved estimation of catches of non-reporting fleets: The collection of historical and current information on the landings of small fresh tuna longliners in ports in the Indian Ocean has improved the accuracy of earlier estimates. The more complete Vessel Record also permitted the estimation by flag of the catches of deep-freezing longliners.

IOTC/OFCF sampling programmes: The collection of information on the activities of fresh tuna longliners landing in Phuket, Penang and Indonesia has continued during 2002 and 2003. This has led to more complete and accurate estimates of catches of these fleets. Other valuable data collected in the scope of these programmes refer to length frequencies which will allow length-length, length-weight and weight-length relationships to be established.

Plan of Action in Indonesia: A large scale operation involving several local and foreign institutions was initiated in April 2002 in Indonesia. The primary objective of this multi-lateral cooperation is building the necessary capabilities in the country, so as to allow Indonesia to generate good quality statistics in the near future. Sampling of landings of fresh tuna longliners operating in this country started in June 2002 , with more than 2,500 sampling conducted (200,000 fish monitored) between June 2002 and June 2003, with coverage levels ranging from 30% to 40% of the catches unloaded by longliners in Indonesia.

Japan NC and CE: New estimates of catches of Japanese longline vessels for 1950-1969 were conducted during 2002 on the basis of new information reported by Japan. New CE data was also submitted for 1950-2001 to replace previous estimates that did not consider the IOTC boundaries but the FAO ones.

Indonesia NC: The NC for 1975-2001 was replaced by new estimates that took into account the IOTC boundaries in the East.

Taiwan NC: The catches of Taiwanese longliners were updated during 2002 with new catches added for the period 1954-1965 and 1966-1978 catches updated.

A general discussion took place regarding issues associated with billfish data, particularly swordfish data, and implications for assessments of this species. The magnitude of the data collection quality problems facing the IOTC was emphasized, particularly in regard to trying to determine catches by the very large scale artisanal fisheries . While identifying the problems associated with this is relatively easy, coming up with resources to tackle these problems is a major barrier. The support provided by the IOTC-OFCF project will continue to improve the catch estimation, through separation of unidentified billfish catches into separate species.

National reports on fisheries and statistics

Four fisheries were examined by the WPB, through documents proposed by Spain, Seychelles and Reunion (France).

Document WPB-03-03 presented a descriptive analysis of the activity of the Spanish surface longline fleet targeting swordfish (*Xiphias gladius*) carried out in 2001 in waters of the SW Indian Ocean (FAO51). Data on catch, effort and CPUE is summarized in a 5x5 degree/month format. A total of 10 longline spanish vessels fished in the Indian Ocean during the year 2001. The total nominal catch was 1,860.2 t round weight. Only two of these vessels carried out activity in this ocean all year round while the rest of the vessels alternated between these waters and other oceans. For descriptive purposes, graphs and plots are presented showing annual catches, annual nominal effort, and nominal CPUEs by year and semester in a 5x5 degree square format. The information presented also updates previous papers.

Document WPB-03-05 presented the trends of three different longline fisheries in the Seychelles. The local pelagic longline fishery targeting swordfish started in the Seychelles in 1995. There are currently 10 vessels are active. This document describes the evolution of catch in number and nominal weight from 1995 to 2002. Fishing effort increased from 31,480 hooks in 1995 to 235,057 in 2002, is concentrated on the northern part of the EEZ, in an area of approximately 240,000 km². Swordfish’s catches in number represents 57.1% of total annual catches, followed by yellowfin (16.2%) and bigeye (10.2%). The by-catches constituted of sharks (7.8%), sailfish (3.8%), marlin (1.6%) and other species

(3.0%). Since 2000, some local longliners changed their fishing strategies to target sharks. Annual swordfish CPUE show a significant decreasing trend with a maximum in 1998 (22 fish.1000 hooks-1) and a minimum in 2002 (10 fish.1000 hook-1). No significant trend is observed for tunas. On a monthly basis, high CPUE's on swordfish are obtained from April to June (17 to 22 fish.1000 hook-1) and between December and May for tunas (CPUE Dec. to May : 5.4 for yellowfin and 3.1 for bigeye). Predation data were also analyzed since 1995. Swordfish is the species with most attacks, 55.8% of total predation, followed by yellowfin (12.8%) and bigeye (10.4%). Mean predation rate for these three species is 1.5 fish per thousand hooks (3.0 for swordfish). During the period 1995-2002, the predation rate was highest in 1998. No monthly trend is observed. Monitoring of size frequency, carried out since 1995 do not show important variation of mean length since 1997, with LJFL ranging between 136 and 139 cm. There are seasonal variations in swordfish length with larger fish caught between March and June.

The document also provided a comparison with Taiwanese longliners activities in the Seychelles EEZ from 2002 to 2003. Tunas are the main species caught in number with 61% of total commercial species. Swordfish represents only 25% of the total catch. The maximum CPUE were obtained for yellowfin with a mean of 4.8 fish per thousand hooks. No significant monthly trend is observed. Swordfish CPUE is higher in the northern and central western regions of the Seychelles' EEZ. The opposite is observed for yellowfin and bigeye.

Recent trends in the Réunion longline fishery are discussed in Document WPB-03-07, after the end of the five-year longline research program (PPR) led by Ifremer from 1996 to 2001. The number of vessels is now decreasing as the catches of large pelagic fish have decreased. Catch of swordfish was reduced by half in the last four years, with no clear trend in the mean length caught from 1999 to 2002. After an initial increase of yellowfin and albacore catch, in 2002 there has been a decrease in the catch of both species. This small longline fishery (comprising only 30 vessels) catches less than 5% of swordfish catch of the Indian Ocean so the decline in the catches has been interpreted as a result of the heavy fishing in the area by other fleets. Fishing companies from La Réunion are facing difficulties and the number of large vessels (which are less cost effective) is decreasing.

As few logbook data have been collected since the end of the research program in 2001, it has not been possible to conduct further GLM analyses as those undertaken in the previous meeting.

In the discussion following this presentation, the group noted that an apparent local depletion has been observed in various Indian Ocean swordfish fisheries, with a rapid decline of the CPUE after few years of high catch rates. This phenomenon seems to be typical of many swordfish fisheries. for example, on the east coast of Australia, rapid expansion of a swordfish fishery in the 1990s appears to have resulted in significant localised depletion of swordfish stocks. The fast decline of local abundance is probably related to the limited movement of some fractions of stocks (so-called viscosity of the stock), a hypothesis which has been proposed for some highly migratory species.

On-going observer programmes

The WPB was informed that a domestic observer programme has begun on Australian tuna/swordfish longliners in 2002. Only a small number of observer trips have been conducted so far but it is expected that a report on this program will be available at the next WPB.

A sampling programme aboard French and Spanish purse seiners started six months ago, with the main objective of collecting data on by-catch with coverage of 5 to 10 percent of the fishing trips.

A small-scale observer program on Taiwanese longline vessels began in 2002 and is ongoing.

The WPB welcomed and encouraged these initiatives, noting that onboard observers are in the best position to collect critical sex-specific size data required to estimate length - weight conversions, and recommended that such measurements be done routinely.

Review of data issues

Analysis of Taiwanese data

, CPUE and size for swordfish caught by Taiwanese fleet. The Taiwanese longline fishery commenced in the mid-1950s, first in the northern and eastern Indian Ocean and expanded extensively to the three major oceans. During late 1960s to the early 1970s, the main catch in the Indian Ocean was yellowfin tuna. Later the main target species was shifted to albacore. Since 1980s, some of the longliners, together with newly built larger vessels with super cold freezers (below -60°C), started to shift their target to bigeye and yellowfin tunas. In addition to the three tuna species, swordfish has also become a seasonal target species to some of the vessels since 1990s.

Taiwanese exploitation of swordfish can be divided into three periods. Before 1985, annual swordfish catch was low (< 2,000 t) ; between 1986-91 this increased to moderate levels (3,000 - 5,000 t) ; since 1992 catch has remained high (> 9,000 t), with the record of 18,000 t in 1995 (Figures 4 and5).

Analyses of the spatial and temporal variation in catches and CPUE, indicate that the swordfish was a seasonal target species to the fleet after 1992. Most of the catch was made in Areas 3 (off Somalia) and 7 (off Madagascar), and in the third quarter (Jun-Sep). High CPUE areas were also noted in these time-area strata. Mean weight in the third quarter was fluctuated between 60-70 kg and stayed at the level about 65-70 kg in 1990s. As a whole, the catch size in length was in the range of 120-200 cm with mode of 140-170 cm. Preliminary CPUE standardizations were conducted by GLM with main factors of year, quarter, area and target effects in the paper. All the runs show that, among all factors, target effect contribute most to the model variance and need to be further discussed and studied.

In discussion of WPB-03-08, the meeting recognized the valuable contribution in new data and analyses provided by Taiwanese scientists. Unfortunately, data on gear configuration of Taiwanese longliners (eg hooks per basket) and the heterogeneity of the configuration among vessels. are available only since 1996. This limits the scope for standardization of CPUE.

It was also noted that the Taiwanese data and analyses presented include the catch by large, deep-freezing vessels only and thus swordfish caught by the Taiwanese fleet of (smaller) fresh-tuna longliners were not taken into account.

The WPB agreed that the spatial stratification of swordfish catches presented in WPB-03-08 reflect the aggregation of catch and effort across the Indian Ocean better than the stratification used in the 2001 meeting, and suggested that future analyses of both Japanese and Taiwanese data adopt these strata.

The presentation in WPB-03-08 of size-frequency data for swordfish in Taiwanese catches from 1978-2001 provided the first opportunity to examine spatial and temporal variation in size distributions in the different areas. These data are collected routinely by vessels through the measurement of the first 30 fish (regardless of species) landed on each shot.

The WPB noted the difficulty in identifying targeting given that data on hooks-per-basket have been collected only after 1996. Taiwanese longliners target swordfish in areas 3 and 7, but in other high catch areas swordfish are mostly caught as bycatch with bigeye as the main target species.

Predation by mammals

The high rates of predation by marine mammals (primarily by the genus *Pseudorca*) are still a problem in the Seychelles swordfish fishery and in other areas also (e.g. La Reunion). This predation is a cause of serious concern for both fishermen (as this may have a severe negative impact on their profit) and scientists (as these fish are not routinely recorded as removals from the population).

The IOTC programme for a predation survey has had mixed returns. Data has been forthcoming from surveys conducted in the Seychelles swordfish fishery, but there has been little or no return from other regions. The success of the Seychelles survey has highlighted the need for this type of research and for similar data to be obtained from other regions.

Sex-ratio data

The sex ratio by size is a variable across fisheries and strata, indicating that it is important that sex-structure be incorporated into the formulation of stock assessment models in future. It was suggested that the sex of processed individuals could be determined from sample tissues, and this potential should be further explored.

Use of sport fisheries statistics to obtain indices of abundance

A recent consultancy was carried in the context of the preparatory work for the Indian Ocean Tuna Tagging Programme (IOTTP) on the potential for sportfish tagging of tunas in the Indian Ocean. A survey of recreational fishers in key Indian Ocean countries was conducted to determine potential for tagging. Positive responses were received from sportfish anglers and charter operators in seven countries – South Africa, Kenya, Tanzania, Mauritius, Australia, Mozambique and Indonesia. It is likely that some billfish would inevitably be tagged with tags supplied for the tuna tagging program. This should not necessarily be discouraged since there is currently no centralised billfish tagging initiative in the Indian Ocean.

The consultancy report concluded that support for an Indian Ocean sportfish tuna tagging program to supplement the IOTTP was not only feasible but advisable. A strong side benefit of initiating a widespread angler-based program would be the establishment of a network of recreational fishers throughout the region with obvious benefits regarding returning tags and cooperation in other projects of the Commission. One such project might be the compilation of historic catch/effort data from sportfish fisheries (including those targeting billfish). This could be extended to routine collection of such catch and effort information into the future.

The catch rates of sport fisheries which are actively targeting billfish in various places of the Indian Ocean could provide useful indices of abundance, at least at a local scale. They could also provide an index of the sizes of fish taken which could be used as a potential indicator of stock status. It was noted that these data might well cover long periods of time. Such data set indices could probably be obtained from Mauritius, South Africa, Australia, Kenya and the United Arab Emirates.

Better species identification of marlins

The IOTC Secretariat report underlined that many artisanal and industrial fisheries have been reporting their catches as “billfishes” without species identification. This statistical problem is partly due to the difficulties faced in the identification of these species, especially when they are landed as processed carcasses. Australian scientists have recently developed identification sheets allowing a simple species identification of this group. The WPB recommended that the Secretariat obtain copies of these billfish identification sheets and circulate them to all statistical offices connected with billfish fisheries.

3. REVIEW OF NEW INFORMATION ON BIOLOGY, ECOLOGY AND FISHERIES OCEANOGRAPHY

SWORDFISH

Reproduction

Document WPB-03-03 on sex ratio patterns and gonadal indices of the swordfish caught y the Spanish fleet was presented. This paper presents a description of the overall sex ratio and sex ratio at size for the swordfish caught by the Spanish surface longline fleet operating in the Indian Ocean. The results obtained from the sampling of 23,648 swordfish specimens point to differences in sex ratio values both overall and by size class, among the different areas of the Indian Ocean analyzed. In addition, an analysis of the gonad size and weight of female swordfish specimens resulted in gonadal indices, based on different definitions and their equivalences. The results would suggest that specimens in the northwestern area of the Indian Ocean would be in advanced stages of maturation-reproduction and on the verge of spawning, which would suggest that this area is the most conducive to maturation and spawning processes as compared to other zones.

Growth

Document WPB-03-10 on swordfish growth in La Réunion area was presented. As non-validated age reading of spines may seriously underestimate the age of old individuals, a re-analysis of the spine samples to determine the periodicity of the light-coloured rings at the margin of the spine to determine whether rings were indeed annual has been conducted. Unfortunately, the results obtained to date have been inconclusive and further work will be necessary.

STRIPED MARLIN

A verbal review of information on the biology and fisheries for striped marlin in the Indian Ocean was presented by Don Bromhead from the Bureau of Rural Sciences (Australia). Striped marlin occurs throughout the Indian Ocean north of 45°S. Based on spatial shifts in mean quarterly longline catch rates, areas of high abundance appear to shift from more northern waters (Arabian sea, Bay of Bengal) in the first and second quarters, south to waters off northwest Australia, and off central east African coast, in the third quarter. Early Japanese surveys indicate evidence for separate spawning grounds in the eastern and western Indian Ocean. There have only been five tag-recaptures of striped marlin in the Indian Ocean and on the whole, information relating to stock structure and movement patterns is very scarce. Analyses of tag-recapture data in the Pacific indicate that striped marlin may not be as highly migratory as other marlin species, with some evidence for broader regional fidelity (no transoceanic recaptures have been recorded from over 400 recaptures in the Pacific). The presentation also highlighted the need for research not only into stock structure, but age validation and growth studies to assist in assessments.

In the subsequent discussion, it was noted that determining stock structure is the highest research priority for striped marlin and other billfish species in the Indian Ocean. This would be best addressed by a combination of genetic research and tagging. The WPB suggested that the Secretaria provide a support platform for those wishing to undertake such research, by coordinating the collection of samples for genetic studies from various regions of the Indian Ocean. Progress on this type of research could be reported through a dedicated page in the IOTC website.

There is also a need for further analyses of standardized CPUE trends for striped marlin. Previous standardisations presented to the WPB noted concerning declines in CPUE for striped marlin in the

Indian Ocean (see Campbell and Tuck, 2000; Uozumi, 2000). Collaborative analyses on fine scale catch and effort data should be pursued.

4. REVIEW OF STOCK INDICATORS

CATCH TRENDS

Changes in fishing zones

Figure 6 shows the species composition of the Taiwanese and Japanese fisheries from 1970 to 2000. After 1992, a very strong seasonal signal during the months of June-September is observed regarding swordfish catch by the Taiwanese fleet. On the contrary, for the Japanese fleet, the catch composition does not change during the year. The evolution of the geographical distribution for the Taiwanese fisheries shown in Figure 7 indicates that swordfish is dominant in the catch in the southern and central areas of the western Indian Ocean (Areas 3 and 7, see Figure 13 for definition of areas).

The WPB discussed a series of maps (Figure 8) to describe the evolution of the Japanese and Taiwanese swordfish fishery in the Indian Ocean. In particular, the analysis concentrated on catch histories in the heavily exploited areas 3 and 7, noting the difference in species composition of the catches of these two fleets in area 7, especially since 1990. These differences emphasized the fact that area 7 is a heterogenous area that includes three ecosystems where different species of large pelagics predominate (Figure 9) This complicates the interpretation of the CPUE trends for the area 7. The key conclusions of this review are as follows:

1. Japan was the original fleet to catch swordfish in the Indian Ocean (although not as a target species) since 1950s. Since then, numerous other distant water and Indian Ocean coastal nation fleets have developed longline fisheries targeting swordfish (See Figure 10)

2. Total longline effort across all fleets has been highest in areas 3 and 7 in the past decade.

3. There has been a rapid increase in Taiwanese catches of swordfish in area 7 and 3 since 1990 (Figure 7), with a decrease in albacore catches as targeting to swordfish increased. The Taiwanese swordfish fishery is seasonal, with boats moving into area 7 during the southern-hemisphere winter months (June to September) to target swordfish. In contrast, Japanese catch composition in area 7 shows that swordfish has remained a relatively minor component – the dominant catch being tuna species. It appears likely that these differences in species composition are the result of changes in gear configuration and time of day of setting (e.g. Taiwanese fleets setting at night, Japanese fleets setting during the day and therefore taking little swordfish). Unfortunately, time of setting information for the Taiwanese fleets has only been recorded since 2002, which complicates CPUE standardisations and their interpretation.

4. The longline fleet in La Réunion also targets swordfish in area 7, but in the last quarter of the year.

5. Total annual catches of swordfish from area 7 alone account for almost 50% of the catches.

REVIEW OF CPUE TRENDS

CPUE of the Taiwanese longline fleet

Document WPB-03-08 analyzes the catch and effort data from Taiwanese longliners and presents a standardized CPUE series for the period 1968 to 2001. The nominal series shows a large increase in 1992 which is considered to be due to targeting. The standardisation uses an area stratification (10 areas) based on considerations of the characteristics of the Taiwanese fishery. This stratification differs from that used by the WPB on Japanese CPUE data in the past. Standardisation was done on data aggregated by 5x5-degree areas and month. Due to a lack of information on hooks per basket data prior to 1996, a proxy variable had to be constructed for targeting. Three approaches were considered, but trends in the standardized index were very similar for the three approaches. The overall standardized CPUE series shows a slight increase between 1984 and 1997, a slight drop in 1998, but remains flat through to 2001.

CPUE of the Japanese longline fleet

Document WPB-03-02 presents an updated standardized abundance index for swordfish based on data from Japanese longliners. The area stratification and terms included in the GLM were the same as for the series used in the last stock assessment for swordfish (WPB 2001). The estimated value of the index in 2002 was decreased to 76% of the value in 2000. The decrease is mainly due to a decrease in the western IO.

Further analyses of CPUE

The group noted the great advance made by having a standardized CPUE series for the Taiwanese fleet compared to the previous WPB meeting where only nominal CPUE were available.

During the meeting, a number of further analyses were requested for the Taiwanese data. First, some slight changes to the area stratification were proposed to reduce the number of areas, and to combine those considered to be sufficiently similar in terms of the fishery and/or the likely underlying swordfish density. The revised areas, based on the numbering in WPB-03-08: 1, 2, 3, 4, 5 and 6 combined, 7, 8 and 9 combined, 10 (see Figure 13). Second, runs based on set-by-set data, rather than the aggregated data, were requested. Third, the inclusion of a year-area interaction term was requested, with the standardized CPUE series based on area-weighting of the interaction terms.

One of the main concerns with the standardisation results relates to the issue of targeting. Only recent data (1996 onward) contain hooks per basket information, and the shot by shot records do not contain information about time-of-day (e.g day or night setting). It is known that the Taiwanese fleet changed behaviour to target swordfish in certain areas and months since 1992, and this is difficult to deal with in the standardisation. It should be noted that the interpretation of the data with regard to targeting has been a major difficulty in the past, and appears to remain a difficult aspect of standardisation, particularly when the full historic time-series is used. Exploratory analyses during the meeting suggested that, depending on how the proxy-variable for targeting is defined, there is a possible danger of removing some of the signal related to abundance in the data through the standardisation process. A new targeting proxy variable was suggested based on considerations of the proportion of swordfish in the catch for different categories of numbers of hooks per basket (from those records where hook per basket information was recorded). On the basis of this, three categories of ‘targeting’ were defined: proportion of swordfish in the catch >14%, between 8 and 14% and less than 8%. It was, however, noted that sets which used small numbers of hooks per basket tended to have high proportions of swordfish in the catch, but also tended to have high CPUE (Figure 14). This indicates the potential for confounding and hence a danger of standardising out the abundance signal in CPUE, resulting in a index that does not respond well to changes in abundance.

The Japanese data were also re-analyzed using the new area stratification defined above, to allow area by area comparison of the Japanese and Taiwanese standardized CPUE series.

Results from further analyses

Results from the re-analyses for the Japanese data showed relatively large decreases in areas 3, 5&6 (combined), and 7 since 1990. This coincides with the timing of increased catches. Further discussion of area 7 indices, interpretation and implications is given below. Due to low sample sizes in area 8&9, which leads to very high variability and wide confidence intervals in the area-specific CPUE series, it was considered that this area should be excluded from an overall index for the Japanese fleet.

It was noted that the distribution of residuals was improved for the new analysis based on the re-definition of areas, since it is no longer bi-modal, as it was the case in the analysis in WPB-03-02 (Figure 15). The long tail in the distribution comes from residuals for area 8&9 where the sample size is low.

With regard to the Taiwanese data, a comparison was made between results from two models: (a) using hooks per basket as a covariate, and (b) using the new categories for the % swordfish in the catch, as defined above, instead. This analysis was done for the subset of records which contain hooks per basket information (data after 1996). Figure 16 shows that the new categories of % swordfish in the catch leads to a standardized CPUE series which is not very dissimilar from the series based on hooks per basket. This gives some confidence that the proxy-variable for target may be performing reasonably well, at least over some time periods.

Results of the re-analyzed full time-series of Taiwanese shot-by-shot data using the new categories of % swordfish in the catch are shown by area in Figure 17 together with the standardized Japanese CPUE series and total catches.

The areas where most of the catches are taken, areas 7 and 3, were considered in more detail. Both the Japanese and Taiwanese series show declines, particularly since 1992 when the catches increased substantially. It was noted that area 7 (the area south of Madagascar and off the coast of southern Africa) is a heterogeneous area oceanographically and ecologically, and that a shift of a fleet within the regions could lead to changes in species composition and in CPUE. The fleet movements in this area are summarized in section 4 and Figures 6, 7 and 8. In area 3, the Japanese series shows a decline as the total catches increase, but the Taiwanese series is relatively flat and much less variable than the Japanese series.

The WPB noted that the patterns seen in the Japanese standardized CPUE series, viewed together with the catch series in each of the areas are consistent. This leads to increased confidence on the use of this series in an assessment model. The WPB considered that there are two issues that need further consideration concerning the standardization of the Taiwanese CPUE series. It should be noted that the difficulties do not lie with the data but rather with the proper interpretation of the data. The first issue is targeting. There are still some concerns that the proxy target variable may not be performing well over the full time series, and the possibility of confounding between CPUE and % swordfish in the catch which could lead to the removal of signal from the series. This may happen if the dataset is unbalanced. The second issue is that although the index may perform well in some areas, in other areas where there is less targeting on swordfish, the index may be less informative. Combining the indices from all areas may also then be less informative.

Eastern and Western Indian Ocean

The WPB also looked at standardized CPUE indices for areas 3 and 7, representing the main swordfish fishery areas in the western Indian Ocean and area 4, 9 and 10, representing the eastern Indian Ocean. The Taiwanese index for areas 3 and 7 combined is reasonably flat prior to 1992, and then shows some decrease since 1992. The Japanese index also shows a decrease since the 1990's.

The picture is much less clear for the eastern areas where the variability is apparently higher than in the western areas. The Japanese index shows a decrease in area 4 since about 1997, but the Taiwanese index shows a slight increase over this period. The catches have only increased in the last few years. It was noted that in area 4, the Taiwanese fleet is not setting for swordfish, but uses deep longline targeting bigeye.

Trends in mean length and 90th percentile of length

The average weight in the catch of the main longline fleets does not show any consistent trend (Figure 19) with the possible exception of a decrease in the size caught by the Seychelles's fleet. For the larger, more mobile fleets this overall trend might be affected by fleet movements between areas or documented changes in fishing practices (e.g. the increase in weight in Spanish catches).

When Taiwanese size data for all areas are aggregated, there is little evidence of changes over the last 20 years in size distribution of swordfish (Figure 20). Similarly, mean length at the 90th percentile of these distributions show strong interannual variability, but no clear trends (Figure 21). The WPB noted that in Area 7 large fish (>220 cm OFL) were absent from the catches. However, in the past (including periods prior to the increase in exploitation in the early 1990's) there have also been occasions when large fish were absent from the size frequencies and then re-appeared after a couple of years. These indicators do, however, need to be monitored, particularly over the next few years. Size indicators for the whole fishery and by area should be considered.

Production modeling of swordfish

A large number of assessment runs with the 'ASPIC' software, which fits the Schaefer production model to data, were made at the meeting using the different indices. Due to a lack of time to fully evaluate the different assessments and diagnostics, results are not presented in detail in the report.

Runs were based on the Japanese or Taiwanese series alone, or on the Japanese series and the Taiwanese split into two time-periods, one prior to 1992 and one from 1992 (when targeting switched to swordfish) converged. As anticipated, some runs based on flat or on contradictory indices did not converge. Concerns were expressed about some of the runs with high and probably biologically unrealistic assumed or estimated values for rate of increase, r (e.g values of 3). It was noted that r and K are highly correlated, and that estimates of quantities such as the biomass ratios or fishing mortality ratios are likely to be more stable.

The WPB noted that most runs in the analyses estimate MSY-levels below the current catches, and indicate that the biomass is near or below Bmsy.

It was noted that there are still many weaknesses in the analyses which need to be considered or addressed at the next meeting (see Research recommendations).

Summary of trends in indicators and assessment

Consideration of the stock indicators and the assessments suggest that the stock is likely to be near or below the Bmsy level. This is indicated by some of the assessment runs, but can also be concluded from the relative change in the standardized CPUE series since the 1990s. Although there is high uncertainty, the indicators and assessments suggest that the situation may be more serious in the Western Indian Ocean than the Eastern Indian Ocean.

The total catches have apparently decreased slightly over the recent five years after reaching a peak of 40,000t in 1998, however, the effective effort (estimated as the catch divided by the standardized Japanese CPUE) has continued to increase over this period. This suggests that the decrease in the catch is not as a result of a reduction in effective effort, but more likely to be as a result of a decrease in the swordfish biomass (see Figure 18).

The WPB agreed that there was scope for improvements to the standardisation and interpretation of CPUE and assessments. On the one hand the Japanese fishery does not target swordfish, so that the interpretation of the CPUE data is relatively simple, but this fleet only takes a relatively small proportion of the catch. On the other hand, the Taiwanese fleet takes the majority of the catch, but targeting practices for swordfish have changed dramatically and this makes standardisation of CPUE more difficult. There is scope to use the Taiwanese size frequency data, which were available at this meeting, to start developing a size or age-based model, and other forms of production model (e.g. the Fox model) should be considered.

It was considered encouraging that there are not yet clear signals of declines in the size-based indices, but these indices should be carefully monitored. It was noted that since females mature at a relatively large size, a reduction in the biomass of large animals could potentially have a strong effect on the spawning biomass.

Concerns were also expressed with regard to the apparently localised behaviour of swordfish. There is some indication of localised depletion in response to high catches in some areas. There is a need to have a better understanding of the spatial characteristics and viscosity of swordfish including around islands such as Reunion and Seychelles.

Stock status and Management recommendations

Given the two year period since the last WPB meeting and concerns in 2001 over the status of swordfish, the 2003 meeting concentrated its efforts on swordfish assessment.

Catch, effort and size data for the Taiwanese deep-freezing longline fleet were made available for use at the meeting, and a Taiwanese scientist provided valuable scientific support to the WPB. These efforts are acknowledged and appreciated. Adding the Taiwanese data to those available through the IOTC Secretariat, enabled examination of a range of stock indicators for the swordfish, and analyses using production models.

The WPB was able to improve significantly on the procedures and analyses conducted at the 2001 WPB. The standardized CPUE of swordfish for both the Japanese and Taiwanese fleets show continuous declines since the early 1990's, particularly in the Western Indian Ocean. There is also significant evidence for localised depletion of swordfish stocks around La Réunion. These decreases in CPUE follow substantial increases in catches throughout the 1990's, particularly in the Western Indian Ocean. These declines in CPUE have continued over the last few years despite recent decreases in catches. The majority of production modelling runs indicates that the current stock is near or below Bmsy.

On the basis of the production models and the stock indicators, the WPB concluded that the current level of catch (about 30,000 tonnes) are unlikely to be sustainable. Of particular concern are the trends in abundance of swordfish in the SW Indian Ocean, where the highest catches are currently taken.

The WP considered that any further increase in effort in the Western Indian Ocean (particularly the SW) would increase the risk of overfishing the swordfish stock. Thus, the Working Party considered that any increase in the catch of, or fishing effort on, swordfish should not be allowed.

The indicators suggest that a comprehensive assessment of swordfish stocks in the Indian Ocean should be conducted as soon as possible.

6. RECOMMENDATIONS

Recommendations concerning data

The WP noted and made special acknowledgement of the contributions of Taiwan to the meeting. The advances in swordfish stock assessment made at the 2003 meeting were facilitated principally through access to the Taiwanese fine scale CPUE and size data.

1) Taiwanese data: The data deposited at the Secretariat for the Taiwanese fleet does not include information on catch and effort between longitudes 20° and 30°E. Given the importance of this area (southwest Indian Ocean), which has been the most heavily exploited for swordfish, it will be important to request submission of the missing data.

2) Marlins and sailfishes: there is a critical lack of statistical data for this group of fishes. It is absolutely necessary to better estimate catches and discards by species and by gear, by size and sex.

3) Purse seine landings: It is strongly recommended that past and future catches of marlins taken as by-catches by purse seiners be estimated. The yearly landing of marlins by tropical purse seiners should be estimated, based on a analysis of the observer data, and landing data of this fleet should be well followed in the future (preferably by species and by size). It is also recommended to develop permanent observer programmes on these fleets, at least at a small scale, in order to better estimate by-catches of billfishes.

4) Sex ratio by size: It is necessary to sample the size of swordfish and marlins as a function of their sex simultaneously.

5) IOTC-OFCF project: The WPB emphasizes its support to the Japanese IOTC-OFCF project and recommends that priority be given to countries with substantial catches of swordfish and billfishes which are not properly monitored or are reported as aggregates (e.g.: Sri Lanka gillnet fisheries).

6) Written **statistical reports** should be obtained from scientists from each fishing country on all fisheries, even when this country cannot participate in Working Groups. The IOTC Secretariat should request these reports before WPB meetings.

7) Billfishes length measurements: Length data should be reported to the IOTC in a standard format to facilitate comparison of data from different countries. When these lengths are collected in a non-standard way, they should be converted to the standard form of reporting using well-described methods. The basic data used to establish these conversions should be kept by IOTC. The WPB strongly recommends that size measurements should be always taken in straight length, never in round length (this is because the condition factors and shapes of fishes are highly variable at a given size between time and area strata).

Research recommendations

1. Swordfish stock structure and tagging of swordfish

The WPB considered tagging swordfish as being of key importance to determine realistic hypotheses concerning stock structure. Genetic results are clearly of great interest, but they cannot be used to make realistic hypotheses on movement rates between strata. It was recognized that tagging of swordfish is a difficult and expensive task. However, taking into account the absolute need to validate growth and to determine stock structure, the WPB strongly recommend conducting swordfish tagging in the IOTTP (as was planned in the original IOTTP).

Such tagging could be done in various ways such as:

1. Doing scientific tagging, primarily with electronic tags, using small rented longliners with short sets of few hooks; the good tagging results obtained by Carey are proof that swordfish tagging is feasible.

2. Encouraging longline fishermen to tag small swordfish. Such tagging is already conducted in Australia and could be done by observers. They would have limited goals but they could provide valuable information concerning swordfish movements.

2. Swordfish growth

Further research is recommended to improve knowledge concerning swordfish growth; it was recommended to try to validate the growth studies already done, and to conduct similar comparative studies in other areas.

3. Size data analyses

The following additional analyses of Taiwanese size data are recommended:

- Comparison of size frequency distributions for areas 3 and 7,
- Conversion of lengths to ages using different assumptions on sex ratios at size/age.
- Examination of trends in the 90% quantile for the whole Indian Ocean and specifically for areas 3 and 7.

Where size data are available for other fisheries the trends in size over time should be similarly examined.

4. Stock status indicators

Further research is recommended concerning the definition and calculation of stock indicators that would be useful to follow the status of stocks of billfish species. Special attention should be given to the choice of indicators which could well measure changes in abundance of older fishes (which are the first to disappear in case of overfishing) and changes in the geographical patterns of the fisheries. The various stock indicators recommended by the WPB in 2001 should be calculated in advance of the WPB meeting in cooperation between scientists from fishing countries and the IOTC Secretariat; and these indicators should be available at the beginning of the WPB meetings.

The WPB noted Document WPB-03-09 which outlines proposed work on this topic in a project which has recently started at CSIRO, Australia. Progress on and results from this project will be presented to the future meetings of the relevant IOTC Working Parties.

5. Analysis of apparent movement of swordfish based on fishery data

The analysis of size specific CPUE by sex and by time and area strata, together with biological data on feeding, sex ratio, reproductive condition etc offer potential to evaluate the apparent movement and stock structure of swordfish. These studies are highly recommended.

6. Stock assessment – CPUE Standardization

Following analyses at the 2003 WPB the following further efforts towards standardization of the CPUE series from Taiwanese fleet would be valuable:

- Attempts should be made to improve the definition of variables that could be used as a proxy for targeting.
- Consideration of alternative ways of combining area-specific indices into a global index using different weighting schemes.
- Consideration should be given to defining area strata that take into account environmental factors and fishery distribution and characteristics.

Given the importance of these recommended actions to the swordfish assessment, the WPB encourages that collaborative work that would address these issues be initiated.

Efforts should be made to provide additional CPUE series from other fisheries (e.g. La Réunion, Seychelles) for the next WPB.

7. Stock assessment – Modelling

Ideally, at the next WPB a suite of different types of stock assessment models (including stock production and simple size-based models) should be applied to the available data. The IOTC Secretariat and the WPB Chair will assist in the co-ordination of stock assessment efforts before the next WPB meeting.

8. Research on biology of Istiophorids

- Genetic studies of the main Istiophorid species should be undertaken, concentrating on obtaining robust sample sizes from widely separated locations in the Indian Ocean. If genetic studies cannot commence in the near future, samples should still be collected and archived.

- Hard parts from billfish (marlin, sailfish) should be collected and archived for future age estimation studies. The third (largest) anal spine is probably best for this purpose, but this needs to be verified for each species (with respect to the extent of the matrix in larger fish).

- Popup satellite tagging experiments should be conducted on blue ,black and striped marlins to provide information on many aspects of their biology, including long-term vertical behaviour, movement and mixing rates.

- Increased tagging of billfish in the Indian Ocean should be encouraged on an opportunistic basis. This may be achieved through a coordinated, Indian Ocean wide sport fishery tagging programme, if initiated, as recommended by a recent IOTC consultancy. The forthcoming IOTTP will ensure widespread publicity and offers of rewards for tag returns, enhancing such a sportfishing based tagging programme.

- Improved catch and effort statistics should be collected for artisanal fisheries of coastal countries with the help of IOTC and of the IOTC-OFCF project.This applies to all

Istiophorids, but especially sailfish in areas of high recent catches such as Sri Lanka, Iran and Indonesia.

Selected catch and effort statistics should be collected from key billfish sportfishing areas to provide CPUE indices.

- Selected indicators of stock status should be better identified, selected and prepared before the next WPB meeting and be made available to the WPB allowing to evaluate stocks trends, independently of stock assessments analysis.

7. ANY OTHER BUSINESS

Election of a new Chairperson for the period 2003-2005

The Working Party on Billfish unanimously agreed to re-elect John Gunn to chair the WPB for the next biennium.

6. ADOPTION OF THE REPORT AND ARRANGEMENT FOR NEXT MEETING

The report of the WPB was adopted on November 12th, 2003. It was agreed that a meeting of the Working Party on Billfish should be held in 2004. Conditional on the approval of the Commission, the details of dates and place and venue are to be arranged by the Secretariat.

APPENDIX I: LIST OF PARTICIPANTS

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APPENDIX I. AGENDA OF THE MEETING

1. Opening of the Meeting

2. Review the statistical data for billfish species and the situation in reporting countries on data acquisition, for reporting to the WPDCS.

3. Review new information on the biology and stock structure of billfish, their fisheries and related environmental data.

4. Review of new information on the status of billfish.

4.1. Stock status indicators

4.2. Stock assessment

4.3. Likely future trends under alternative exploitation scenarios

5. Develop technical advice on management options, their implications and related matters with priority given to the situation of swordfish.

6. Identify research priorities, and specify data and information requirements, necessary for the Working Party to fulfill its responsibilities.

7. Any other business

8. Adoption of the Report

APPENDIX III: LIST OF DOCUMENTS

WPB-03-01	Report on the Status of the Billfish statistics gathered at IOTC. *IOTC Secretariat*
WPB-03-02	Update of standardization of swordfish CPUE of Japanese longliners in the Indian Ocean. *H.Saito* and *Yokawa,K.*
WPB-03-03	A description of the activity of the Spanish surface longline fleet targeting swordfish (X*iphias gladius*) in the indian ocean with special reference to the year 2001. *B. García-Cortés, J. Mejuto, A. Ramos-Cartelle*
WPB-03-04	Sex Ratio Patterns And Gonadal Indices Of The Swordfish (*Xiphias gladius*) Caught by the Spanish Surface Longline fleet in the Indian Ocean. *Blanca García-Cortés and Jaime Mejuto*
WPB-03-05	Evolution of swordfish Longline Fishery (*Xiphias gladius*) Operating in the West Indian Ocean From Seychelles*. Bertrand Wendling and Vincent Lucas*
WPB-03-06	Characteristics of swordfish (*Xiphias Gladius)* catches achieved by experimental fishing using instrumented longline in the Seychelles Exclusive Economic Zone. Preliminary Results Of An Experimental Long Line Fishing Program: « Programme d'Action De La Pêche Palangrière Seychelloise – PAPPS ». *Bertrand Wendling, Vincent Lucas, Rose Marie Bargain, François Poisson, Marc Taquet*
WPB-03-07	Longline fishery evolution in La Réunion. Focus on the exploitation level of swordfish (*Xiphias gladius*) *D. Miossec and J. Bourjea*.
WPB-03-08	Information on the Indian Ocean swordfish stock from Taiwanese tuna catch statistics and estimation of its abundance index. *S.K. Chang*
WPB-03-09	Proposed work on stock status Indicators for billfish and tropical tunas .*M.Basson and N. Dowling*
WPB-03-10	Technical note: validation test of anal spine method for ageing swordfish *D. Miossec*

APPENDIX IV: FIGURES REFERENCED IN THE TEXT OF THE REPORT

Figure 1: Catches of Swordfish per gear and year recorded in the IOTC Database (1962-2002).

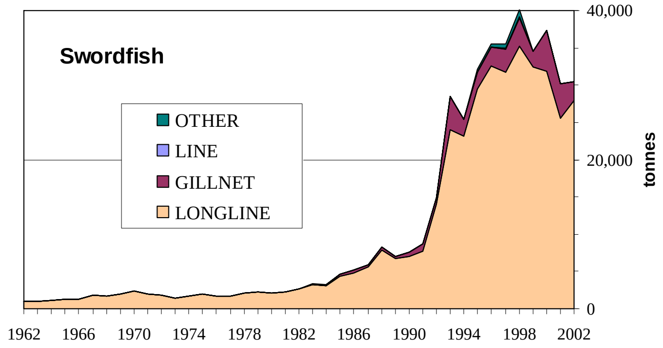
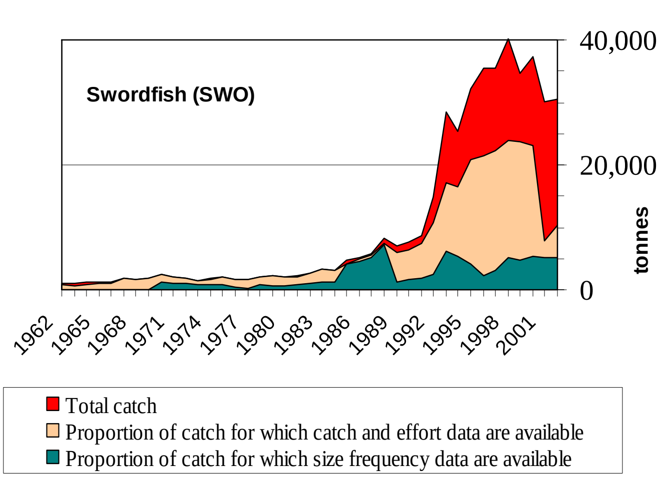
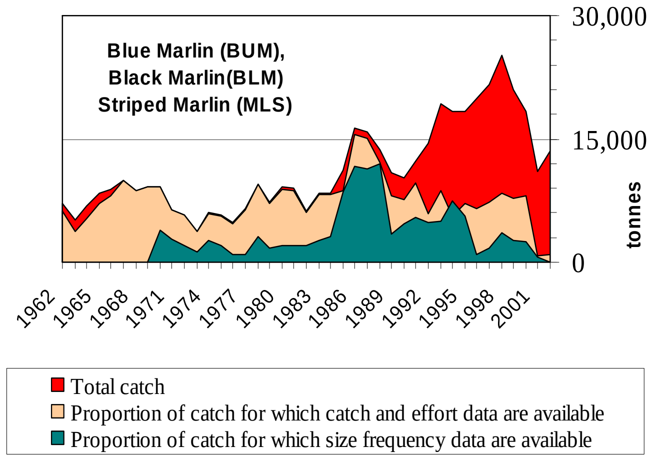


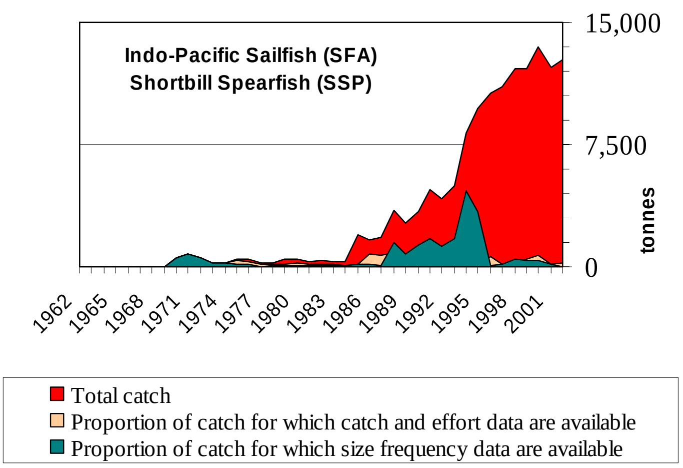
Figure 2 : Proportion of the total catch (NC) of swordfish (a), blue, black and striped marlin (b),and sailfish and shortbill spearfish (c) for which catch and effort data (CE) or size frequency data (SF) are available.



(a)



(b)



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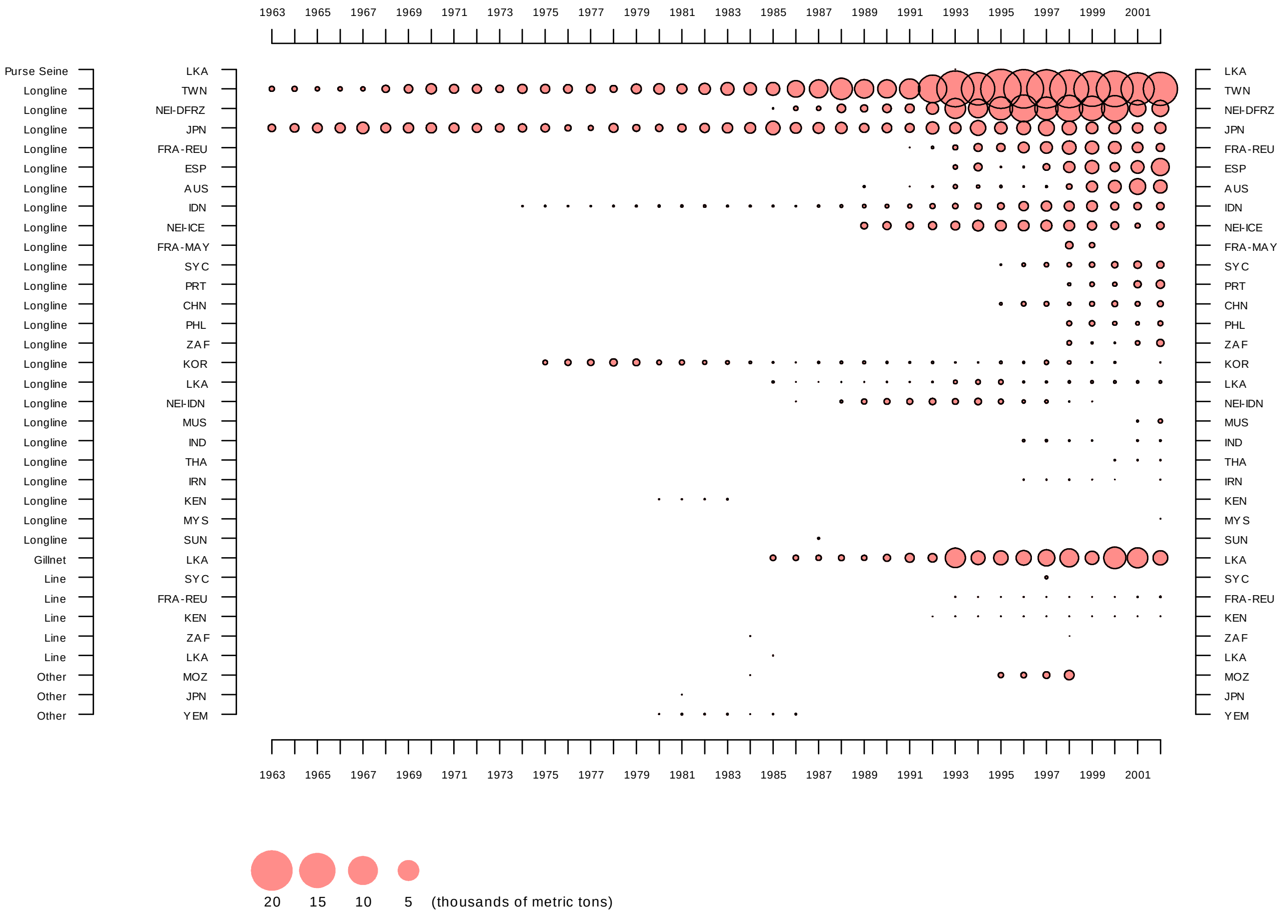

Figure 3 :Catches of swordfish in the Indian Ocean for the period 1963-2002, in thousands of metric tons by gear and country/fleet

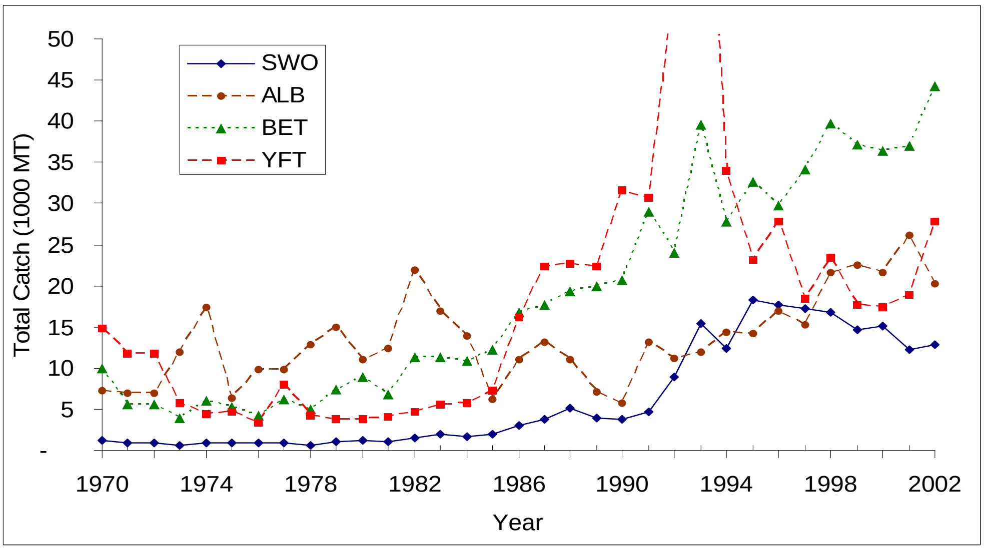

Figure 4 : Annual catches of the major tunas (ALB, BET, YFT) and swordfish (SWO) of the Indian Ocean by Taiwanese longline fishery, 1970-2002. YFT catch of 1993 is omitted.

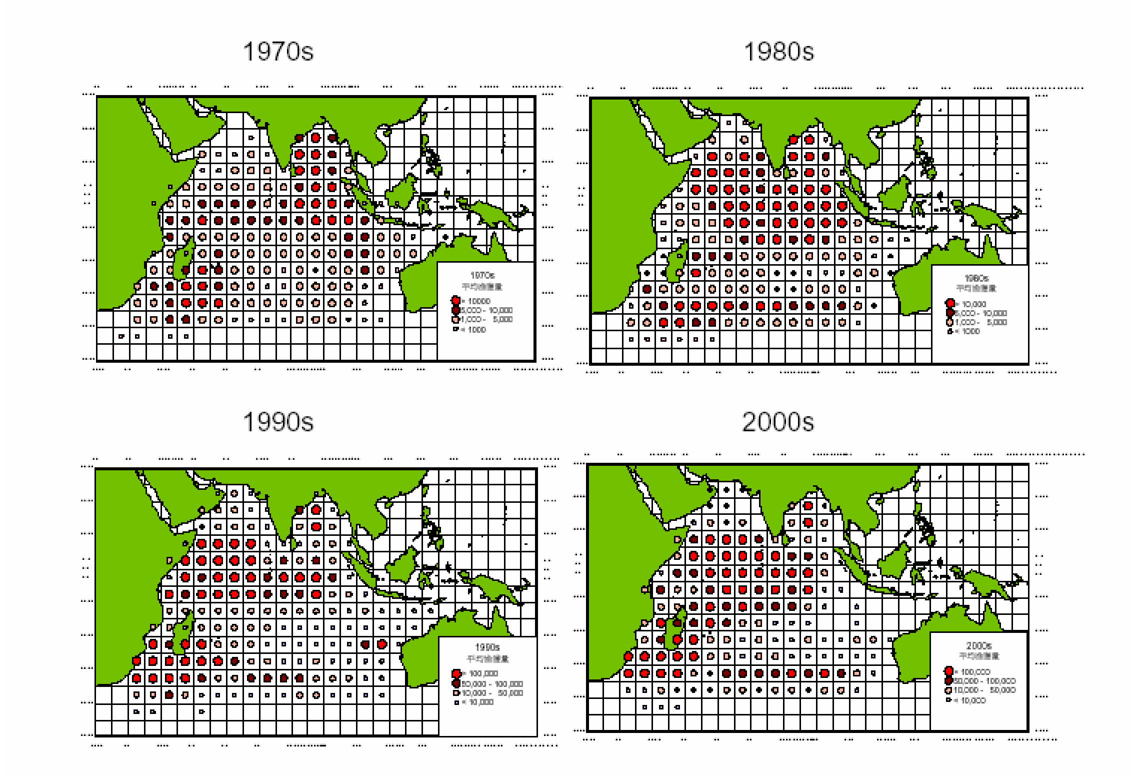

Figure 5 : Annual average swordfish catch distribution by decades during 1970-2002, by Taiwanese Longline fishery. Note the scales of 1990s and 2000s are ten-times of those of 1970s and 1980s.

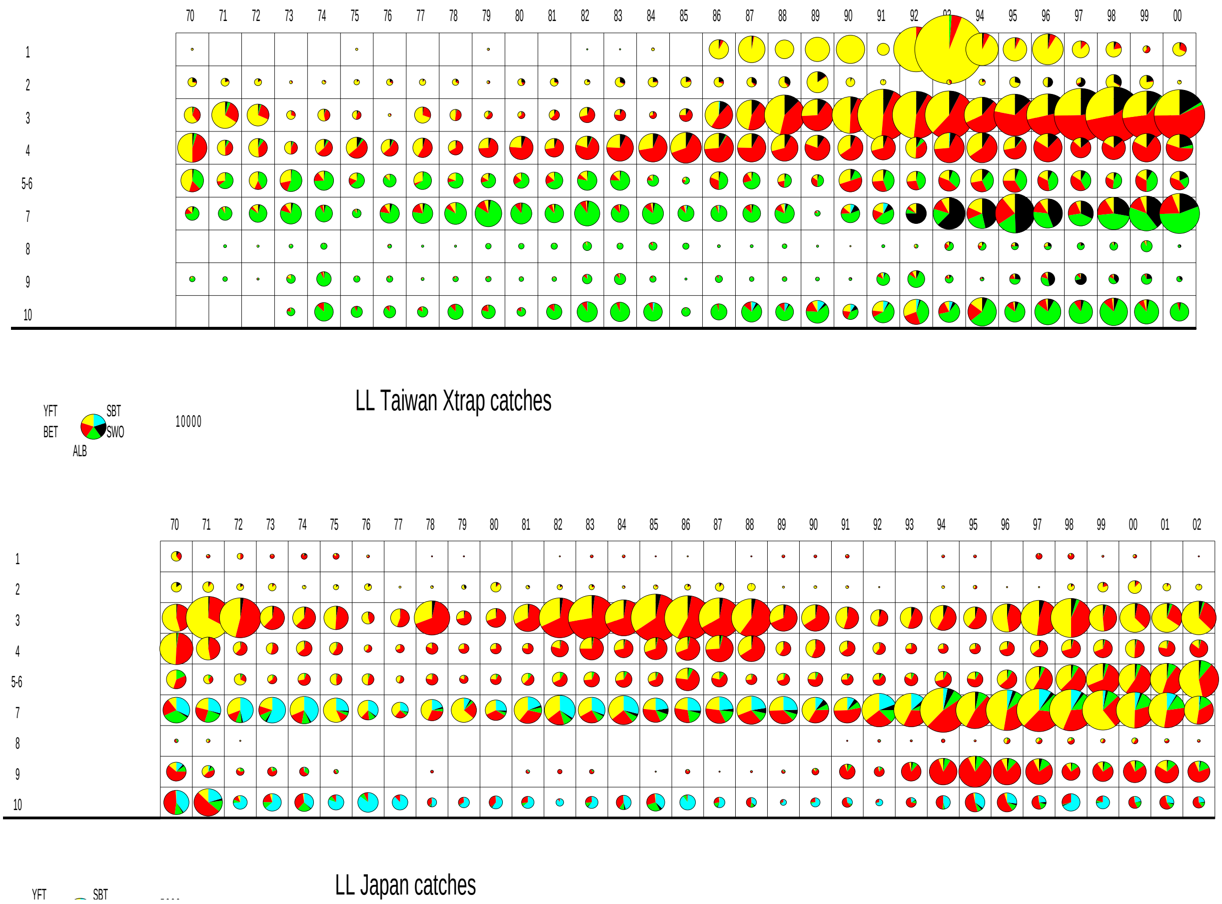

Figure 6 : Time and space diagram of total yearly catches (SWO, BET, SBT, ALB, YFT) of Taiwanese and Japanese longliners by area

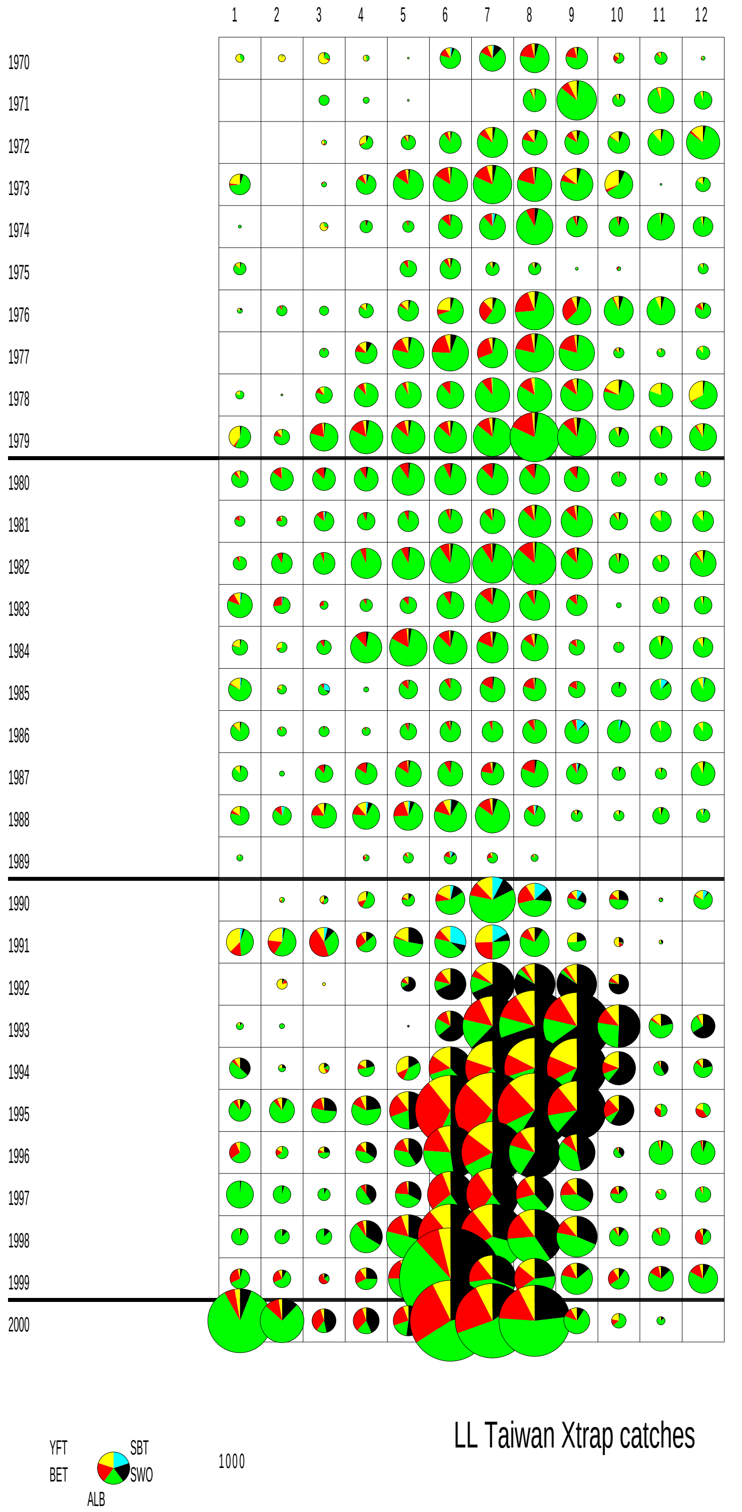

Figure 7 : Time and space diagram of swordfish total yearly catches (swo, be, sbt, alb,yft) of Taiwanese longliners in area 7. Catches are extrapolated to total catches.

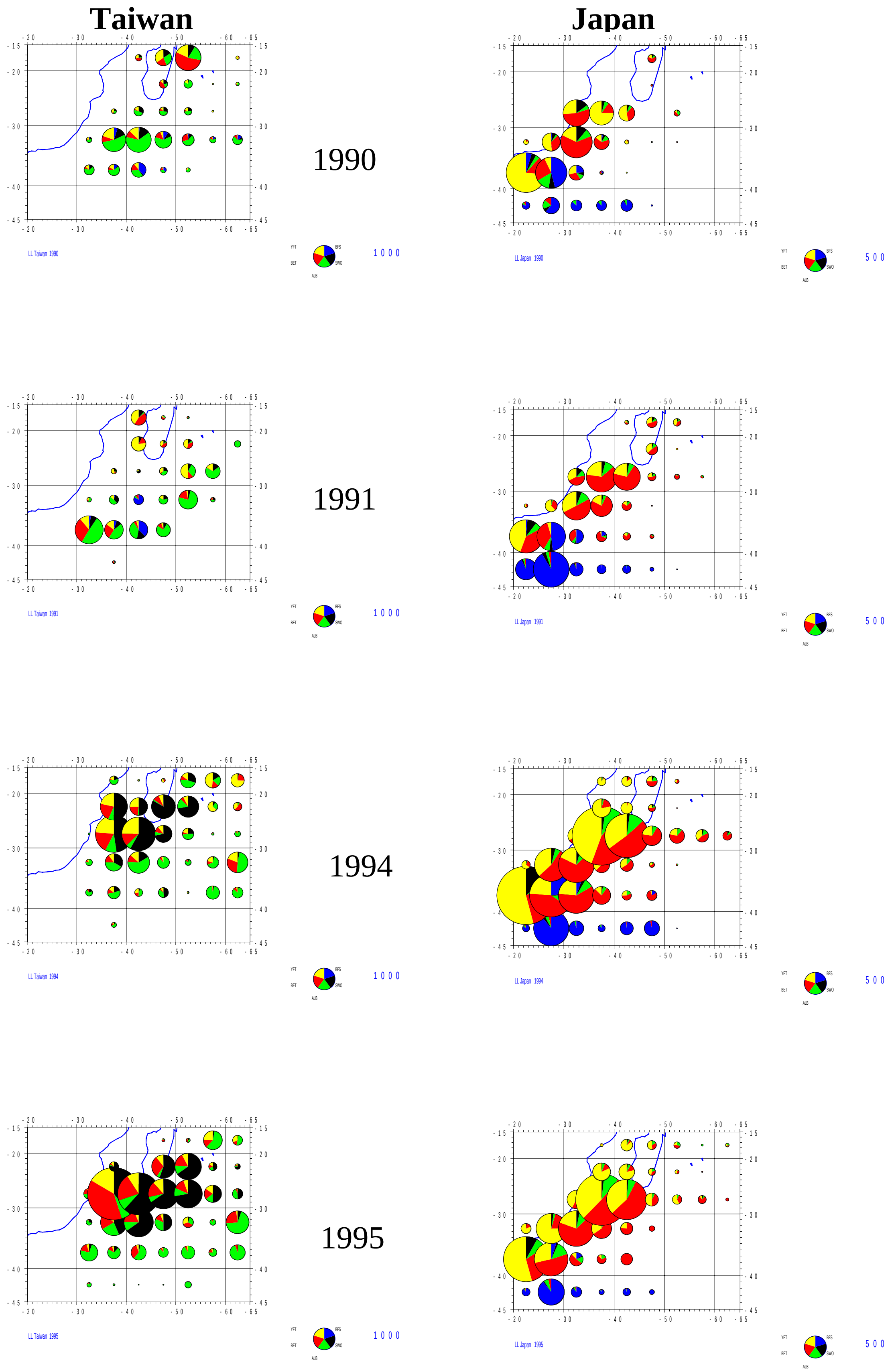

Figure 8 : Evolution of the species composition in the catches of the Taiwanese and Japanese LL fleets from 1990 to 1995 in area 7 (see Figure 13 for a description of the areas).

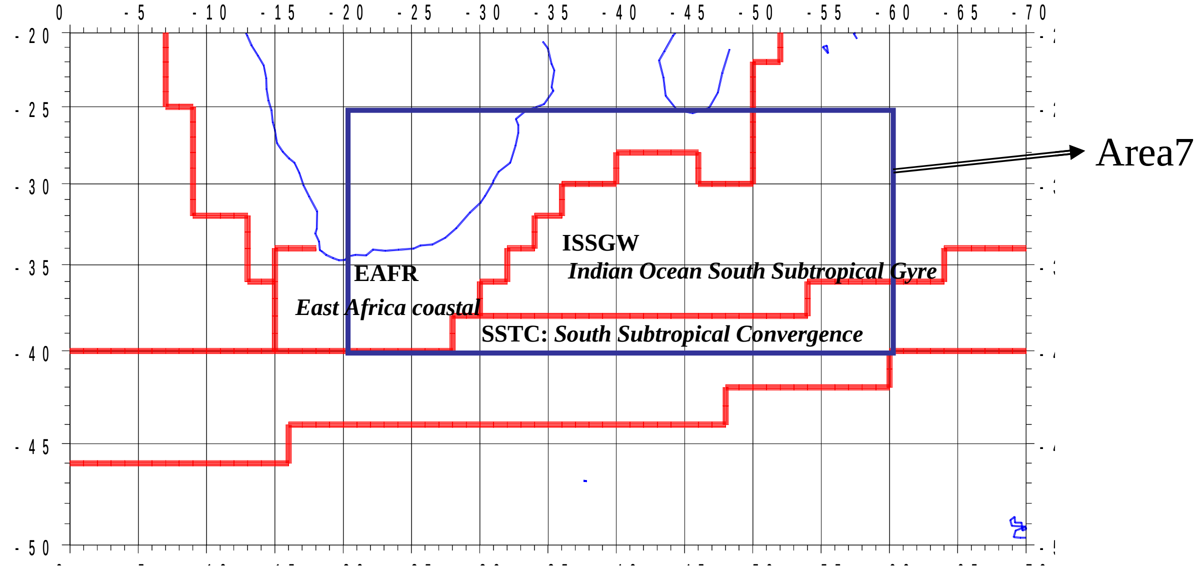

Figure 9: Location of area 7 regarding ecological areas defined by Longhurst (1998); EAFR: East Africa coastal, ISSGW: Indian Ocean South Subtropical Gyre, SSTC:South Subtropical Convergence.

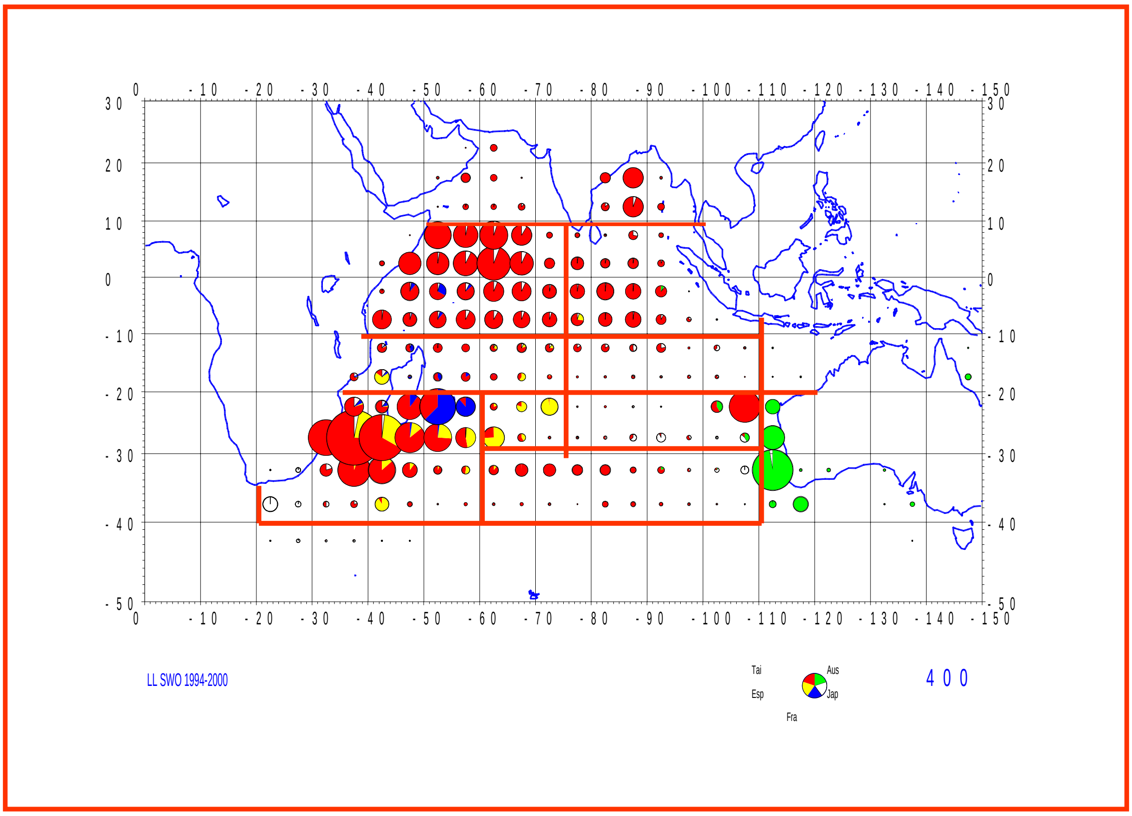

Figure 10: Swordfish catch done by fleet between 1994and 2000

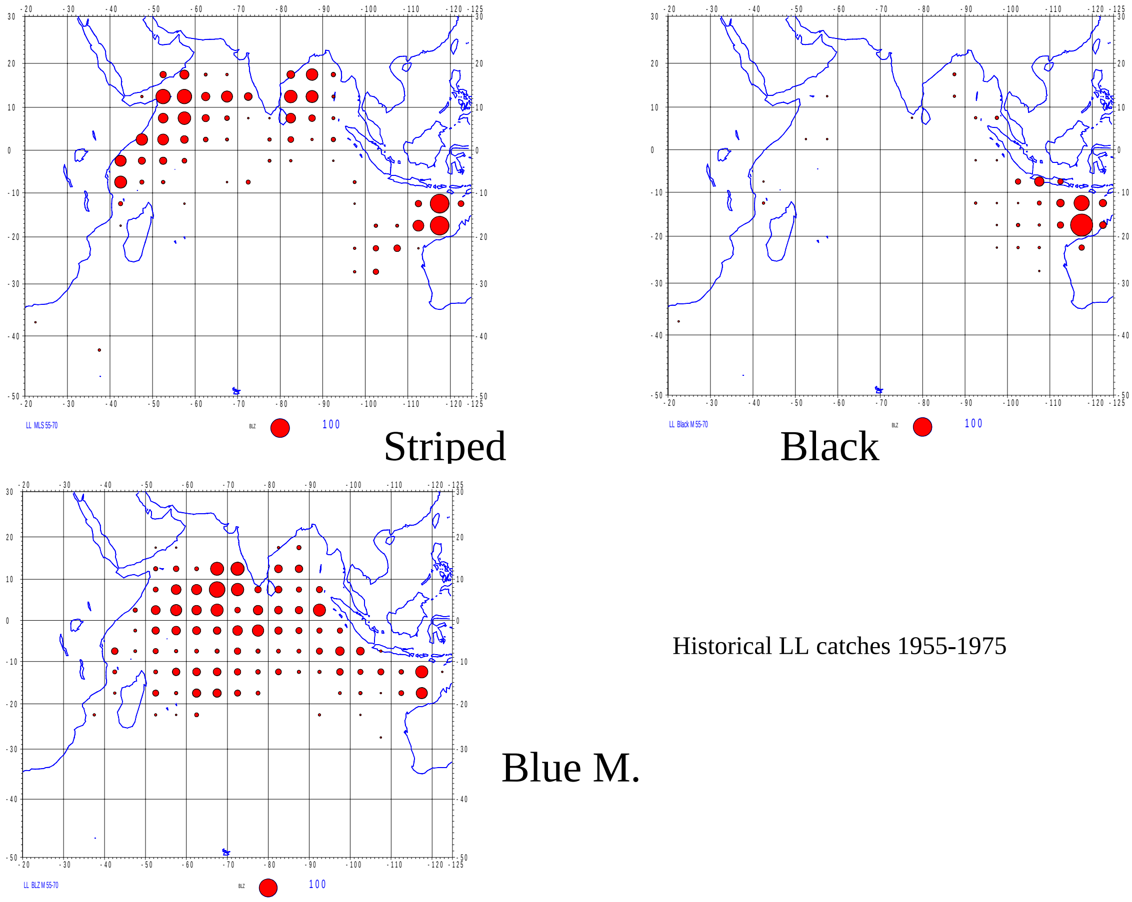

Figure 11 : Historical LL catches between 1955 and 1975 for striped, black and blue marlin.

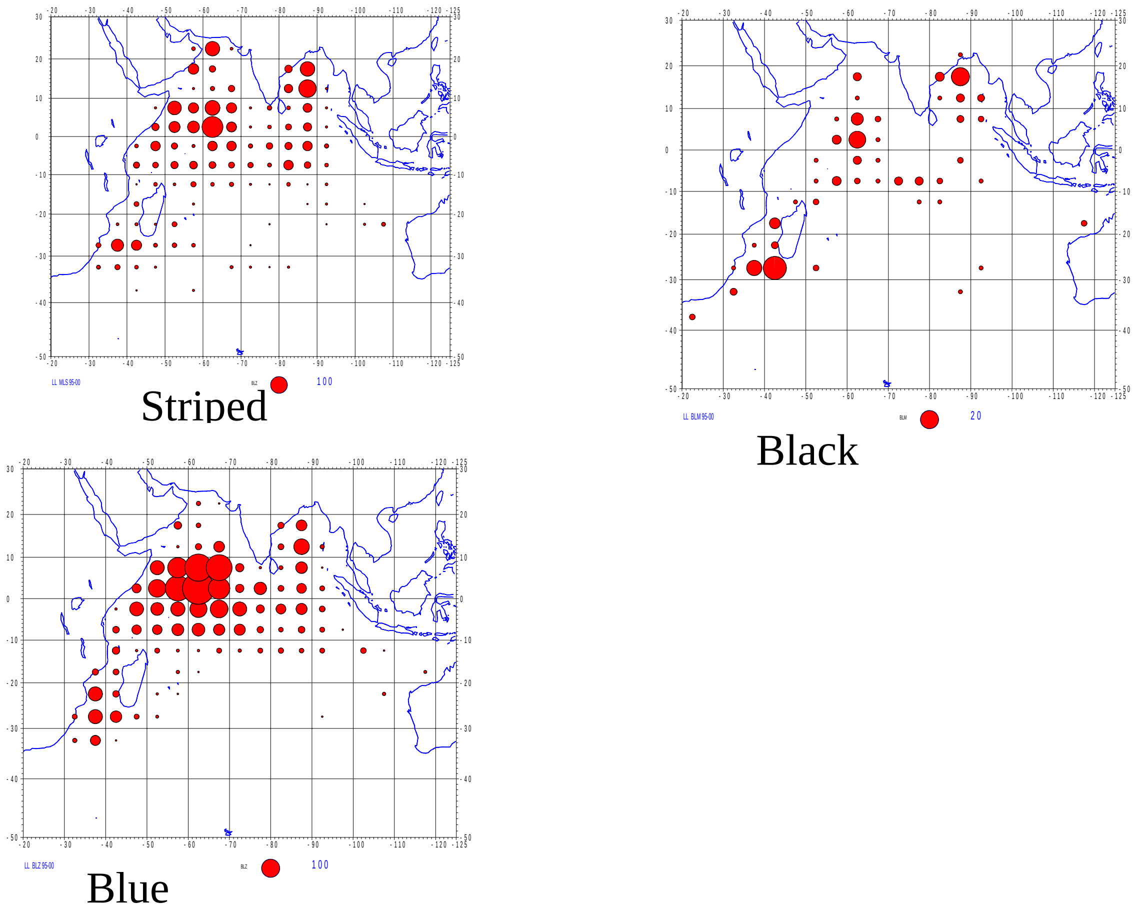

Figure 12 : Historical LL catches between 1995 and 2000 for striped, black and blue marlin

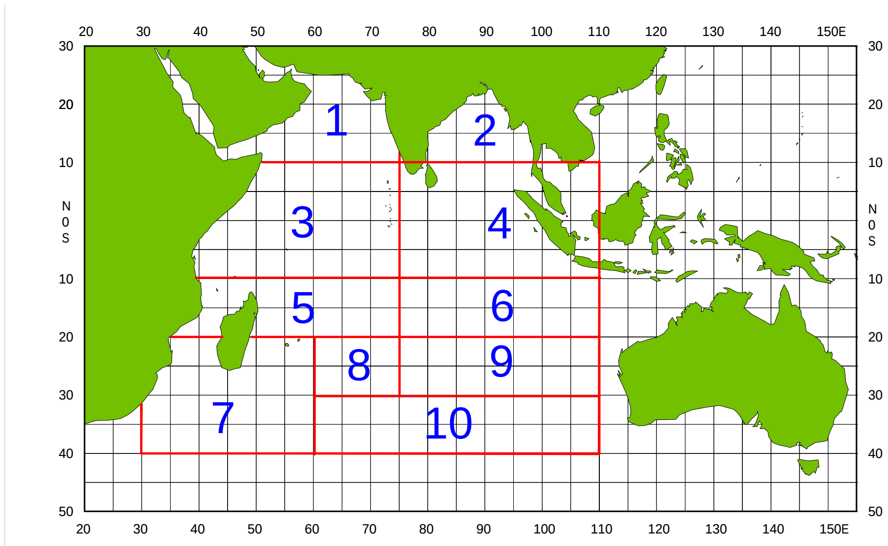

Figure 13: Areas used in the CPUE standardization for the Japanese and Taiwanese fleets.

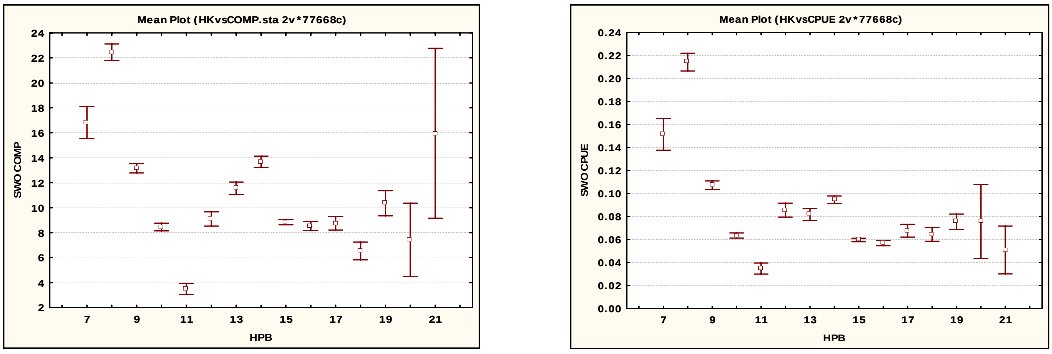

Figure 14: Swordfish percentage composition (left panel) and swordfish CPUE (right panel) as a function of number of hooks per basket.

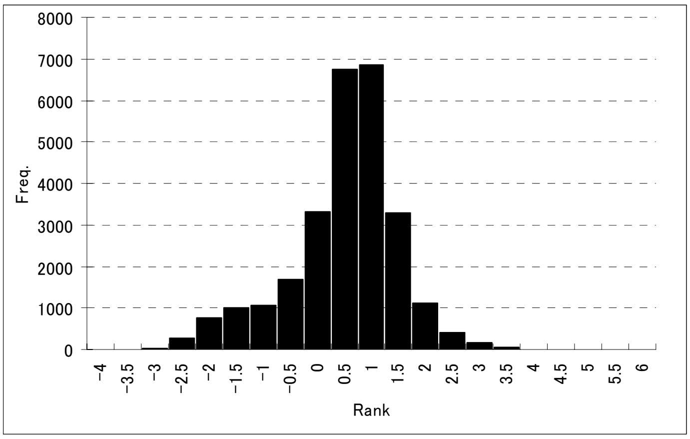

Figure 15: Pattern of residuals for the GLM standardisation of the Japanese CPUE conducted during the meeting.

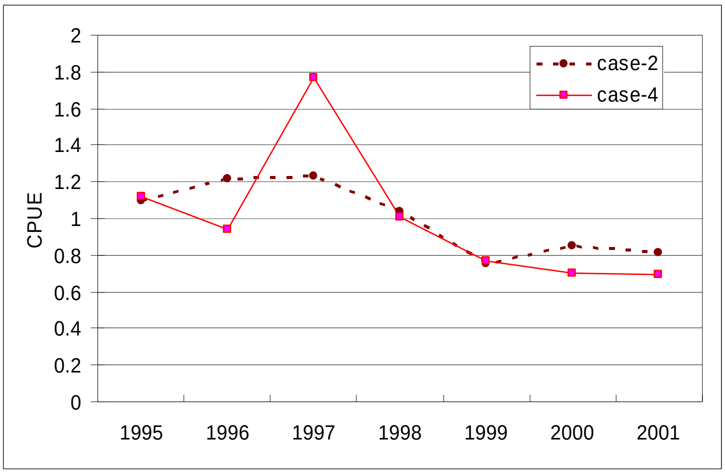

Figure 16: Comparison of the CPUE for the Taiwanese fleet, standardized by the number of hooks per basket (case 4) and categories based on the proportion of swordfish in the catch (case 2).

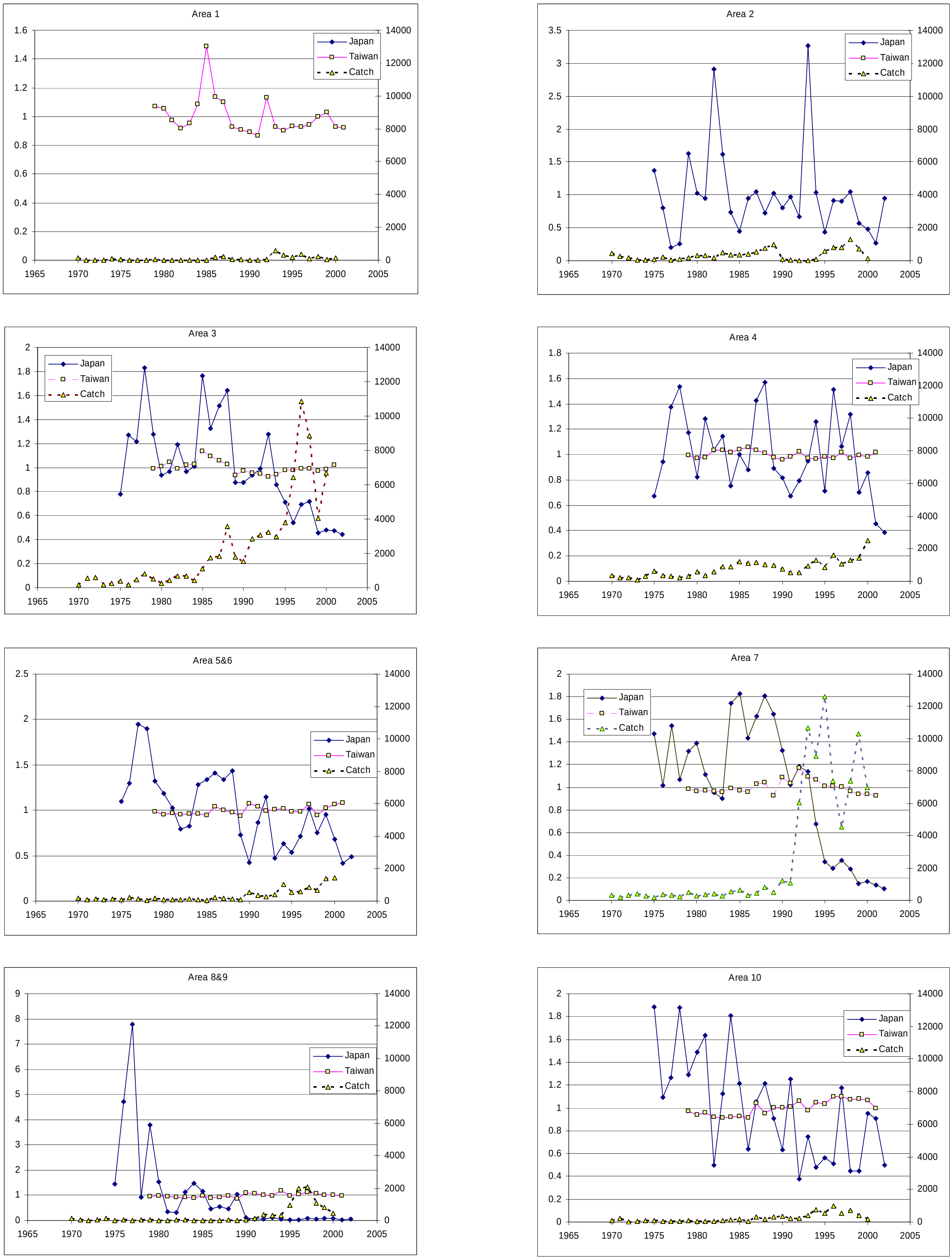

Figure 17. Standardized CPUE indices as calculated during the meeting for the Japanese and the Taiwanese longline fleet (rescaled to their averages), and total catch by area in metric tons.

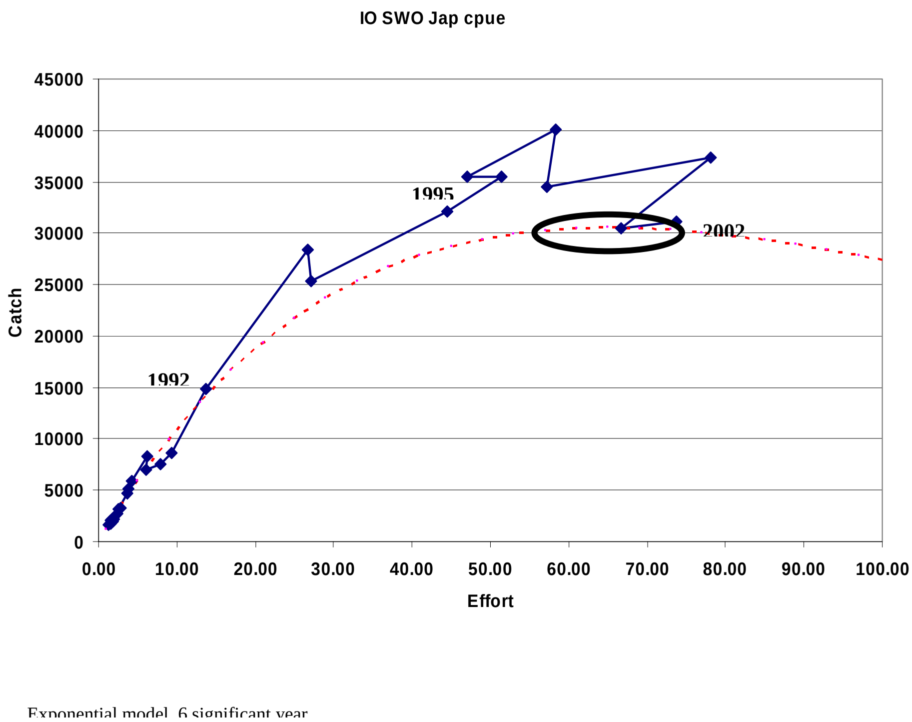

Figure 18: Possible interpretation of the evolution of catches and effort in relation to an equilibrium production model. Effort represents effective effort as estimated from the standardized Japanese CPUE and total catches.

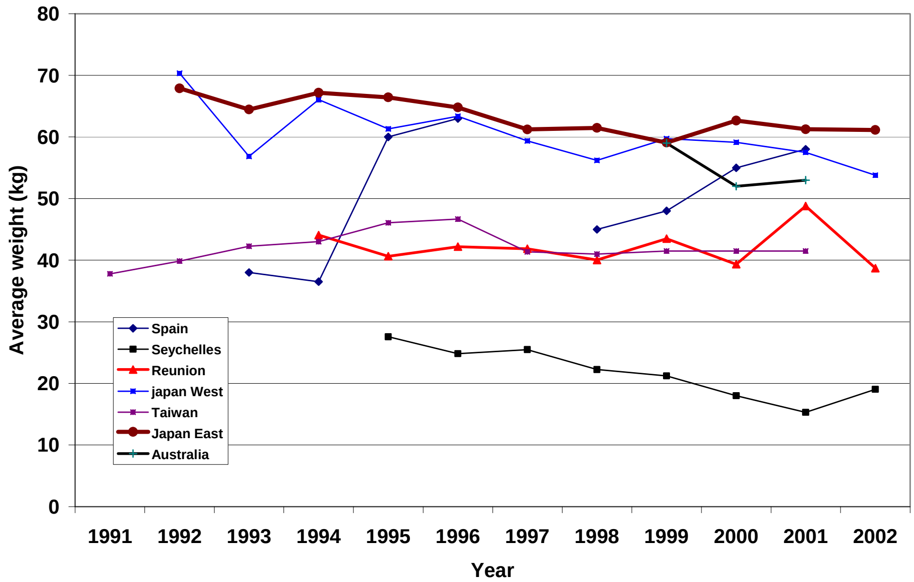

Figure 19: Average size of swordfish in the catch for the main longline fleets(data for Australia are trunk, not whole, weights).

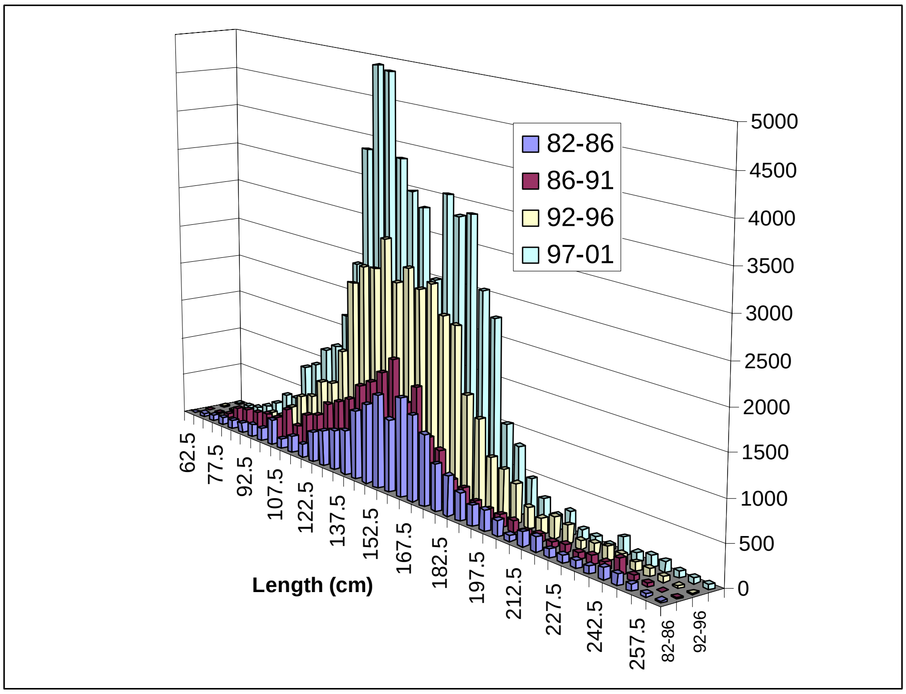

Figure 20. Size distribution of swordfish caught by the Taiwanese Indian Ocean longline fishery.

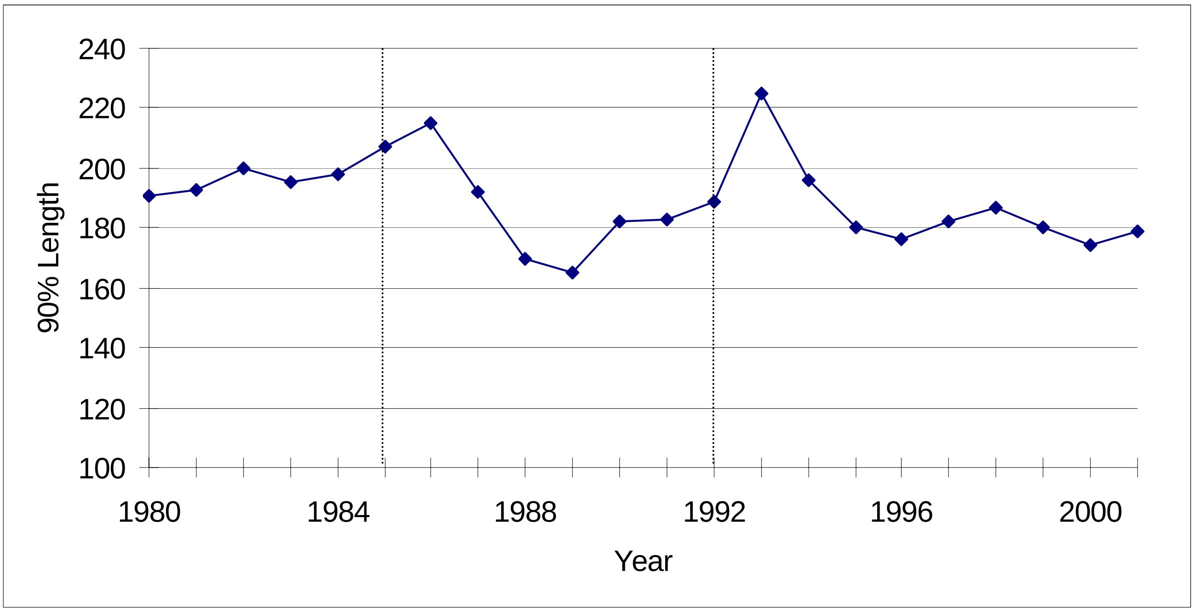

Figure 21. Temporal trend in 90th percentile length of swordfish in the Taiwanese Indian Ocean longline fishery.