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

Report of the First Session of the IOTC Working Party on Billfish

Victoria, Seychelles October 2-3, 2000

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EXECUTIVE SUMMARY

The First Meeting of the Working Party on Billfish took place in Victoria, Seychelles on October 2-3, 2000, involving 18 participants from 11 countries or organisations. John Gunn from CSIRO, Australia was elected as the Chairman of the Working Party for the next biennium.

The Working Party concentrated on reviewing the data situation for the species involved noting that while data concerning the major longline fleets are reliable, there are significant gaps in the information available from coastal (artisanal) fisheries and for unreporting fleets flying flags of convenience. In particular, the statistics for istiophorids suffer from problems of species misidentification, high levels of discard for sailfish and shortbill spearfish and the poorly reported catches from artisanal and sport fisheries.

The total catch of billfish hase increased considerably in the past 15 years, largely due to increases in the take of swordfish and Indo-Pacific sailfish. The available data suggest that the catches of marlin species have remained reasonably stable over this period.

Swordfish has become an important species primarily in the western Indian Ocean where it has been targeted by some longline fleets. A preliminary assessment on the basis of data from Japanese and Taiwanese longline fleets yielded inconclusive results regarding the current status of the stock of swordfish. However, the Working Party noted that an increase in the catches and effort such as the one seen in recent years is unlikely to be sustainable. Therefore, it recommended that the situation of the resource be monitored closely in the future.

No new assessments were presented regarding istiophorid species. Therefore, the Working Party reviewed the latest indices of abundance published in the literature. These analyses indicate negative trends in indices of abundance for black marlin and sailfish for recent years and less clear trends for blue and striped marlins. The Working Party noted that these analyses should be considered preliminary and that more effort needs to be placed in the standardisation of catch-and-effort data.

1. Report of the First Meeting of the IOTC Working Party on Billfish, 2-3 October 2000, Mahe, Seychelles

The First Meeting of the Working Party on Billfish took place on October 2nd and 3rd, 2000 and was attended by eighteen participants from twelve organizations. John Gunn[1] was elected as the Chairperson for the next biennium. The Working Party approved the agenda as listed in Appendix II and agreed to review the documents listed in Appendix III.

2. Review of Data Related issues

Nominal Catch (NC) Data

The first catches of billfish recorded in the IOTC nominal catches (NC) database were made in 1970, by longline gear. Although catches of these species did occur before that year, they were not reported as billfish. Rather, they were aggregated with other species or species groups, usually under the NEI (not elsewhere included) category. Catch and effort data, however, have been reported since 1952 when the Japanese longline fleet started operating in the Indian Ocean. Other key issues regarding billfish data gathered at the IOTC Secretariat, which are important to bear in mind are:

- **Mislabelling**: Billfish are almost always a bycatch and are usually aggregated with other species as Marlins NEI, Billfish NEI or Other tuna and tuna-like species NEI. In the last case, catches are not even listed as billfish.
- **Underreporting:** Billfish, especially the smaller sizes, are sometimes discarded. Logbooks statistics seldom or never include discards.
- **Non-reporting:** Catches of sport fishing boats that usually target billfish are almost never reported.

Therefore, although most of the data stored in the IOTC databases are considered accurate and reliable, the databases are far from complete (Figure 1). Longline and gillnet fisheries are responsible for most of the catches of these species, while low catches have also been reported by handline, troll line and, to a lesser extent, hook-and-line fisheries.

Review of Longline Data

The total billfish catch amounted to some 85,000 tonnes in 1998, a fourfold increase in less than 15 years. While catches of swordfish and Indo-Pacific sailfish have been increasing, especially since the early nineties, this has not been the case with the marlins which do not show a clear trend. (Figure 2)

Japanese and Korean longliners have been catching billfish as a bycatch since they started operating in the Indian Ocean. This was also the case with Taiwanese boats until the early nineties, when some boats started to target swordfish. Also involved in the swordfish fishery are the French (based in Réunion), Spanish and Seychelles fleets, which started operating in 1991, 1993 and 1995, respectively. Ten South African longliners targeting swordfish have also operated from Port Elizabeth since 1998. The catches of these vessels have not been reported.

Other longline fleets for which important swordfish catches are assumed, especially over the last 15 years, are those whose catches have been estimated by the Secretariat. These fleets include two types of vessels:

- **Small longliners (<100 GRT) targeting fresh tunas for the sashimi market:** Although yellowfin and bigeye tunas are the target species, important catches of swordfish and marlins also occur. This fleet, mainly composed of boats from Taiwan, China , started operating in the Indian Ocean in the early eighties and has grown significantly since 1985, when fresh tuna became the main product for the sashimi market. The catches from 1985 to 1999 were first estimated this year by the Secretariat. It is important to mention that an increasing number of Taiwanese boats have been changing flag and are currently flying the flag of the country where they are based. Thus, all longliners operating from Indonesian ports are flying the flag of this country since 1995. Although the landings of these vessels are

[1] CSIRO, Australia

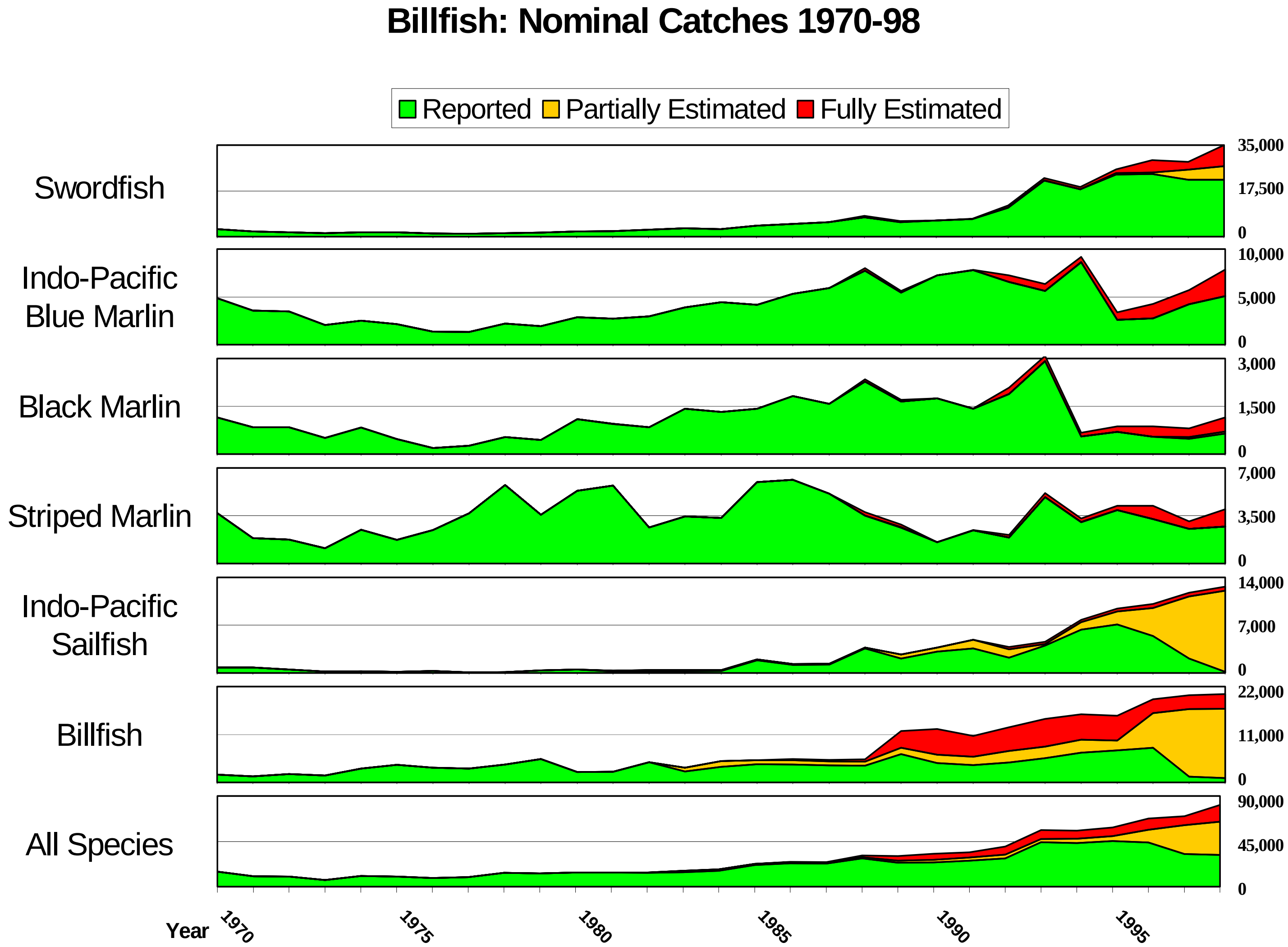

Figure 1. Catches of billfish in the period 1970-1998 (in t).

well monitored in Indonesia, the catches have not been reported to IOTC since 1995. This situation needs to be improved in the future as about 1,000 longliners are estimated to operate from Indonesian ports.

- **Large deep-freezing longliners (>100 GRT) flying flags of non-reporting countries**: the number of longliners operating in the Indian Ocean flying flags of non-reporting countries has been increasing constantly since the mid-eighties. As most of the boats were assumed to be owned from Taiwan, China and operating in the same manner as the Taiwanese fleet, the estimated catches include important catches of billfish. Nevertheless, more information is needed regarding this fleet to make a better estimate of its catches, especially for the years before 1998.

Marlins are caught primarily by longlines. The Indo-Pacific blue marlin is the species more often caught, followed by striped and black marlins. While the longlines catches of the three main longline fleets (Japan, Indonesia and Taiwan,China) have been more or less stable this is not the case with gillnets which reported important catches of, especially blue and black marlins, from 1987 to 1994. The decrease in the catches after that year is not a real decrease but comes from Sri Lanka aggregating the catches of these species as billfish.

Almost no catches of short-billed spearfish have been reported to IOTC (only for the last three years). This species is caught by longlines and gillnets, but is either discarded or recorded as Indo-Pacific sailfish due to its low value. Both species are only marketed locally.

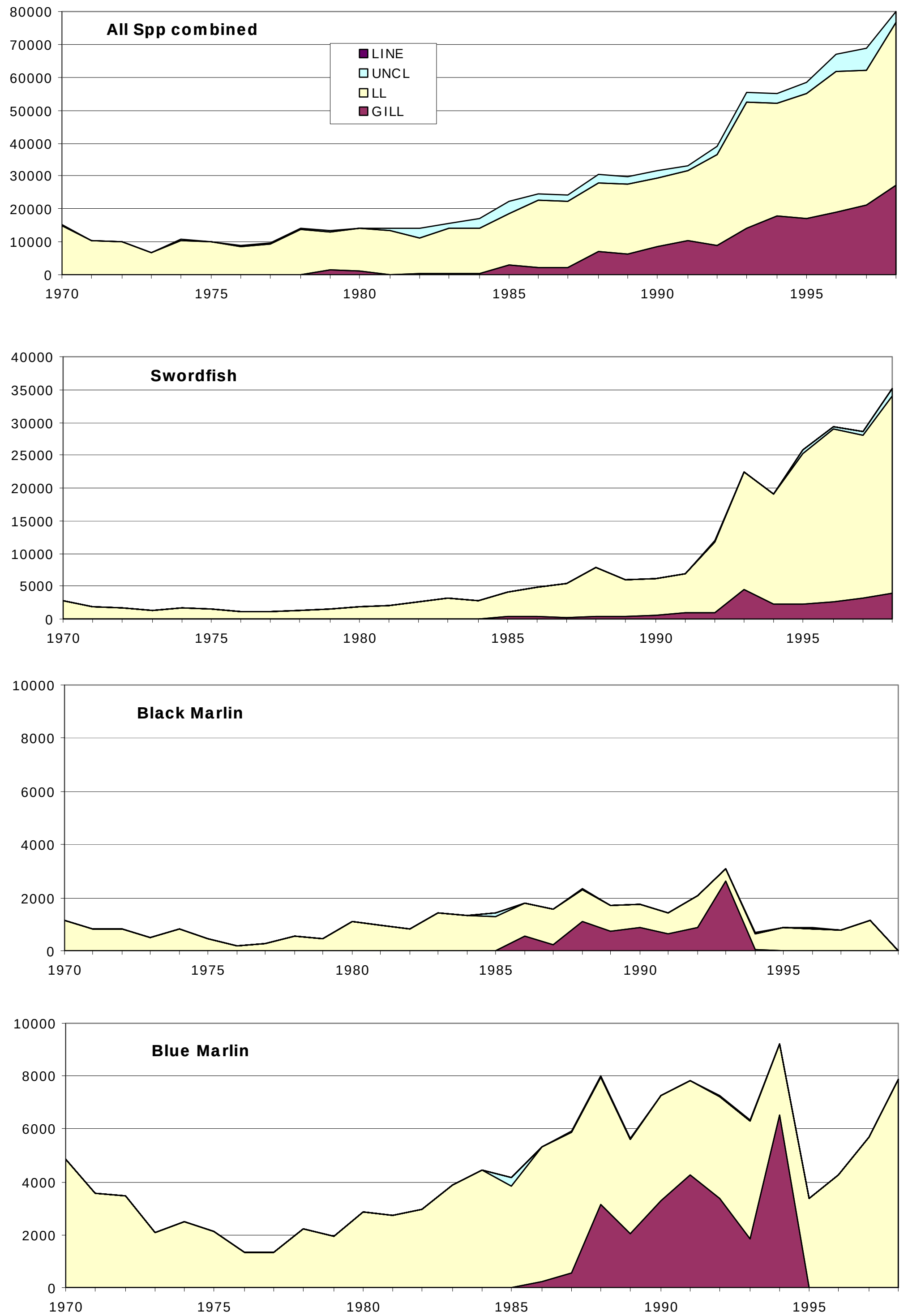

Figure 2. Catches (in t) of billfish species in the Indian Ocean by gear during the period 1970-1998.

Review of Gillnet Data

Although there does not seem to be any artisanal fishery specifically targeting billfish, billfish catches with gillnets have been increasing constantly. The gillnet fishery of Sri Lanka, after years of continuous development, is currently taking most of the reported billfish catches (Figure 2).

Catches of Indo-Pacific sailfish have been increasing constantly, especially since the early nineties (a fivefold increase in the last ten years), most of which is attributable to the gillnet fishery in Sri Lanka and to a lesser extent to Iran, Oman and Pakistan gillnet fisheries. Catches of longlines and artisanal gears, however, remained stable over the time.

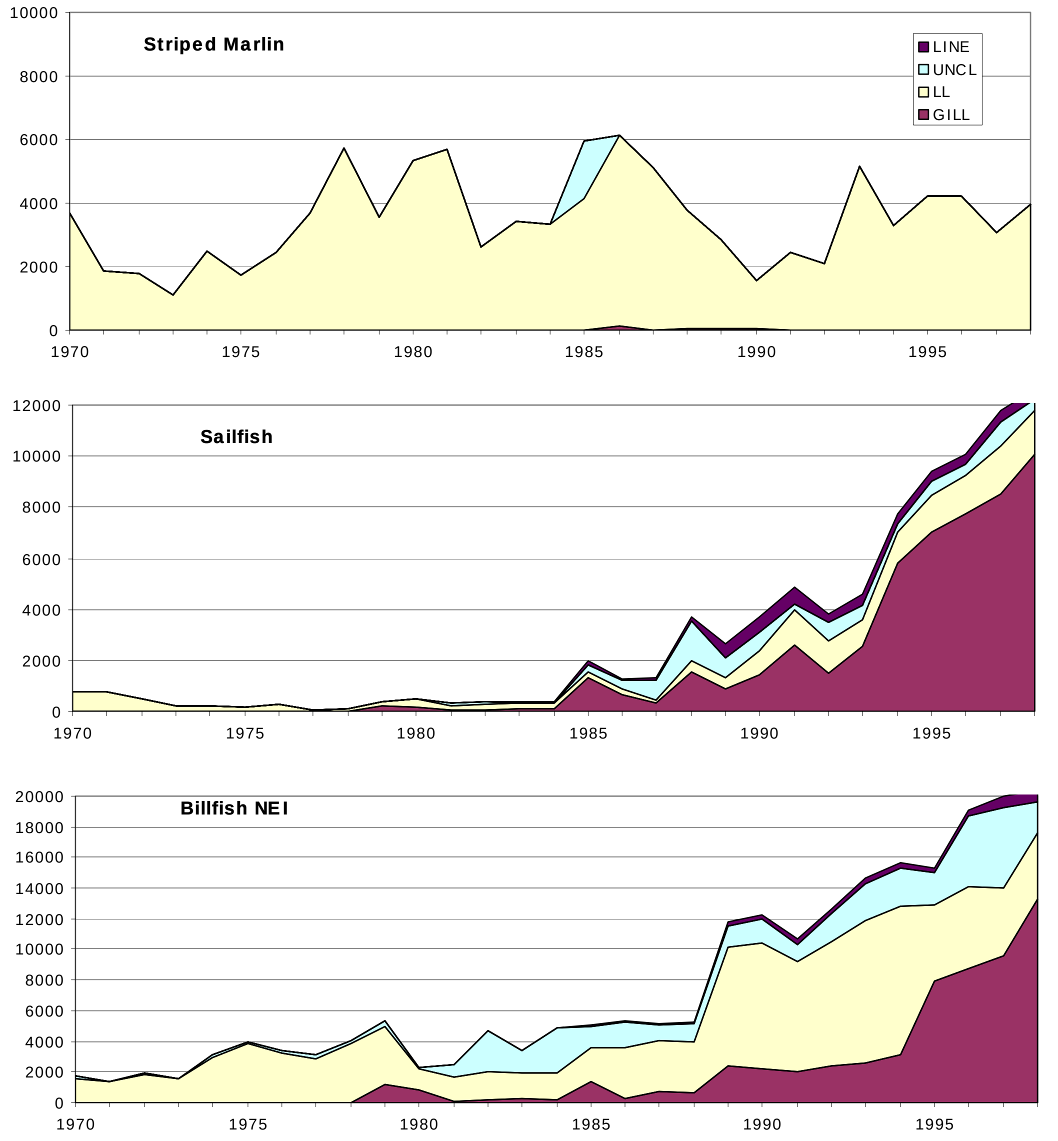

Figure 2 (cont). Catches (in t) of billfish species in the Indian Ocean by gear during the period 1970-1998.

Review of other gears

Billfish catches reported under other gears such as handline and troll line have never been high (Figure 2). Small catches, in particular by troll lines, are reported from countries such as France (Réunion), Comoros, Seychelles, Mauritius and South Africa, and are expected to occur in Madagascar, Kenya, Tanzania and other coastal countries.

Catch and Effort (CE) Data

Catch-and-effort data are more or less complete for the large longline fleets (Japan, Korea and Taiwan, China) or those targeting swordfish, such as the Taiwanese , French, Spanish and Seychellois fleets. These statistics are not available for the South African, Indonesian (initially Taiwanese), Portuguese fleets and NEI. Catch-and-effort data for gill nets and line are scarce and incomplete.

Size Frequency (SF) Data

The situation for size-frequency statistics of these species is the same or even worse. For the Taiwanese longline fleet, only data from 1985 to 1988 were reported. Almost no size-frequency statistics exist for any other fisheries.

Length-frequency data for swordfish have not been reported in a standard form from different fisheries and cannot be readily compared. For example, in Réunion and in the Seychelles, lengths have been reported as pectoral to anal fin lengths (PAL), whereas other countries (e.g. Australia and Japan) often report eye to caudal fork length (EFL). Réunion has a conversion factor for PAL to EFL; however, these conversions are not necessarily simple linear conversions. The Working Party recommends that lengths be measured in a single form (e.g. EFL).

General Discussion

In the discussion following the presentation by the Secretariat, it was observed that significant gaps in data are related to coastal (artisanal) fisheries. Sampling programmes may be required to rectify this situation.

The Indonesian tuna and billfish fisheries are among the largest from the coastal states in the region but suffer from inadequate statistics. Historical data and first-hand information on recent longline fishing operations are not available, although the Secretariat is exploring this issue, and no information is available on the artisanal fishery. Obtaining detailed information on catch, effort and size-frequencies is important for both segments of the fishery, as catches are large. Indonesia is now gathering data from Indonesian-flagged Taiwanese-owned vessels using Indonesian ports. The Indonesian longline fisheries take place in an area that is considered to be the main spawning grounds for billfish. The area is roughly a triangle defined by Java and the west coast of Australia.

It was also proposed that a review be conducted on the bycatch of billfish by purse-seine fleets in the Indian Ocean. Currently bycatch of billfish by purse-seine fleets is considered to be negligible. However, literature for similar fleets in the Pacific and Atlantic Oceans, as well as historical observer data in the Indian Ocean indicate that significant catches of billfish occur (of the order of 1,000 t in both the eastern and western Pacific Ocean). Thus, the Working Party recommends that historical observer data for the Indian Ocean should be reanalysed to incorporate catch estimates in the billfish statistics.

Review of new information on fisheries

Swordfish

Document WPB-00-01 provides an overview of the activity of the Spanish surface longline fleet targeting swordfish in the Indian Ocean from 1993-1999. The fishery commenced in September 1993 when five vessels began exploratory fishing in international waters in the western Indian Ocean. Exploratory operations continued until August 1994, with about 690 t of swordfish caught in that year. Only one vessel continued fishing with longlines in the area through 1995 and 1996. In 1997, two vessels fished in the western Indian Ocean for about 6 months and caught more than 500 t of swordfish. In 1998, a total of eight vessels fished for about 9 months. From November 1999 to February 2000, two vessels were involved in further exploratory fishing in the southwestern areas, and an additional seven vessels fished throughout 1999. Spanish longline catches of swordfish in the Indian Ocean were 508 t, 1425 t and 2013 t in 1997, 1998 and 1999, respectively. The CPUE ranged from 15.6 fish/1,000 hooks in 1993 to 6.5 in 1996, and stood at 7.3 fish/1,000 hooks in 1999.

The information presented in the paper is the result of voluntary logbook submissions and individual fish measurements provided by skippers. The response by the skippers is good and a high percentage of the fleet is covered.

Some trips during the initial stages of the programme (1993-1994) and in the past year (1999) had observers on board collecting information. In particular, it was noted that the observers had recorded the size distribution by sex for 65% of the catch. From some effort recorded in the northern Indian Ocean off the coast of Somalia, it was observed that the catches were not important and likely the result of vessels transiting to and from the Red Sea. The information from this programme is available as aggregated monthly data by 5x5 degree areas and has been submitted to the Secretariat.

Document WPB-00-06 considered the data situation for the French longline fleet based on Réunion Island fishing for swordfish in the southwestern Indian Ocean since 1991. IFREMER has been compiling information from logbooks and regularly sampling at-sea and landings since the beginning of this fishery. Fishing companies are requested to provide data to the fisheries administration on landings by species at the end of each fishing trip.

The number of fishing craft involved is recorded by size category and gear. Thus, accurate figures are available on annual nominal catch by species and gear and annual fishing craft statistics by gear and boat size class. The IFREMER laboratory, in association with longline fishermen, has implemented a logbook monitoring system. Logbooks provide information on daily fishing effort, catches by species, discards and vessel operations. As logbooks only record a proportion of the fishery, a raising factor must be applied. All data, including biology, are computerised and stored in an integrated database.

Since 1991, except for 1997, effort has been increasing steadily. There are currently 31 boats in the fishery, classified in three size-classes; small (less than 10 m), medium (from 10 to 16 m) and large (over 16 m). The smaller boats typically stay at sea between 2-3 days, while the large vessels may have trips of up to 30 days. The number of boats for all classes has increased over the years, with some large boats moving to the Pacific Ocean over the last year (1999). The contribution of the largest vessels to the fishing effort has decreased slowly, especially in 1999. Thus, for the first time in 1999, the number of hooks set by small longliners (<16 m) exceeded the number of hooks set by large (>16 m) vessels.

The longline catch of swordfish was 278 t in 1991, increased to a high of 2076 t in 1998 and decreased to an estimated 1926 t in 1999. The swordfish component of total longline landings (by weight) ranged from 54% in 1993 to 71% in 1994, and averaged 66% over the 7 year-period. Albacore tuna (12%), yellowfin tuna (11%) and bigeye tuna (3%) contributed about 26% of the total catch of the pelagic fish during the same period. The percentage contribution by billfish and sharks were respectively 4 and 2%.

The fishing grounds of the Réunion longliners are located to the West and South of Réunion both in the EEZ and in international waters. The swordfish CPUE (number of fish caught per 1,000 hooks) has exhibited a significant decrease (down to 8-9 individuals) since 1994. Clearly, the definition of a better abundance index (including kilometres of line, number of hours per number of hooks set...) seems crucial to understand the evolution of the CPUE.

In the ensuing discussion, it was indicated that the results presented in this paper are preliminary, as the program only started in 1998. Logbook data submission has varied over the years. In 1993, the logbooks of about 37% of all trips were recovered for data collection. The coverage peaked in 1995, with about 99% of the logbooks for all trips, and went down in 1999 to about 46%. In general, the coverage for large vessels seems to be higher than the coverage for small and medium vessels. The aggregated information from the logbooks is consolidated into a database, and is provided to the Secretariat.

It was observed that new EU regulations would make compulsory the submission of logbook data for any vessels larger than 10m, however, for the smaller vessels, the programme would still have to rely on voluntary submissions of logbooks.

Document WPB-00-08 presented a summary of a detailed report on global swordfish fisheries. The report summarises information on the biology of swordfish and provides details on six key fisheries that target swordfish (the east coast of Australia, Chile, the U.S. fishery in the northwestern Atlantic, the Japanese fishery in the northwestern Pacific, the Mediterranean and Hawaii).

Longline fisheries targeting swordfish in the Australian Fishing Zone (AFZ) off eastern and western Australia have developed rapidly in recent years. The value of fishing permits to operate in Australia's Eastern Tuna and Billfish Fishery and Western Tuna and Billfish Fishery is increasing at a rapid rate. New and larger boats are entering the fishery and investment in the fishery has increased dramatically, although the impact of present levels of fishing effort is not known. Several swordfish fisheries in other parts of the world, however, have shown an initial rapid expansion and then declined, prompting concern over the species' ability to support intensive harvesting. Views on swordfish status are polarised between the fishing industry and conservation groups, with scientists in the middle ground. Conservation groups, for example, instigated a boycott of swordfish in restaurants in the United States and are calling for a complete ban on longline fishing

Among the key conclusions of the report is the observation that the average size of the fish captured in many heavily exploited swordfish fisheries has reduced significantly. However, there is no evidence of recruitment overfishing. The clearest example is in the Mediterranean fishery where the average size of swordfish captured was 48 kg during the period of peak catches in 1980 and decreased to 10 kg by 1997. Despite this large drop in average size, catches of swordfish in the Mediterranean have been stable at about 14,000 t since 1990.

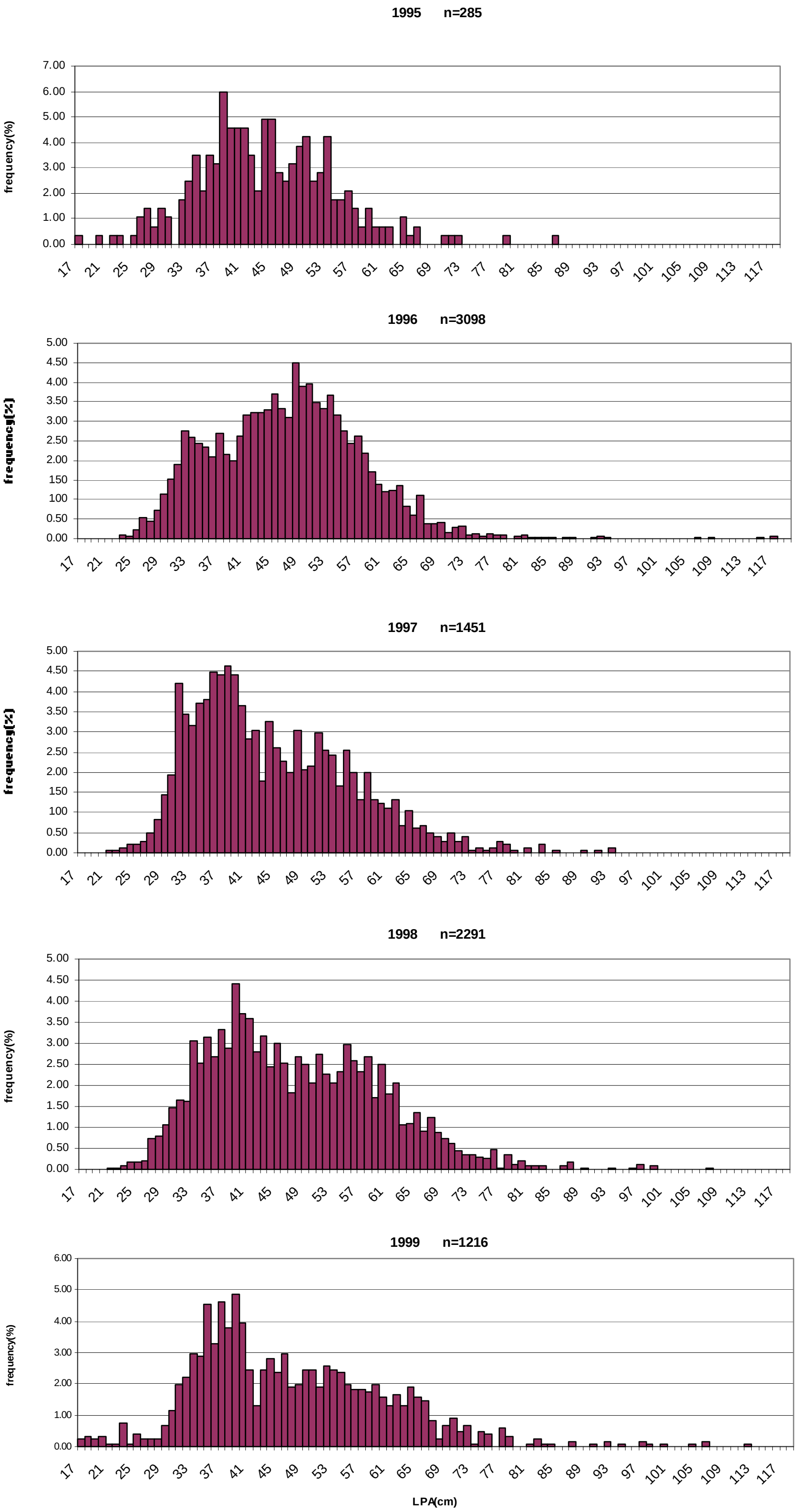

Figure 3. Size frequency distribution for swordfish caught in the Seychelles-based longline fishery (from WPB/00/05)

It was indicated that the Australian fleet grew from 10 vessels in 1997 to 39 vessels in 1999, with catches increasing from 15 t in 1997, to 200 t in 1998 and over 1,000 t in 1999. Although there are no observers onboard the vessels, Australian law makes the submission of logbook data compulsory, so this information is available. However, it was noted that data reported to IOTC might have to be aggregated, due to the need of maintaining confidentiality of individual vessel information.

In the east coast longline fishery of Australia, about 90% of all individual swordfish landed are measured. It is expected that similar levels of coverage will be attained in the Australian longline fishery in the Indian Ocean in the near future.

In the Indian Ocean there is no documented evidence of a decline in the size of swordfish caught in the longline fisheries despite the fact that Australia has a rapidly expanding swordfish fishery in the EEZ in the Indian Ocean and there was an extensive Japanese longline fishery for 40 years prior. Despite the previous exploitation of swordfish off western Australia, large fish has dominated the domestic catch of swordfish. This suggests that the Japanese tuna longline fishery bycatch of swordfish may have represented a low rate of exploitation

Document WPB-00-05 was discussed in terms of the data situation for swordfish in the Seychelles-based longline fishery. The document only discusses data from the local boats (with Seychelles flag), although it was reported that Seychelles also has provided licenses for a number of French, Spanish and Indonesian longline vessels. The data collection program, which started in 1995, obtains logbook data, landing weights from fishing companies, length frequencies and information on predation rates.

The size frequency distributions reported in the document (Figure 3) seem to indicate an increase in the proportion of smaller fishes, but it was concluded that this could be the result of a change in the fleet behaviour (i.e. changes in the minimum size retained by the fishermen) or in the fishing grounds. It was also mentioned that the reported length-frequency distributions were typical of swordfish catches in tropical waters.

Istiophorid billfishes

The presentation on statistics on billfish for the Indian Ocean raised several issues regarding Istiophorid billfishes. Sailfish is the main Istiophorid caught, with an estimated annual total of 13,000 t reported. However, in 1998, an estimated total of 20,000 t of ‘unspecified’ billfish (or billfish nei) highlights problems with the species composition in the catch data. Two issues contribute to this situation:

Difficulties in identification of Istiophorids are common. This may be due to:

a) *Problems arising from the literal translations from Japanese:* The Japanese name for blue marlin is *kurokajiki*, meaning black marlin and for black marlin is *shirokajiki*, meaning white marlin. The latter is not so important since the true white marlin, *Tetrapturus albidus,* does not occur in the Indian Ocean. However, the designation of blue marlin as black marlin is thought to seriously compromise the veracity of the catch records.

b) *The problem of identification of carcasses that have had the head and fins removed.* It was noted that carcasses could still be identified by genetic means (but would require a field test kit), or by trained personnel using certain diagnostic features. A guide to the Indo Pacific Billfishes, produced by the Australian Government, includes such information.

Other relevant factors regarding Istiophorids in data collections include:

- Nearly all sailfish are caught by coastal gillnets (and are important to those fisheries).
- Almost all sailfish and shortbill spearfish caught by longline in the Indian Ocean are discarded.
- Sport fishery catches of billfish are very poorly reported in statistics.

In the discussion it was established that, because little or no billfish is imported into Japan from other countries, the NEI component of billfish could not be divided into the constituent species from import records. It is not clear if import data from Taiwan,China exist.

General Discussion on the Data Situation

Regarding the overall data situation for billfish, the findings and conclusions of the working group could be summarized as follows:

- The most complete data sets in terms of spatial and temporal coverage come from the Taiwanese and Japanese fleets, covering the whole Indian Ocean for more than 30 years. Given the importance of Taiwanese catches of billfish, the Working Party encourages the active participation of scientists from Taiwan,China in its meetings.
- The most important catches are those of Japan, Sri Lanka and Taiwan,China. The Taiwanese fleet targets swordfish, while the Japanese fleet targets other species, with swordfish as a bycatch. The Sri Lankan catches are from gillnets which do not target any particular species.

- A large percentage of the longline fleet has not been reporting. Catch estimates are based on the number of operating vessels, and partial vessel registry information is only available from 1998. Efforts to reconstruct historical catch data based on alternative sources of information, such as market data, customs declarations, and/or processing plant records should continue.
- The quality of the size-frequency data that exists is good in general, however, the coverage is not good across the Indian Ocean fisheries. It is important to obtain size data from the Taiwanese fleet, and the Working Party recommended that efforts continue to make such data available to IOTC
- To perform effective stock assessment based on age-structured models, information about sex ratios and length-frequency by sex is essential.
- It is encouraging to see that there is an effort to obtain reliable logbook data for the Spanish and French swordfish fisheries.
- To attempt to rectify the situation regarding aggregation of all Istiophorid species in Sri Lankan records, it was recommended that IOTC request that individual species be identified and recorded in this fishery.
- It is important to obtain better data from the sport fisheries that target billfish. This might be achieved by contacting and liasing with key personnel in clubs and in the charter industries in the main countries involved in sport fishing. Historic club, tournament and charter log information has proven to be very useful in other areas, and routine monitoring of organized events is not difficult.
- An attempt should be made to obtain estimates of Istiophorid bycatch of purse seine fisheries by exploring all possible sources of data, possibly using as reference methods used in the Pacific.
- It seems evident that performing good stock assessments for the species would be difficult due to gaps and uncertainties of currently available data.
- It was noted that concentrating on areas of very high catches could be an effective approach to study abundance trends. Historically, billfish data are aggregated with other fisheries, which may dilute or confuse population trends in billfishes.
- The possibility of obtaining historical market information to be used to validate and fill the gaps in the species composition of the catches was discussed. It seems that this may be possible for the Japanese fleet, and a portion of the Taiwanese fleet for which the catches go to sashimi markets.

3. Review of biological and fisheries data relevant to billfish

Swordfish

Stock structure

WPB-00-Inf1 provides information on the stock structure of Pacific swordfish based on sequencing mitochondrial DNA. The paper provides evidence for separate stocks of swordfish in the Pacific Ocean and, therefore, has significant management implications.

These results from the Pacific Ocean highlight the potential value of detailed genetic studies on swordfish in the Indian Ocean. Australia has commenced work on a project to investigate potential genetic differentiation among swordfish in the Indian Ocean and these data would be compared with fish from the Pacific. The Working Party recommends that IOTC contracting and collaborating parties cooperate to ensure that samples are obtained from a wide range of swordfish fisheries in the Indian Ocean.

Size and sex composition

As reported in document WPB-00-06, at least 2,600 fish are measured each year in Réunion. Swordfish caught by the longline fishery are within a range of 17-116 cm PAL (LJFL: 63-321 cm). There is no real trend of the annual mean PAL length from 1994 to 1999. It dropped rapidly in 1995 before increasing and remaining quite stable in 1996 and 1997. An upward trend is observed after 1998. It is also important to point out that the largest fish are caught between September and November. Data on sex composition of swordfish caught by domestic longliners are presently limited to fish sampled at sea by observers. As with other billfish species, swordfish males are smaller than females.

Due to the sexual dimorphism of swordfish and the larger maximum size and faster growth rates of female swordfish it is important to develop sex specific age and length data for this species. Unfortunately, it is difficult to obtain data on the sex of swordfish due to the lack of observers on most longline vessels, the lack of sex specific characters and the fact that the fish are often landed as trunks. Efforts to develop methods to determine the sex of swordfish (as well as tuna and billfish species) based on biochemical indices (e.g. sex specific hormones in muscle tissue) are underway and may be available in the near future.

Reproductive studies

In the vicinity of Réunion Island, all maturation stages can be observed throughout the year. A gonad index has been calculated from 1996 to 2000 (July), for 908 females ranging from 67-289 cm LJFL and for 485 males ranging 67-213 cm. Swordfish with the highest gonad index are caught from October to March, indicating that spawning occurs in the southern hemisphere summer. Ripe females can be caught up to April. Swordfish larvae have been reported in the literature in the Mozambique Channel during the months of January as well as off the east Coast of Madagascar and are abundant between 12°S and 17°S, in the eastern part of the South Equatorial Current both to the east and west of Madagascar. In other studies, swordfish larvae have been found south of Sumatra.

The relationship between the gonad index and LJFL shows that the smallest mature female found in this fishery was 152 cm in length. The highest gonad index encountered was 15.47, for a 184 cm fish caught in December with gonads weighing 9,640 g. Different maturation states have been assessed histologically using standard tissue staining, sectioning, slide preparation and analysis. All stages of maturity and cells at different stage of ovogenesis have been described. During the two year period, 1,269 swordfish were sexed in order to determine sex ratio. Individuals from both sexes are present throughout the year, but females are predominant except in September and October.

Swordfish are broadcast batch spawners with very high fecundity. Spawning is believed to occur every few days during the peak of the spawning season; however, the number of ova released during each spawning event is unknown. The Working Party noted that peak gonadal indices are not necessarily the most effective means to identify the time of spawning and this information should be supported by histological examination of gonadal tissues, as is being done in the Réunion study.

Age and growth

An ageing study based on anal fins has been undertaken in partnership with the IFREMER team of LASAA[2]. A total of 902 swordfish fins have been collected throughout the year since the beginning of the programme. Each spine section picture was stored with TNPC[3] software developed by LASAA/IFREMER for digital image processing of calcified structures.

The Seychelles Fishing Authority has also been conducting preliminary work on estimating age of swordfish. This research will continued in collaboration with Réunion and LASAA scientists. Australia has carried out some research on age and growth of swordfish and further work is planned for Indian Ocean swordfish during 2001. These research programmes are based on the interpretation of presumed annual increments in anal fin rays.

Research on catchability

A study to better understand factors affecting catchability of swordfish by longline gear has been undertaken in Réunion. and A total of 16,296 hook timers have been deployed since July 1998 with 60 to 400 set per fishing operation. Of the 517 swordfish hooked, 48% were caught during the 3 hours following the hook deployment, but 290 were lost (56%), showing a high level of lost fish.

Stock assessment

Document WPB-00-02 presents the results of the estimation of an index of abundance based on data from the Japanese fleet and the application of a production model to estimate the productivity of the population. Standardization of swordfish catch per unit effort (CPUE) caught by Japanese and Taiwanese longliners in the Indian Ocean were attempted in order to evaluate the influence on the stock of the current drastic increase of

[2] Laboratoire de Sclérochronologie des Animaux Aquatiques

[3] Traitement Numérique de Pièces Calcifiées

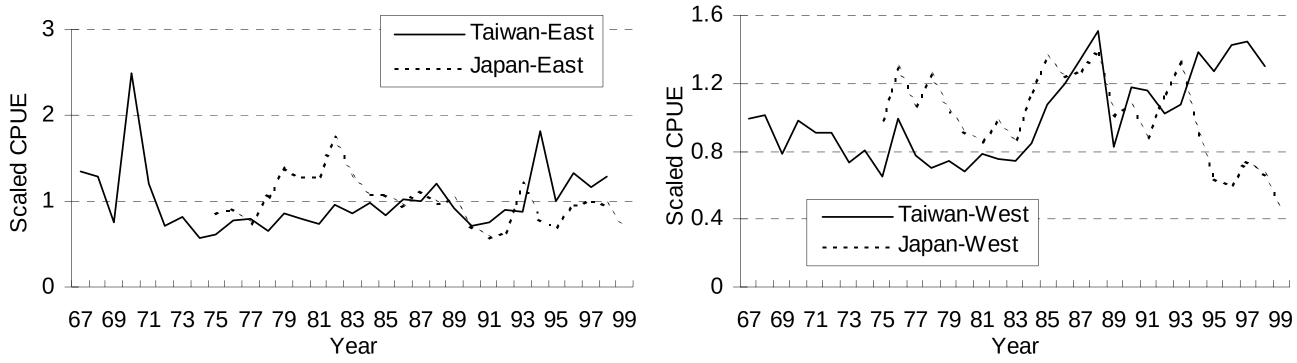

Figure 4. Standardized CPUE for the Japanese and Taiwanese longline data for the eastern (left panel) and the western (right panel) Indian Ocean. Indices are scaled to the mean of the historical data series, which is represented as 1 in the figures.

swordfish catch. Two series of standardized CPUE series showed opposite trends especially in 1990s when the catch of swordfish increased rapidly (Figure 4). The main reason for this was likely to be the lack of information about the shift of targeting from tunas to swordfish that was believed to have occurred with Taiwanese longliners.

An attempt was made to fit a standardized CPUE of Japanese longliners and total catch to a non-equilibrium surplus production model, but reliable parameters could not be estimated. This could be attributed to the uneven contrast between the sudden increasing trend of total catch and slower decreasing trend of CPUE of Japanese longliners in the 1990s (Figure ??).

In the discussion following the presentation of the paper, the WPB made a number of suggestions for further work on these analyses. It recommended investigating the sensitivity of the results of the GLM analyses to using fewer, larger areas to improve the number of observations in each cell. It also suggested that inclusion of environmental information in a habitat model could better explain interannual variations.

It was recommended that the same units be used in the production model and the index of abundance. In other oceans, large changes in average weight in the catch have been seen, so it would be preferable to calculate the index of abundance in weight, rather than in numbers of fish. The Working Party agreed with the authors' conclusion that the results of the production modelling are unreliable. This is due largely to the fact that the rate of decline in the abundance index is relatively slow compared with the rate of increase in the catches, and this results in unrealistic parameter values for the intrinsic rate of increase and the carrying capacity. It was also recommended that the sensitivity of the results to models other than a Schaefer model be explored.

The Working Party noted that recent catches in the western Indian Ocean are much larger than in the eastern Indian Ocean and that more caution might be required if there are different stocks in the two basins (see Figures 5 through 7)

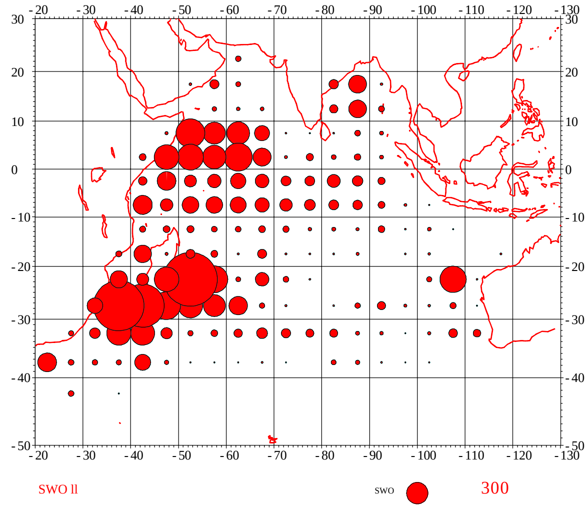

Figure 5. Longline catches of swordfish in the Indian Ocean from 1994-1998.

The Working Party noted the different trends shown by the Japanese and Taiwanese CPUE. Further research should be devoted to clarify the reasons behind such discrepancy, as they lead to different conclusions regarding the status of the swordfish resource. The difference in setting practices between Taiwanese and Japanese longliners was questioned. In personal communications, Taiwanese scientists indicated that the Taiwanese fleet does use night sets and this could explain some of the critical differences in the data.

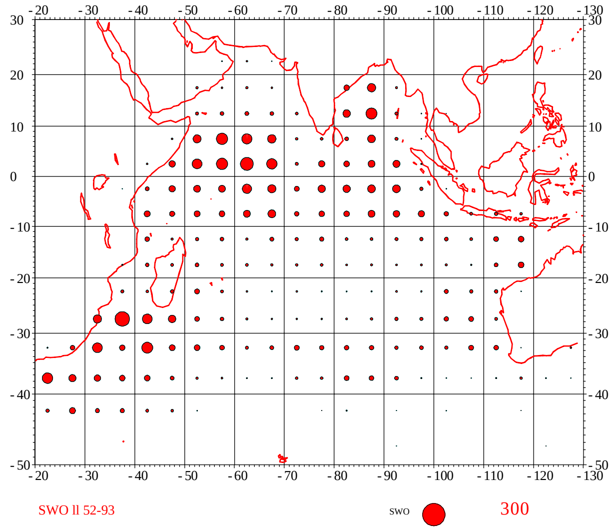

Figure 6. Longline catches of swordfish in the Indian Ocean from 1952 to 1993.

The Working Party noted that although there is uncertainty over which trend is correct, the Japanese trend in CPUE shows a decline and there has been a 700% increase in the catch of swordfish in the western Indian Ocean. A continued increase in catch and effort of this magnitude in the southwestern region is unlikely to be sustainable. These facts suggest that IOTC should monitor the situation closely during the next few years and work towards stock assessment should proceed.

The WPB agreed that a general rule in fisheries is that, when the fishing effort exerted on a long-living species such as swordfish is increasing very quickly, there is an increase of catches. However, this catch will not be sustainable under constant effort. A lower level of equilibrium catch, which corresponds to each level of fishing effort, will be observed, but only after several years of stable efforts. This duration corresponds approximately to the number of year classes significantly exploited by the fishery, e.g. more than 5 for swordfish. Because of this potentially dangerous disequilibrium between stock and fisheries, the rate of increase of the swordfish fishing effort (and catches) should be stabilized (or kept at moderate levels) and closely monitored.

The Working Party noted that it appears that the exploitation rate exerted on tunas and billfishes at a local scale (for instance within a 5°-month strata) may be a source of potential bias in the relationship between CPUE and biomass relationship. This is primarily because the CPUE obtained by longlines in each 5°-month stratum on a given biomass of tuna at very high levels of local fishing effort tends to be much lower than the CPUE obtained at low levels of effort. This potential problem may be more severe for bycatch species such as billfishes, than for a target species such as BET. This relationship between local CPUE and local efforts should then be analysed by simulation models and by analysis of catch and effort data, taking into account, as an explicit parameter of the statistical model, the total fishing efforts exerted in each time-area strata (by all the LL fisheries).

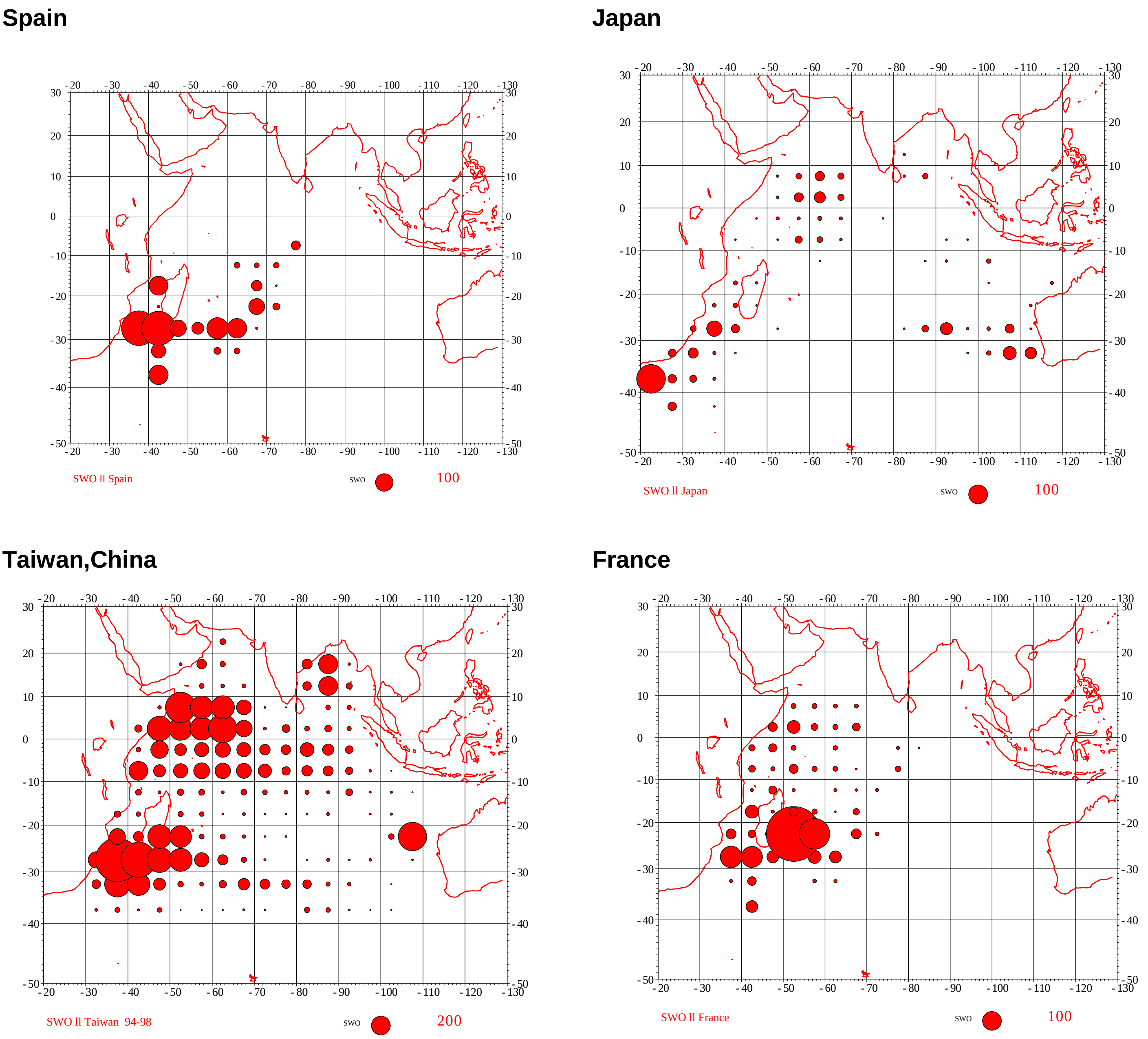

Figure 7. Catches (in t) by different longline fleets during the period 1994-1998.

Research recommendations for Swordfish

- Studies to determine the stock structure of swordfish in the Indian Ocean should be encouraged and should involve further cooperation in the collection of samples for analysis. Various approaches should be considered, including genetic investigations, calcified tissue chemistry and identification of parasites.
- Length data should be reported in a standard format to facilitate comparison of data from different countries.
- It is critical to the development of assessment model that age and growth studies be continued. Furthermore, validation studies should be carried out to determine the level of accuracy of age estimation methods employed.

- Studies on the movement and migration of swordfish at most stages of their life history should be investigated through the use of opportunistic tagging using standard techniques as well as archival and pop-up tags.
- Research should be continued on the development of methods to determine the sex of swordfish based on samples such as muscle tissue that are readily obtained.
- Further work on stock assessment on Indian Ocean swordfish is urgently needed. In the first instance, cooperation is required on the development of a standardized CPUE series, particularly if the series is to include environmental data. An option is the establishment of a working party that would focus on the standardization of CPUE.
- French scientists should continue with investigations of environmental variables and their impact on the abundance and distribution of swordfish. Australia has investigated this question in the Coral Sea and has found several variables that are very useful in defining the basis for variability in swordfish catch rates. Australian and French scientists should cooperate in these research activities.
- A combination of indicators of stock status would be valuable in the assessment of swordfish stocks in the Indian Ocean, particularly in light of the fact that there is conflicting catch rate information from Japanese and Taiwanese data. Size data is likely to be an important indicator for swordfish in the absence of a reliable stock assessment. Unfortunately, size data has not been made available from all the swordfish fisheries although, in some cases, these data do exist.

Istiophorid Billfishes

Biology of black marlin

A brief synopsis of the biology of black marlin was presented in WPB-00-09. The taxonomy and distribution of black marlin is quite well understood. Black marlin is a single species throughout its range (Indo-Pacific), often aggregating near land masses, rather than throughout the open ocean. Results from fish tagging in the Pacific from sport fisheries indicate rapid, widespread movements throughout that ocean. Some annual homing is also indicated by recapture data, at least off eastern Australia. A recent genetic study has indicated no evidence of stock separation throughout the species' range. However the study involved relatively small sample sizes in some areas, especially the Indian Ocean, and recommended a further study to compare stocks from the Indian and Pacific oceans, since there is some possibility of gene flow between the two basins. Growth rates of black marlin are not well quantified, although early growth rates (for the first two or three years of life) have been estimated with some reliability. Age at first maturity has been estimated, and longevity is 'guesstimated' at 20-30 years. Known spawning areas are quite restricted compared with other billfish species. Batch fecundity and spawning frequency are unknown. A major gap in knowledge of the life cycle of black marlin is early life history. Larvae have only been collected in small numbers, and juveniles of less than about 90 cm (LJ-CF) are extremely rare in catches of either commercial or recreational fisheries. Ultrasonic telemetry has shown black marlin to be strongly surface oriented, spending the great majority of time above the thermocline. The deepest dive recorded was 178 metres. More data are needed over longer periods, and for more fish, before confident, general statements can be made regarding long term behaviour. Popup satellite tagging will hopefully provide such data in the future.

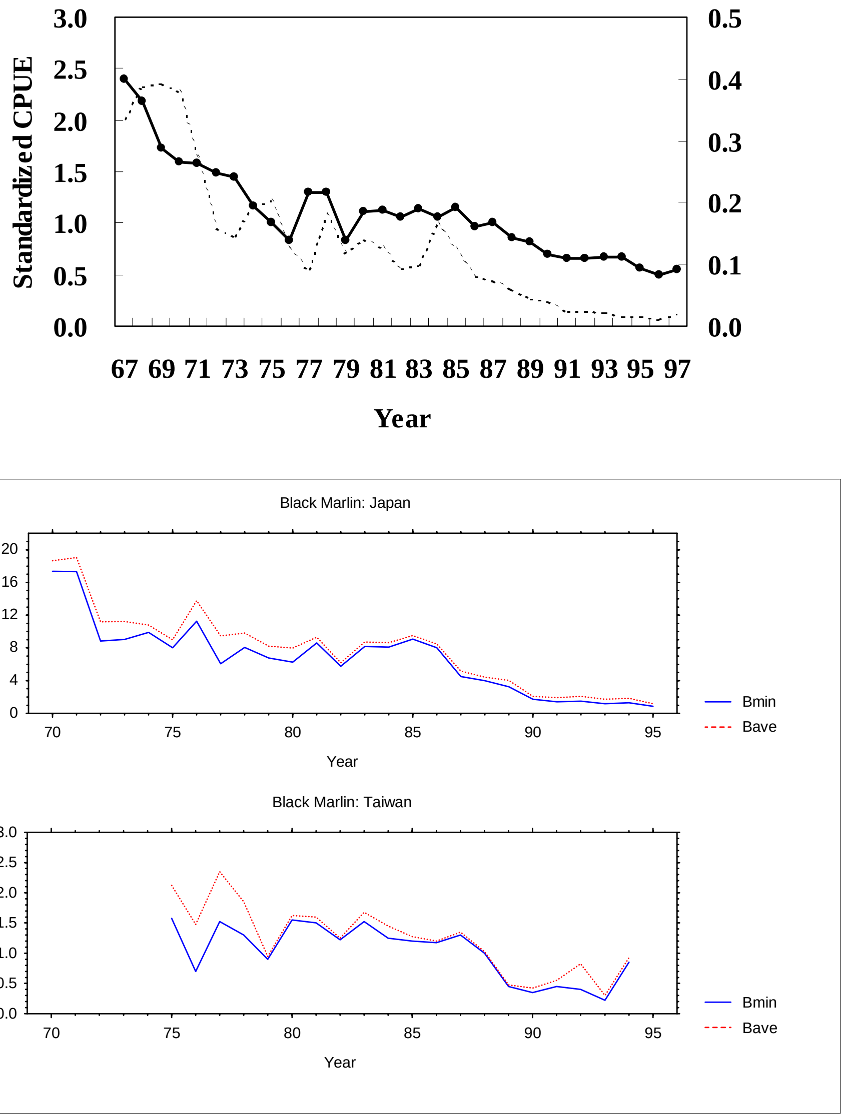

Figure 8. Indices of abundance of black marlin from Uozumi (2000) (upper panel) and Campbell and Tuck (2000) (lower panel). In the upper panel, the solid line shows the standardized CPUE scaled by adjusting the value in 1975 to 1.0 and the dotted line shows the nominal CPUE. In the lower panel, solid and dotted lines shows the results of two different methods (see Campbell and Tuck (2000) for details)

It was noted that black marlin and yellowfin tuna appear to occupy similar, surface habitat, and this knowledge may be important in the development of standardized CPUE data for input into stock assessment models for Indian Ocean black marlin.

Biology of blue marlin

A brief synopsis of the biology of the blue marlin was presented in WPB-00-10. The taxonomy and distribution of blue marlin is quite well understood. Blue marlin is now regarded as a single species throughout its range (Indo-Pacific and Atlantic), even though there are some genetic differences discernible between the Atlantic and the Indo-Pacific regions. The accepted scientific name for all blue marlin is now *Makaira nigricans*. Blue marlin is regarded as the most tropical of the marlin species, and is generally associated with open ocean or island habitats. Anglers have tagged blue marlin mainly in the Atlantic and Pacific oceans. Transoceanic movements have been recorded in the Atlantic and, in the Pacific, very long distance movements have also been recorded. Although there have been very few blue marlin tagged in the Indian Ocean (and no recaptures from these fish), two remarkable recaptures have been recorded for the species in the Indian Ocean. One fish was tagged off eastern Australia and recaptured south of Sri Lanka, while the second was tagged off the eastern United States

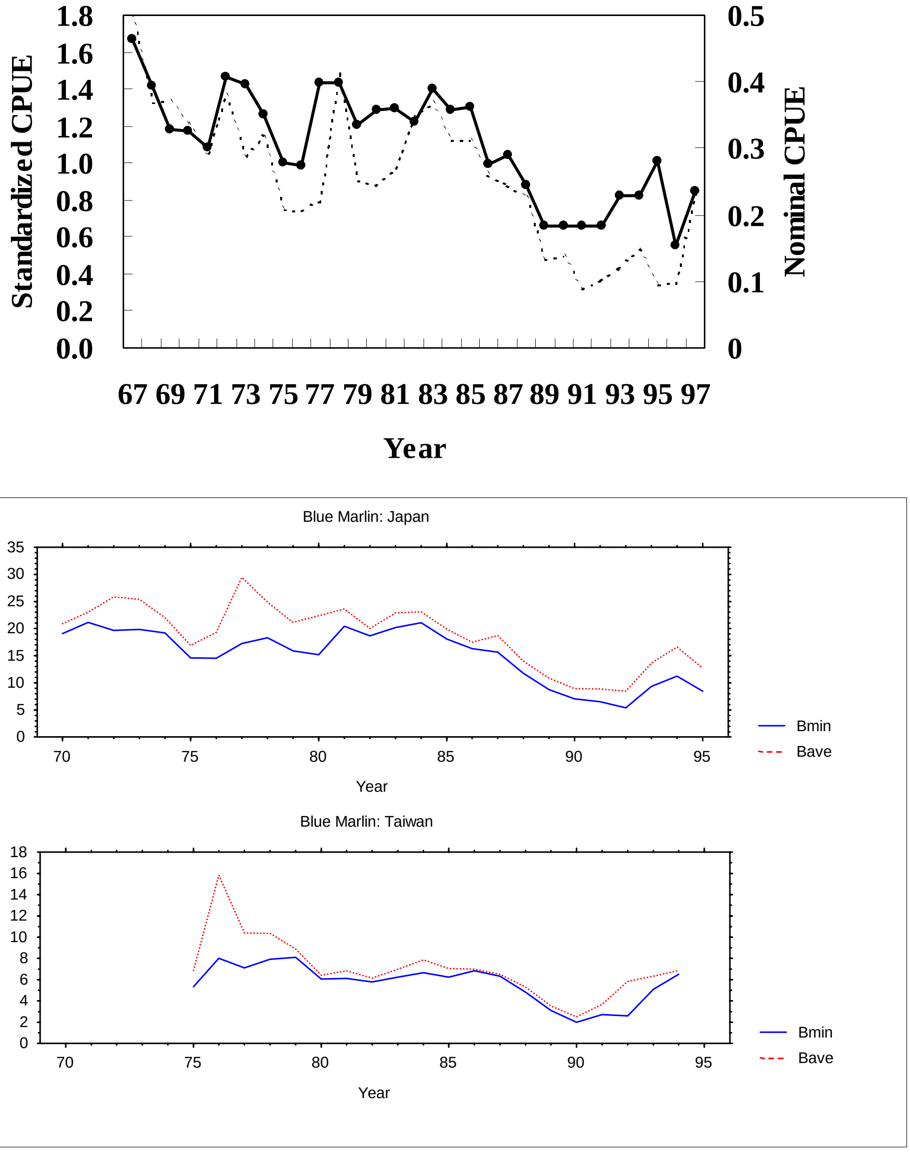

Figure 9. Indices of abundance of blue marlin from Uozumi (2000) and Campbell and Tuck (2000). See caption of Figure 8 for details.

and recaptured near Mauritius. Genetic studies of blue marlin have failed to detect stock structure throughout the species' range in the Indo Pacific, but as with black marlin, sampling in the Indian Ocean has been poor.

Growth rates of blue marlin have been studied in all three oceans. Studies from Hawaii and from Mauritius have indicated quite slow growth rates (for example, males attaining a size of only 97-114 kg by an age of 11-12 years). These studies were based on counting ridges on the tiny otoliths of blue marlin and must be regarded with some doubt since the method has not been validated. On the other hand, daily ageing of small blue marlin in the Atlantic has indicated a very rapid growth rate, reaching about 30 kg in the first year of life. (This rate also agrees with estimates for the cogeneric black marlin). The two largest Istiophorids on record were both blue marlin caught off Hawaii. Better studies of the growth rates of blue marlin throughout its range are required. As an aside, the author noted that much larger fish caught in commercial fisheries are sometimes anecdotally referred to, but he has not been able to verify any of these. He requested that colleagues attempt to verify any such anecdotes in future.

Based on larval distribution, blue marlins have very broad spawning areas in the tropical Pacific. Several spawning areas have been identified in the Indian Ocean. Definite observations of annual spawning of blue marlin have been made at Mauritius and Hawaii. Size at first maturity from Hawaiian samples has been recorded at 31 kg for males, and 80 kg for females. Ultrasonic telemetry indicates that blue marlin, like other Istiophorids, are highly surface-oriented, rarely diving below the thermocline. The deepest dives recorded have been to about 210 metres. As with black marlin, more observations through popup satellite tagging are required to obtain a broader understanding of long-term vertical (and horizontal) behaviour.

Recommendations on research on biology of Istiophorids

- Genetic studies of the main Istiophorid species should continue, 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 are probably the 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 and black marlin 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 could be achieved as a 'by-product' of the longline-tagging component of the Tuna Tagging Programme, and also by instigating a coordinated, Indian Ocean wide sport fishery tagging programme.

Istiophorid assessments

In the absence of documents dealing with recent stock assessment of Istiophorids, a comparison between the results of Uozumi (2000)[4] and Campbell and Tuck (2000)[5] on standardization of CPUE trends from the Japanese longline fleet was conducted by the Working Group. The Campbell and Tuck (2000) study also reported on the Taiwanese longline data. Different standardisation procedures were employed in the two studies and comparison of the results is not necessarily straightforward. Looking at each species in turn:

Black marlin

Both standardisations showed negative trends since the origin of the fisheries and these trends are apparent in both the Japanese and Taiwanese data (Figure 8). The Working Party noted that the analyses were preliminary and that more work would be required before these data could be interpreted with confidence.

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Blue marlin

The two studies found similar trends for the standardised blue marlin CPUE data from the Japanese fishery (Figure 9). Furthermore, the Taiwanese data showed a similar trend. Standardisations of the Japanese and Taiwanese data showed stable CPUEs before the mid 1980s followed by a downward trend until the mid 1990s, and then, a slight upward trend at the end of the data set.

Striped marlin

The different analyses again showed similar trends, with a marked increase in CPUE over a four year period from 1978 to 1981 (this also occurred in the standardisation of Japanese longline CPUE for bigeye tuna), followed by a decline until the early 1990s, continuing in the Campbell *et al* analysis, but stabilizing in the Uozumi analysis (Figure 10). The data seem to suggest increased vulnerability or targeting, but since this species is not directly targeted, a strong signal of increasing vulnerability is indicated, possibly as a result of changed fishing practices. It was agreed again that more work was required on this analysis.

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[4] Uozumi, Y. 2000. Standardization of catch per unit of effort for Swordfish and Billfishes Caught by the Japanese Longline Fishery in the Indian Ocean. *Proc.7th Exp.Cons. on Indian Oc. Tunas*:179-191.

[5] Campbell, R. A and G. N Tuck. 2000. Preliminary analysis of billfish catch rates in the Indian Ocean. *Proc.7th Exp.Cons. on Indian Oc. Tunas*:192-210.

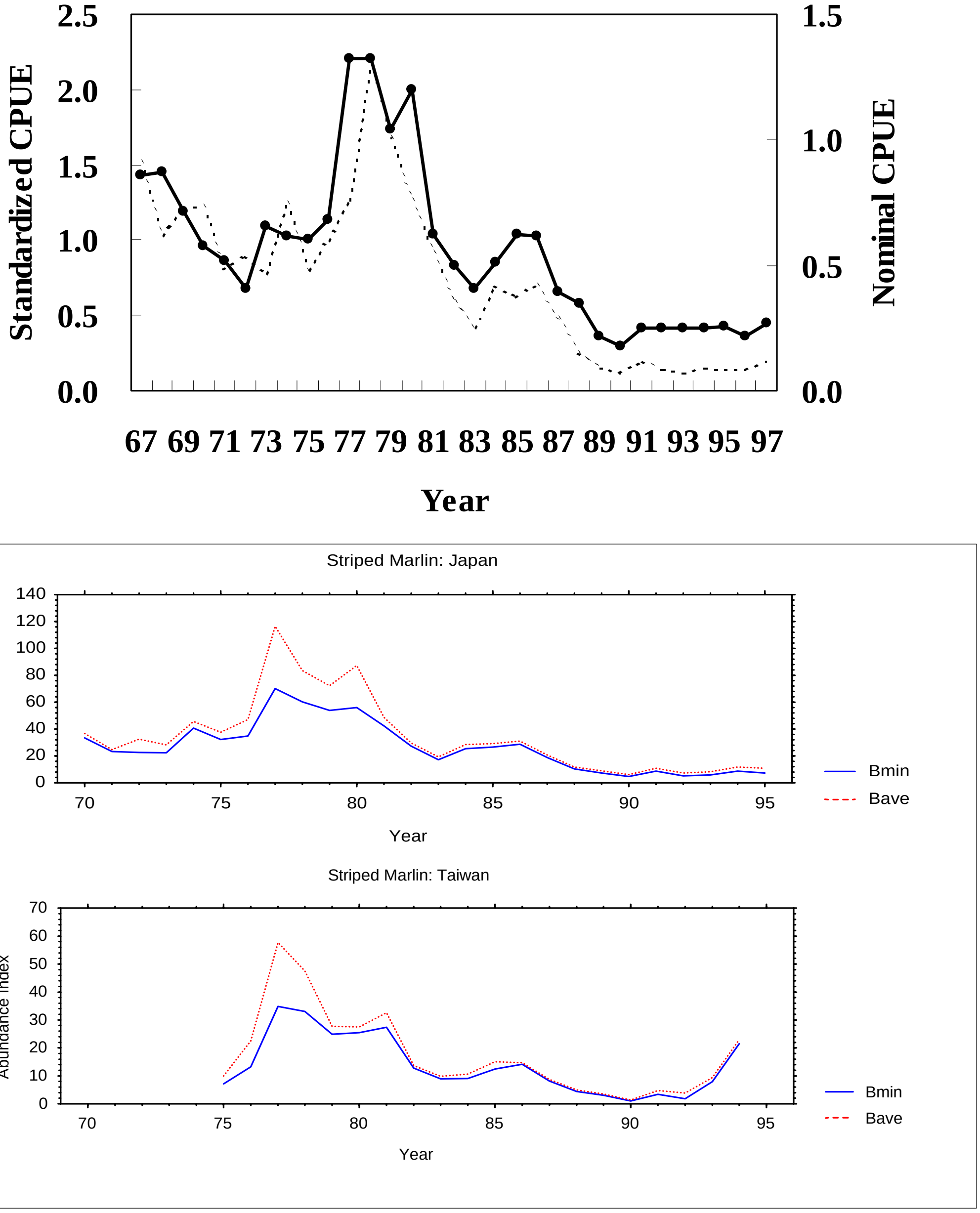
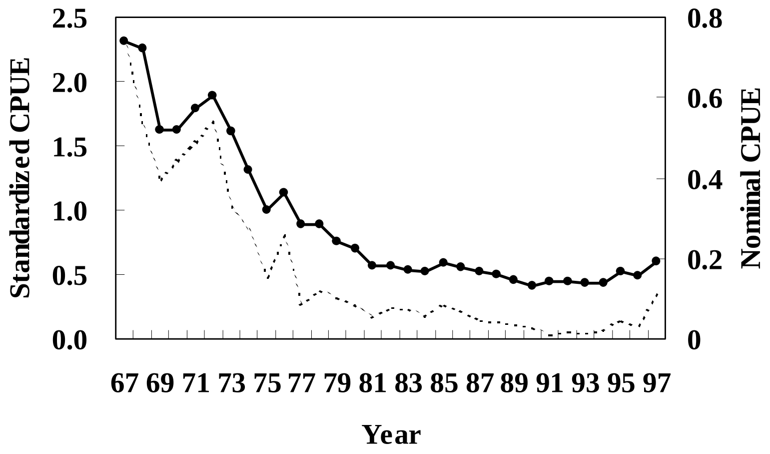


Figure 10. Indices of abundance of striped marlin from Uozumi (2000) and Campbell and Tuck (2000). See caption of Figure 8 for details

Sailfish

Noting that sailfish and spearfish are lumped in Japanese data until 1994, the trends for sailfish show a marked downward trend that stabilised at a low level in the mid 1980s for Uozumi's analysis, but continued downward from Campbell *et al* (both only used Japanese data) (Figure 11). The rapid increase in the catch of sailfish by Sri Lanka occurred in the mid 1990s, and does not explain the downward trend prior to that time. It was agreed that other fisheries should be considered in analysing sailfish data, in particular, sport and artisanal fisheries.



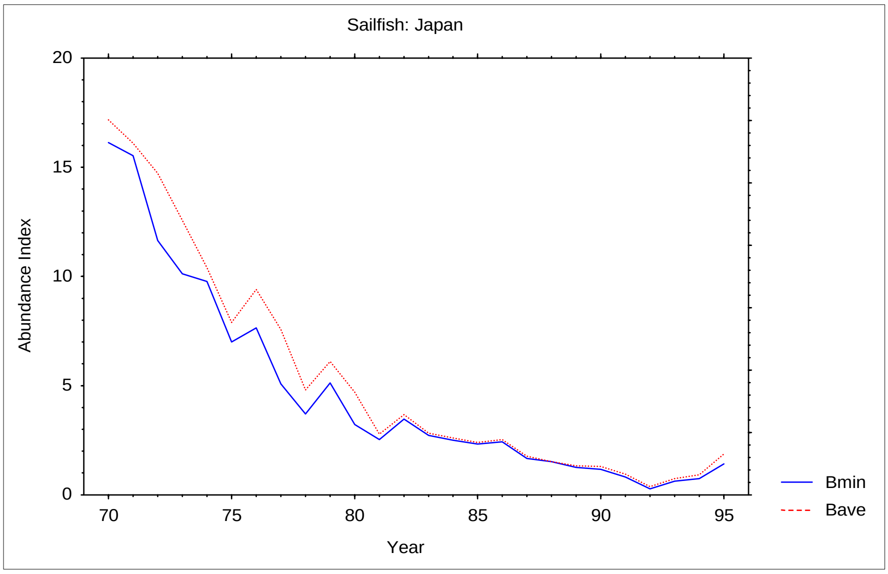


Figure 11. Indices of abundance of sailfish from Uozumi (2000) and Campbell and Tuck (2000). See caption of Figure 8 for details.

General Discussion

The general discussion which ensued this review noted the usual caveats regarding the use of CPUE data to assess billfish status (e.g. billfish are non-target species) and also noted that the standardizations performed to date must be considered preliminary. Nevertheless, there was sufficient consistency in the trends shown for black marlin, striped marlin and sailfish since the 1970s and blue marlin since the 1980s to warrant precaution and further focused analysis of this problem.

There was also a discussion about Istiophorid data and the suitability of these data for stock assessments. It could be possible to conduct a stock assessment on marlins, similar to that shown for swordfish in document WPB-00-26, as it could be possible to obtain standardized indices, especially from Japanese data, with adequate coverage of the data. It was also agreed that the main or core areas of marlin distribution should be concentrated on if assessments were to be done (this was the case for an Australian overview of billfish in the eastern Indian ocean).

Research recommendations

- Future research on Istiophorid billfishes should also involve increased collection of statistics from other coastal fisheries and sport fisheries.
- Additional research should be made in the standardisation of catch and effort data from Istiophorid species.

Predation by marine mammals and sharks on longline caught fish

Predation by marine mammals and sharks on longline caught fish is a significant problem in the Indian Ocean. Japan has collected data on predation on longline caught tuna during 1954, 1955 and 1965-1981 and an analysis of these data was presented at the second session of the WPTT (WPTT-00-Inf7).

A new Japanese survey of predation by marine mammals and sharks on longline caught fish in the Indian Ocean commenced on 1 September 2000 (WPB-00-04). The survey involves recording of information on damage to longline caught fish. None of the skippers interviewed mentioned marine mammals as part of the bycatch, but they have been reporting that marine mammals feed on the longline catch before it can be harvested. From photographs taken by fishermen and scientific observers, the short finned pilot whale (*Globicephala macrorhynchus*) and false killer whale (*Pseudorca crassidens*) have been identified as the species involved. Those cetaceans seem especially interested in the swordfish. They usually eat the body of the fish, leaving part of the head. From logbook data, fishermen have recorded the catch completely destroyed by marine mammals for 3-4 consecutive days. In this case, the attitude of the skipper is to move to another area. Loss due to marine mammals is underestimated as only the cases where at least 80% of the hooked fish are consumed are taken into account. Fishermen are convinced that the whales learn to follow the longline vessels; this question is poorly understood and researchers worldwide are just beginning to address this topic. The global percentage loss due to marine mammals established from logbook data appears to be increasing, with a peak in 1998 (5.5% of the swordfish annual catch), whereas discards due to sharks are quite stable (around 3%).

Predation on longline caught fish appears to be seasonal around Réunion and occurs in the summer. The most common identified predator is the false killer whale. In Seychelles, predation is a year-round problem and rates of up to 25% have been recorded through the voluntary logbook programme.

4. Management recommendations

The Working Party concluded that there was insufficient information available on which to base recommendations on specific management action. This is based on the preliminary nature of the information available on billfish in the Indian Ocean, the need for further work and the lack of evidence for demonstrable declines in the status of stocks.

However, the Working Party noted that although there is uncertainty in relation to the interpretation of the CPUE data for swordfish, the Japanese trend in CPUE shows a decline and there has been a 700% increase in the catch of swordfish in the western Indian Ocean. A continued increase in catch and effort of this magnitude in the southwestern region is unlikely to be sustainable. These facts suggest that the IOTC should monitor the situation closely during the next few years and work towards an assessment should proceed.

5. General recommendations for coordination and collaborative arrangements for research and assessment on billfish species

The Working Party noted and encouraged the on-going cooperation between the Seychelles Fishing Authority and IFREMER (Réunion) in a number of scientific initiatives. These institutions, in addition to IRD, have been collaborating in the preparation of a common scientific observer program on the longline fishery targeting swordfish in southwestern Indian Ocean. To further advance in the knowledge of billfish resources, the Working Party agreed on the following recommendations:

1. Support should be given to collaborative studies on billfish stock structure through techniques such as genetic analysis, hard tissue studies and tagging studies, including the provision of samples for analysis.
2. Steps should be taken to ensure inclusion of data on catch, effort and size-frequency related to fleets from Taiwan,China as this is a very important, but poorly understood component of the Indian Ocean billfish fishery.
3. Members should cooperate in the development of the proposed tagging programme on tropical tunas and swordfish.
4. Further research should be conducted on the links between the environment and catches of billfish.
5. The Secretariat should continue to work with scientists from Sri Lanka to ensure inclusion of detailed data on billfish from the relatively large billfish fisheries of that country.

6. It was noted that striped marlin and sailfish were also important in the Indian Ocean, and that it would be useful to analyse in more detail the situation of these species at the next meeting of the Working Party.

6. Time and location for the Second Session of the Working Party on Billfish

The time and location of the next session was discussed. The Working Party noted that there are heavy logistic demands for the Secretariat if the next meeting is held in conjunction with that of the WPTT. Several options were discussed and no final decision was reached, although the possibility of holding the next meeting in November 2001, in Réunion was viewed favourably by most participants. It was agreed to defer the final decision to a later date. The Working Party also discussed the possibility of focusing the next meeting on a particular species and agreed that this proposal should be presented to the Scientific Committee who would decide on the species to be prioritise.

APPENDIX I: LIST OF PARTICIPANTS

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APPENDIX II: AGENDA OF THE MEETING

1) *Election of a Chairperson.*

2) *Report on the data situation at the Secretariat.*
   Specify data and information requirements that are necessary for the Working Party to meet its responsibilities for reporting to the WPDCS.

3) *Review of new information on the biology and stock structure of species of the relevant species, their fisheries and environmental data.*

4) *Review of stock assessment and other analyses relevant to the evaluation of the status of the stocks.*

5) *Management recommendations*
   If necessary, review of technical advice on management options, the implications of management measures and other issues.

6) *Research Recommendations*

7) *Review of coordination arrangements and promotion of collaborative research on the species and their fisheries.*

APPENDIX III: LIST OF DOCUMENTS

WPB-00-01 A general overview of the activity of the spanish surface longline fleet targeting swordfish (*Xiphias gladius*) in the Indian Ocean for the period 1993-1999. *B. García-Cortés and J.Mejuto*

WPB-00-02 Preliminary stock assessment of swordfish (*Xiphias gladus*) in the Indian Ocean. *Yokawa, K. and H. Shono*

WPB-00-04 Summary of predation surveys and research on tuna longline fishing in the Indian and the Pacific Ocean based on the Japanese investigation cruises (1954, 1958 and 1966-81). *Nishida, T. (editor)*

WPB-00-05 The Seychelles Swordfish Fishery / Programme d' actions pour la pêche palangrière Seychelloise en collaboration avec la France (Réunion). *Bargain,R.M., Vincent Lucas, Andrew Thomas*

WPB-00-06 French Swordfish longline Fishery in south west Indian Ocean: Preliminary results from the PPr Program. *Poisson F. and M. Taquet*

WPB-00-07 Assessment of Black Marlin and blue Marlin in the Australian Fishing Zone - Report of the Black and Blue Marlin Working Group.*Kalish, J., R.Campbell, T.Davis, B.Edwards, G.Henry, B.Lamason, J.Peperrell and P. Ward.*

WPB-00-08 Broadbill Swordfish: Status of World Fisheries. *Ward, P. and S. Elcott*

WPB-00-09 Brief synopsis of the biology of the black marlin, *Makaira indica*, with special reference to the Indian Ocean. *Pepperell, J.*

WPB-00-10 Brief synopsis of the biology of the blue marlin, *Makaira nigricans*, with special reference to the Indian Ocean. *Pepperell, J.*

WPB-00-Inf1 Structure and migration corridors in Pacific populations of the swordfish (*Xiphias gladius*) as inferred through analysis of Mitochondrial DNA.. *Reeb, C.A., L.Arcangeli and B.A. block.*

WPB-00-Inf2 Data and Biological parameter specification for a spatially structured operating model for Broadbill swordfish and Bigeve tuna in the south west Pacific. *Campbell, R.A. and N.A.Taylor*

WPB-00-Inf3 Preliminary stock assessment of the tuna and billfish resources within the western AFZ. *Campbell, R.*

WPB-00-Inf4 Synopsis on the Billfish Stocks and fisheries within the Western AFZ and the Indian Ocean. *Campbell R., G.Tuck, J.Pepperell and J.Larcombe*