Report of the Fourth Session of the IOTC Working Party on Tropical Tunas

Shanghai, People's Republic of China, 3-11 June, 2002

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Opening of the Meeting and Adoption of the Agenda

The Fourth Meeting of the Working Party on Tropical Tunas (WPTT) was opened on 3 June 2002 in Shanghai, People's Republic of China, by the Chairman, Dr. Geoffrey Kirkwood, from Imperial College, London, who welcomed the participants (Appendix I). The Agenda for the Meeting was adopted as presented in Appendix II. As recommended by the Scientific Committee, the WPTT gave priority to assessment of yellowfin tuna. The documents available for discussion are listed in Appendix III.

Review of Data Related Issues

Report of the Secretariat

Document WPTT-02-01, presented by the Secretariat, reviewed the status of the data on yellowfin, skipjack and bigeye tunas held by the IOTC Secretariat.

NOMINAL CATCH (NC) DATA

The nominal catch data series of yellowfin (YFT), bigeye (BET) and skipjack (SKJ) tunas are considered to be almost complete since 1950. Yellowfin and bigeye tunas are mainly caught by longlines and purse seines, while catches of skipjack tuna are reported mainly by purse seines, pole and lines and gillnets. Large increases in the catches of these three species have been noted since the mid-eighties.

The Secretariat conducted a major review of the NC database during 2001. This revision led to slight changes in the estimates of catches (not lower or higher than 10% of previous estimates) of the three tropical tuna species, especially since the mid-eighties.

Although the quality of the information on the three tropical tunas is considered in general to be fairly good, the completeness and accuracy of the records are compromised by:

- **Unreported catches**: several countries were not collecting fishery statistics, especially in years prior to the early seventies, and others have not reported their statistics to IOTC. In most cases, the catches of tropical tunas in those countries were probably minor. Nevertheless, the catches of some important longline fleets are unknown, as it is the case with the foreign longliners operating in Maldives and a fleet of domestic fresh tuna longliners operating in South Africa.
- **Underestimated catches**: catches of tunas and tuna-like species are sometimes reported aggregated[1]. When possible, the Secretariat estimates the species and gear composition of these aggregates but this cannot always be done reliably as the accuracy depends on the assumptions made during the estimation process. In addition, catches in several Indian Ocean coastal countries are probably underestimated as sampled landings are not raised to total catch. This is especially true in the case of Indonesia, Yemen and other coastal countries with important catches of tropical tunas.
- **Discrepancy between nominal catches and catch/effort data for the early Japanese longline fishery:** a discrepancy was found between the reported nominal catches and catch/effort information for the early (1950's) Japanese longline fishery. The current figures in the nominal catches database are lower than those calculated from the catch and effort database.

Uncertainty in the catches may occur in the following cases:

- **Fresh tuna longline fleets**: Although the catches of fresh tuna longline ships based in different ports of the Indian Ocean were re-estimated from data coming from past or recent sampling schemes operated, the accuracy of the estimates is still far from complete, especially in the case of fleets operating from ports not covered by these schemes or past catches estimated on the basis of recent estimates, very far in time.
- **Deep-freezing longline fleets**: Recent estimates of catches of deep-freezing fleets operating under different non-reporting flags, conducted by the IOTC, were possible thanks to an improvement in the reliability and coverage of the IOTC Vessel Record, especially in years prior to 1998. Nevertheless, the estimated catches remain approximations due to the many assumptions made in estimating the total catches and species breakdown.
- **Ex-Soviet purse seiners**: The catches of ex-Soviet purse seiners, operating under the flags of Panama and Belize in recent years, have not been submitted to the IOTC since 1996. The catches estimated since that year and, in particular, the species allocation, are likely to be more inaccurate than those of previous years.

[1] This is the case notably when data are not reported to the Secretariat and have to be taken from the FAO nominal catch database.

CATCH-AND-EFFORT (CE) DATA

The Secretariat notified the meeting that the implementation of validation and verification processes and the preparation and computerization of data recorded under heterogeneous spatial-temporal strata continued during 2001.

Catch-and-effort records are available for the main fleets fishing for tropical tunas in the Indian Ocean, namely baitboat (SKJ and YFT), purse seine (SKJ, YFT and BET) and longline (BET and YFT). Some gillnet fisheries produce substantial catches of tropical tunas, but the contribution of other gears to the total catches is very small, such that the lack of CE data is not important.

Catch-and-effort statistics from the Maldives are available since 1970. Data have been reported by species, month and atoll from 1970 to 1992 but are only available by species and month since 1993.

Catch-and-effort statistics are available for the main longline fisheries, since 1952 for Japan, since 1967 for Taiwan, China[2] and since 1975 for Korea. The statistics provided by Japan and Taiwan, China are in general considered accurate. Nevertheless, the inconsistencies found during the validation of data records for some years, involving the Japanese CE data for 1980 and Taiwan, China data for the period 1990-92, are still unsolved. Furthermore, the Japanese scientists informed on an ongoing review conducted in Japan regarding the longline fleet, aiming to give consistency to the data reported to the IOTC, by considering the changes recently made to the IOTC boundaries and changing the way in which catches and effort were processed. Thus, the CE data gathered at the IOTC refers to updated figures from 1998 to 2000 and former estimates for years prior to 1998.

Korean CE statistics are thought to be highly inaccurate. Many inconsistencies were found in the data, when comparing the catches in this database with those reported as nominal catches, for instance. The Secretariat recommends that this dataset not be used until these issues are resolved.

Catch-and-effort statistics are complete for European-owned purse seiners and those monitored by European scientists, as well as those from Seychelles. Statistics are also available for other countries including Mauritius, Japan and Iran. As is the case for the NC data, the CE data for the purse-seine fleet formerly under the Russian flag are inaccurate and, at this time, are only available to IOTC for short periods of the operation of this fleet.

SIZE-FREQUENCY (SF) DATA

The quality of the data is thought to be good for fleets under European monitoring, apart from the species and size composition for 1997-2000, which are likely to be less accurate due to problems in the sampling on those vessels reported to the Permanent Working Party on Data Collection and Statistics by the scientists responsible. Little or no data is available for Iranian, Japanese and ex-Soviet purse seiners. The size frequency statistics of Mauritian purse seiners have been updated this year being now complete since 1986. Baitboat fisheries have also been reporting size-frequency statistics to IOTC, for which quality is thought good.

For longline fisheries, however, only Japan has been reporting size-frequency data since the beginning of the fishery. In recent years, the number of specimens measured is very low in relation to the total catch and has been decreasing year by year. The size-frequency statistics available from the two other main longline fleets are either very incomplete (Taiwan, China for which only four years are available) or inaccurate (Korea), which invalidates their use. The recovery of size data from port sampling regarding fresh tuna longline fleets operating in Phuket, Penang and, recently, in Sri Lanka continued in 2001 and 2002, with many records input to the SF database.

The availability of size frequency statistics for gears other than pole and line, purse seine and longline is very low. Nevertheless, it is worth mention the recovery of Sri Lankan and Omani length frequency statistics referring to gillnet fisheries in these countries.

Estimation of catches of non-reporting fleets

Documents WPTT-02-02 and WPTT-02-03 present estimates of catches of non reporting fleets conducted by the IOTC thanks to new information available during the last year:

- **Indonesia:** Document WPTT-02-02 is about a major review conducted on the catches of Indonesian vessels in the Indian Ocean. The new catches of artisanal and industrial fleets estimated by the IOTC led to slightly lower catches in years prior to 1991 and much higher catches after that year. These changes in the estimates originated from:
    - **Re-estimation of longline catches**: The estimation of the catches of longline fleets was conducted on the assumption that previous data reported or estimated from the FAO databases were inconsistent due to underreporting of catches and aggregation of catches of domestic and foreign vessels as Indonesian. The new figures estimated were, thus, lower in years where most of the fleet was made up by foreign longliners and higher in recent years, in which all foreign longliners changed the flag to Indonesia. The catches of longliners from 1973 to 1981, previously recorded aggregated, were

[2] Taiwan, China refers to Taiwan province of China.

  estimated separately in order to complete the series. The number of ships and catches estimated for recent years, averaging 70,000 t, situate Indonesia among the most important fishing fleets in the Indian Ocean, second only to the Taiwanese fleet.
  - **Re-estimation of artisanal catches**: The catches of artisanal fleets in Indonesia were only estimated when they have not been reported to the IOTC, since 1993. The data recorded in the FAO databases were used to conduct the new estimates with new figures much higher than those previously estimated. Recent catches amount to more than 110,000 t.
- **Other non-reporting fleets** (NEI): Document WPTT-02-03 presents estimates of catches and number of ships active of fleets operating under different non-reporting flags. The increase in the number of non-reporting fleets in recent times has led to dramatic increases in the catches estimated, reducing in this way the quality of the data gathered regarding the yellowfin tuna, bigeye tuna and, less significantly, skipjack tuna.
- **Purse seine:** The catches of ex-Soviet purse seiners, operating under the flags of Panama and Belize, needed to be estimated since 1995 due to non-reporting. These catches were estimated on the basis of the number of purse seiners operating, previous catches reported and data coming from other purse seine fleets (European Community). Recent catches estimated are around 35,000 t.
- **Fresh tuna longline**: The catches of fresh tuna longliners were estimated according to the port where the different fleets were based. Most of the catches estimated are from Taiwanese longliners according to the information available.
  - **Indonesia**: The catches of foreign fresh tuna longliners based in Indonesian ports were estimated on the basis of catches of domestic vessels. The catches estimated refer to the period 1986-99 with highest catches estimated in the early nineties (around 30,000 t). No foreign fresh tuna longliners have been operating in Indonesia since 1999.
  - **Thailand**: The catches of fresh tuna longliners from Taiwan, China and Indonesia unloaded to processing plants in Phuket were estimated according to the data collected through the AFDEC (Andaman Sea Fisheries Development Centre)-IOTC Sampling Program implemented in 2000. The new catches estimated range from the 700 t in 1994 to 3,500 t in 2000.
  - **Malaysia**: The catches of fresh tuna longliners based in Malaysia were estimated on the basis of previous data recorded (IPTP Sampling Program) and new estimates from Phuket. The series 1989-2000 was estimated with catches ranging from 10,000 to 35,000 t. More accurate estimates will be available from sampling data, which have been collected by FRI (Fisheries Research institute) of Penang since 2000.
  - **Sri Lanka**: The catches of fresh tuna longliners unloading to processing plants in Sri Lanka were estimated on the basis of previous data collected by NARA (National Aquatic Resources Research and Development Agency) in Colombo and estimates from Phuket and Penang sampling. Catches ranging from 300 to 3,500 t were estimated for the period 1990-2000.
  - **Other fleets:** The catches of Indonesian longliners based in Victoria (**Seychelles**) were estimated according to the number of ships reported by the SFA (Seychelles Fishing Authority) and data coming from sampling in Phuket. The catches of fresh tuna longliners based in **Maldives** and **South Africa**, on the contrary, were not estimated due to lack of reliable information on their numbers and activity.
- **Deep-freezing longline**: The catches of large longliners from several non-reporting countries were estimated on the basis of the number of vessels (from the IOTC vessels record) and the catches of Taiwanese longliners, on the assumption that most of the vessels operated as in the same manner as the longliners from Taiwan, China. New information obtained regarding these non-reporting fleets during the last year, especially concerning the number of longliners operating, led to better estimates of catches. Current catches are estimated to be close to 55,000 t.

Review of new data on purse seine fisheries

Document WPTT-02-04 presents the French purse-seiners activities in the Indian Ocean since 1981, including effort, catch by species and fishing mode, catch per unit of effort, sampling and mean weights for the main species. Although there were some changes in the fleet composition, the fishing effort remained relatively stable in 2001. However, there was a reduction in the number of the log school sets (-16%) compensated by an increase in the number of free school sets (15%). Total catches in 2001 have dropped by 10% compared to the previous year. This reduction, however, is not homogeneously distributed among set types or species (catches of yellowfin increased by 21% and declined for all other species). The sampling of year 2001 returned to a satisfactory basis allowing the traditional processing methods to be used to estimate species composition of the catches. The average weights of yellowfin and bigeye tunas in school sets have increased, while they have remained stable on log sets.

Document WPTT-02-28 presents summary statistics of the purse seine Spanish fleet fishing in the Indian Ocean from 1984 to 2001. In 2001 the number of boats remained at 17 units but the total catch decreased by about 12%. This reduction is mainly attributed to a decrease (25%) in the catch from higher-yield log school sets, in spite of an increase of 32% of the catch from lower-yield free school sets. Bigeye catches decrease the most (26%). The fishing area was limited to FAO area F51. The mean weight in the free school catches increased for all the three species, while it decreased in catches on floating objects.

Document WPTT-02-06 presents summary statistics of the purse seine fleets fishing in the Indian Ocean covered by the EC sampling scheme, combining French, Spanish, Seychelles and NEI vessels, from 1984 to 2001. In 2001 there were a total of 50 purse seiners and 8 supply vessels. The total catch was 292,605 t, 12% less than in the previous year. The catch on floating objects (190,382 t) decreased by 20% while the catch on free schools (102,223 t) increased by 11%. Bigeye catches decrease the most (24%). The fishing area was limited to FAO area F51. The mean weight in the free school catches increased, while it decreased in catches on floating objects.

It was suggested that the reported changes in set and catch composition of European purse seiners might be the result of the decline in prices of skipjack tuna, which would create incentives for the fleet to target mainly yellowfin tunas and to apply effort in less traditional areas. However, it was argued that skipjack prices might not have decreased in all EU markets and that, in any case, this reduction took place since March 2001. In spite of this, the same trend (increase in proportion of school sets and yellowfin catches) is apparent in all European fleets. It is possible, therefore, that an area effect may also be operating.

Document WPTT-02-16, containing a collection of figures displaying several aspects of the purse seine fishery in the Indian Ocean from 1982 to 2001 was presented for discussion and as background information for the WPTT.

Document WPTT-02-31, containing a description of the purse seine landings in Phuket, Thailand from 1993 to 2001 was presented to the WPTT. The annual landings (all gears) of tunas in Phuket from 1993 to 2001 varied from 1,750 t to 34,032 t. The purse seine landings show a slight declining trend in 1995-1997, followed by a sharp increase in 1998 and another declining trend since 1999. The catch, effort and CPUE for Japanese surface fisheries show a slight decline from 1995 to 2001, with peaks during the northeast monsoon seasons. EU purse seiners have been landing and transshipping to carriers in the port of Phuket since 1994. In 1998 about 24 EU purse seine vessels fishing in the eastern Indian Ocean landed in Phuket. The species composition of the landings of Thai, Japanese and EU purse seiners ranges from 62-68% of skipjack, 20-30% yellowfin to 7-16% bigeye tunas.

Although no explicit figures were provided, it was indicated that tuna from purse seine activities also end up in the Thai domestic market when rejected for various reason by fish carriers or canneries. The tuna rejects seem to increase during the monsoon season.

Document WPTT-02-25 analyzes catches of yellowfin by size and weight category, paying special attention to the intermediate sizes rare in the purse seine catch. Three weight categories have been established (less than 10 kg, 10-30 kg and more than 30 kg) in order to track the different components of the stock: juveniles (32% of the catch), pre-adults (17%) and adults (51%). Intermediate sizes are mainly caught from July to September (36.4% of the annual catch) and these sizes are more abundant in Somalia, NW Seychelles and Arabian Sea areas, 55.2% of the catches come from floating objects. Three hypotheses are postulated to explain the low presence of catches of intermediate sizes in the purse seine fishery: migration, behaviour and two-stanza growth pattern. The document also presents changes in selectivity due to exploitation and especially to the increasing purse seine effort particularly on floating objects.

It was indicated that the bi-modality of the size distribution of yellowfin catches from purse seiners also exists in the Atlantic Ocean, but this does not seem to be the case in the Pacific Ocean. However there is evidence that the two-stanza growth model applies to the yellowfin in the Indian, Atlantic and Eastern Pacific Oceans. Nonetheless, the other two hypotheses described earlier cannot be ruled out.

Document WPTT-02-20 presents results from information collected by observers on purse seiners and auxiliary boats during the self-imposed moratorium during November 1998 – January 1999. This information was used to estimate the characteristics of FAD deployment and turnover performed by the fleet. FAD deployment included the number of FADs deployed and the number of floating objects found that were marked with a buoy. Twenty-two vessels released a total of 380 FADs during the study period (266 man-made and 114 natural floating objects that were marked with a buoy). These 22 vessels found a total of 191 not-owned FADs at sea that they re-marked with their own buoys, classed as turnover. These results should be interpreted with caution, because data collection was opportunistic and not specifically designed for this study. For this reason, the numbers obtained may underestimate the actual number of FAD inputs and turnover. It is not known whether anomalous behaviour due to the moratorium made the fleet deploy a different number of FADs than in normal conditions.

It was indicated that FAD technology has changed rapidly in the past years and that the type of FADs described in this document has become obsolete. The FADs currently used by the EU purse seine fleet include devices like echo-sounders coupled with satellite data transmission equipment and can be polled remotely. Nevertheless, the WPTT indicated that our current knowledge of FAD and support vessel operations is very limited, and welcomed the information presented in this study. The WPTT encourages further studies on this area.

Document WPTT-02-21 presented an updated analysis of observer data available from the 1998-1999 moratorium in the Indian Ocean, giving information on the number, type and spatial location of the totality of fishing operations performed. An eastward migration of the fleet was observed, with an average yield of 21.6 t per successful set for free school fishing (the main modality used). Skipper estimates of species composition in the catch were compared with observer sampling, showing that skippers underestimate both yellowfin and bigeye tuna in a significant manner in FAD-associated catches. The amount and species composition of discarded tuna is presented. 0.21% of yellowfin, 0.37% of bigeye, and 4.69% of skipjack were discarded. The size frequency distributions of discarded tuna are provided, showing that almost all SKJ discarded was smaller than 1.5 kg. Other observed bycatch species are also listed.

The WPTT considered the type of information presented in this document important, since it can fill important gaps in the current data situation for these species. It is not clear, however, whether the information presented in the document could be applied in a non-moratorium scenario. The WPTT also encouraged further efforts to keep collecting this kind of information.

Review of new information on longline fisheries

Document WPTT-02-08 presents data and a discussion on the trends of longline and purse seine fishery in the Seychelles waters. Since 1997 there has been a decline in the number of longliners licensed to fish in the Seychelles. The main nationalities applying for licenses are Japan, Taiwan and South Korea. The logbook analyses indicate that Japanese fleet targeted bigeye tuna until 1990 and yellowfin tuna thereafter. Yellowfin CPUE for yellowfin fluctuates from 0.25 to 0.36 Kg/Hook, while bigeye CPUE has shown a declining trend from 0.20 Kg/Hook in 1994 to around 0.12 Kg/Hook in 2001. The catch composition of the Taiwanese and South Korean fleets shows a predominance of bigeye tuna in the last four years, with catch rates fluctuating around 0.15 Kg/Hook for bigeye and 0.10 Kg/Hook for yellowfin. The Seychelles longline fleet targets mainly swordfish. Data from this fishery produce catch rates of yellowfin and bigeye around 0.12 Kg/Hook. Length frequency distribution of yellowfin tuna from the Seychelles fishery shows a declining trend of 20 cm in the fork length from 1996 to 2002. Analysis of predation rates by sharks and the false killer whales show that around 20 to 15% of the yellowfin catch were loss to predation during the last 2 years. The number of EU purse seiners active in the Seychelles waters has increased from 30 to 49 vessels from 1984 to 2001. Non-EU vessels (Iran, Japan, Mauritius and Russian) applied for licenses to fish in the Seychelles waters in 1990. There has been a downward trend in the number of the non-EU vessels active from 1992 to 2001. Analyses show that non-EU purse seiners have been fishing mainly on FADs and their catches are dominated by skipjack.

The question of the large difference between catch rates for yellowfin of the Japanese and Taiwanese was raised. It was considered that differences in targeting were the most likely explanation, with the Japanese fleet targeting yellowfin while the Taiwanese fleet is targeting mainly bigeye. However, the use of different gear configurations (e.g.. setting speed) was also suggested as possible factors affecting the estimates.

Document WPTT-02-09 presents preliminary results of a joint research program between the Seychelles Fishing Authority (SFA), IFREMER and the French government, to study the longline fleet targeting swordfish in Seychelles' EEZ. This fishery also catches non-target species like yellowfin and bigeye tunas. Nine longline trips and 77 sets were conducted with the SFA's research vessel; the longlines were equipped with hook timers and temperature/depth recorders to estimate the time, depth and the survival rate of the catch. The longlines were set after sunset and hauled the following morning. Analysis of the yellowfin tuna data shows that most of the fish were caught during the 4 hours following sunrise (6 to 9 am). Survival rate of yellowfin was about 51.2% and the survival period was 4 hours after the time of the catch. Sex ratio for 123 yellowfin tunas sampled was 1.42 (male/female); the mean length for the males was 112.8 cm and 111.35 cm for the females.

It was remarked that these results are preliminary and that more research and analyses are needed to explain many of the results and/or anomalies present in the data.

Document WPTT-02-32, containing a description of the longline landings in Phuket, Thailand from 1994 to 2002 was presented to the WPTT. The annual landing (all gears) of tunas in Phuket from 1993 to 2001 varies from 12,750 t to 34,032 t. The longline landings show a slightly increasing trend since 1994. About 500 longline vessels, mainly Taiwanese, Chinese and Indonesian were recognized operating in the area since 1994. The highest total landing (4,373 t) was recorded in 1999. Fishing takes place mainly in the eastern Indian Ocean during the north-east monsoon season. Yellowfin tuna was the dominant species in the catch of the Taiwanese and Indonesian fleets, while bigeye tuna dominated the catches of the Chinese longliners.

It was noted that most of the swordfish and tuna rejected in the export market ends up in the local Thai markets. It was estimated that about 20-30% of the swordfish, tuna and tuna-like species follow this route.

Document WPTT-02-36 containing a report on the status of oceanic tuna landings from the Indian Ocean at Penang, Malaysia, was presented and discussed. Tuna landings show a declining trend from 1990 (9,543 t) to 2001 (4,447 t). In

2001, 127 longliners (95% of them with Taiwanese flag) landed catches from the eastern Indian Ocean in the port of Penang. A marked seasonal pattern is observed, with most landings taking place during the north-east monsoon (September-March). More than 50% of the landings were yellowfin, followed by bigeye (30-40%) and other species (10% pooled).

The operating pattern of the longline fleet off Malaysia was discussed. It was indicated that it is common for some longline vessels to also act as fish carriers (bring to port the catches of other vessels). The level at which a given vessel acts as a carrier or a normal longline varies among vessels and among trips for the same vessel. It was suggested that this situation could potentially introduce errors and complicate the estimation of fishing effort. It was indicated by the Secretariat that an analogue situation occurs in the longline fleet operating off Indonesia.

Document WPTT-02-37 presents recent trends of Japanese tuna fisheries in the Indian Ocean up to 2000. In 1999, Japanese longliners achieved 20% reduction in the number of distant water longline vessels. The total effort reduced from 125 million hooks in 1997-1998 to around 100 million in 1999-2000. Longline catches for each species in 2000 (1999) were 3,771 t (4,956 t) for southern bluefin, 2,406 t (2,324 t) for albacore, 12,511 t (14,105 t) for bigeye and 14,260 t (15,088 t) for yellowfin tuna. Regarding to Japanese purse seine fishery, the fleet has decreased from 10 vessels (1991-1993) to only two in 2000. Total fishing effort (operation days + searching days) of purse seine increased from 349 days in 1989 to 2393 days in 1992, and decreased to 320 days in 2000. Nearly 100% of operations were made on FAD-associated schools in 2000. Total purse seine catches in year 2000 for each species were 2,327 t, 952 t and 747 t for skipjack, yellowfin and bigeye, respectively.

The question of why catches of yellowfin have increased in recent years in spite of the higher market prices of bigeye was raised. It was observed that Japanese longliners might still be targeting bigeye, since they are apparently using deep longline gears. It was indicated that the depth of the lines can be controlled by the speed at which it is set as well as the material, so the number of hooks per basket is not necessarily a good proxy to identify target species. It was indicated that although market prices of bigeye are higher, yellowfin is still a highly valuable and attractive target. It was also remarked that a possible indication of a change of targeting from bigeye to yellowfin is that the fleet operations shifted towards the western Pacific Ocean, where CPUE of yellowfin is higher than in other waters.

Document WPTT-02-10 contains a brief report on Taiwanese tuna longline fisheries operating in the Indian Ocean. The number of Taiwanese frozen tuna longline vessels in the Indian Ocean, on average, was about 340 during 1998-2001. The mean annual catch of tuna and tuna-like fishes was stable and maintained at about 100,000 t over the past 5 years. Major species caught were albacore, bigeye and the yellowfin tunas accounting for more than 76% of the total catch. The major fishing grounds of this fleet were distributed in areas of 10°S-10°N/30°E-95°E and 25°S-35°S/30°E-95°E. The number of fresh tuna longline vessels was estimated to be about 1,700 during 1997-2000 (including vessels operating in both the Pacific and the Indian Oceans). Total catch of bigeye and yellowfin tunas unloaded in foreign bases in Indian Ocean were stable and estimated to be about 9,300 t, on average, for bigeye tuna, and about 14,500 t for yellowfin tuna during 1997-2001. Implementation of several management measures including bigeye catch certificate, vessel monitoring system and observer program also were reported.

It was indicated that data for the estimates of catches from offshore longliners comes from several sources, including custom information for fish exported to Japan and logbook data. The current coverage of logbook data is close to 20-30% of the frozen tuna longliners.

The question of the possibility of double-counting and reporting was raised, since other countries seem to be collecting information and logbooks for the Taiwanese fleet operation from their ports (*e.g*. Thailand). It was indicated that from the point of view of the Secretariat this does not represent a problem because data for the large Taiwanese longliners are reported by Taiwan, while data for the smaller vessels (fresh tuna) are being obtained by the other countries and/or through the IOTC sampling programs.

Document WPTT-02-38 prepared by the Secretariat containing a graphical summary of the major industrial longline fleets operating in the Indian Ocean was presented as a background document to the WPTT. The document displays charts and graphics describing several aspects of Japanese, Taiwanese and South Korean fleets, including spatial and temporal distribution of the effort, catches, catch by species, and trends on average weight of bigeye and yellowfin tunas.

Review of new information on the biology and environment of tropical tunas

Seven documents dealing with sex ratio, growth, trophic ecology, and habitat were presented and discussed by the Working Party.

Document WPTT-02-15 analyses the sex ratio at size from biological sampling carried out on 1792 yellowfin tunas by ORSTOM (presently IRD) and SFA at the Seychelles cannery during the late 80's and early 90's. The sex ratio is about 50% for sizes below 150 cm FL, with an increase in the proportion of males thereafter. Compared to other oceans (146 cm in Atlantic, 134 cm Eastern Pacific), this increase occurs at a late stage. Provided a relative low number of fish greater than 150 cm in the Indian Ocean purse seine catches, the sex ratio of these catches is well balanced. Combining the sex ratio at size with size distribution of the catches produces different situations among oceans. In the Eastern Atlantic Ocean catches are dominated by males (61% in weight) with a slight dominance of females for fish in the range of 125-140 cm. This pattern does not seem to appear in the Indian Ocean.

It was recognised that continue sampling is necessary, as the basic assumption is that sex ratio has been constant over time. Samplings on longline catches done by observers in Chagos Island seem to support the conclusions of this document. It appears that sampling made from purse seine catches does not introduce any bias on large sizes as the maximum sizes exploited by purse seine and longline are the same.

Document WPTT-02-18 presents a growth study of yellowfin based on length frequency data and modal progression analysis, with sizes ranging from 30 to 180 cm. There are presently two hypotheses on yellowfin growth: (i) that it follows a Von Bertalanffy model (assuming a constant growth rate); and (ii) that it follows a two-stanza pattern (assuming a variable growth rate). Two individual and pooled data sets (size data from EU purse seine catches and size data from the gillnet catches of Oman and Iran) were fitted to five growth models. Unlike the Arabian Sea gillnet fisheries, intermediate size fishes (75-95 cm) are not caught by the present purse seine fishery. The best fit obtained support the hypothesis of a two-stanza growth pattern. For the small sizes (< 60 cm FL) the growth rate is around 1 to 1.3 cm/month. For fish greater than 60 cm FL, the two data sets produce very different growth rates: 4.8 cm/month from purse seine data, 2.5 cm/month from the pooled data set. The comparison with tagging data from Maldives superimposed on the two growth curves suggests a better fit with the slower growth rate of the pooled data set.

Document WPTT-02-22 also addresses yellowfin growth, but in using a different method (MULTIFAN) based on a Von Bertalanffy growth model. The estimated values for K and L_{inf} were respectively 0.14 and 214.5 cm, but the value of the penalty functions indicates that the fit may not be adequate. The relevance of the method was tested on several simulated data sets. These were built in a way to encompass different hypotheses on age selectivity, recruitment and errors on the mean length at age (MLA). It appears that a high accuracy of the estimated K and L_{inf} can obtained in some cases even when the penalty functions are high. The highest departures from the initial values are present in the cases where continuous recruitment (over 5 months), age selectivity and errors in MLA are considered. According to current knowledge, yellowfin meets all three conditions, but the parameters used in the simulation do not necessarily reflect the reality for yellowfin. More precise simulations should be done before assuming that the application of MULTIFAN to these data might provide reliable estimates.

Document WPTT-02-29, a review of biological studies on yellowfin made by the Fishery Survey of India, was presented briefly as the authors were not present at the meeting. This review covers various topics: length frequency of longline catches, length-weight relationships, growth parameters, natural mortality, feeding habits and reproduction. A stable mean weight of yellowfin (34 to 42 kg) over the years is noticed in Indian waters (including Nicobar). Regarding growth, different estimates of K and L_{inf} are proposed, from studies carried out in different regions. There has been extensive work carried out on the diet from gut contents and detailed information on prey species is presented. Squids dominate the diet in most of the areas, especially during April-June in the Arabian Sea, Bay of Bengal and Andaman and Nicobar waters. Pelagic crabs are also well represented together with squids. Fish dominate during July-September, and they cover about 22 families, indicating a high diversity of preys and the non-selective nature of the foraging strategy.

Document WPTT-02-24 presents the current status of research activities undertaken by IRD for a better understanding of the predator-prey relationships of the offshore tropical ecosystems, with emphasis on top-level predators diet. The data collection of stomachs of tuna and other competing high-level predators will continue until 2004. So far, 722 stomachs have been collected in the whole Western Indian Ocean and 232 have been analysed. In the equatorial region, the major feature is the dominance of crustaceans over fish and cephalopods in the tuna diet. The mantis shrimp *Natosquilla* sp. is the dominant prey species, followed by the swimming crab *Charybdis edwardsii* and the cigar fish *Cubiceps* sp.

The diversity of prey found in tuna stomachs does not appear as high as in other areas close to islands or land masses, like in the Andaman Sea or off India. The opportunistic feeding behaviour of yellowfin is also evident from this document, with diets that might rely of seasonal or local abundance of some prey. A comparison with an equatorial region of the Eastern Atlantic suggests that food chains in these offshore ecosystems could be short, and that tuna may have lower trophic levels than expected.

Document WPTT-02-33 is an analysis of the changes affecting the depth of habitat of yellowfin tuna, at interannual time scale, for the period 1955-2001. Two variables are selected to define the habitat: depth of the 20°C isotherm (Z20) that defines the core of the thermocline, and a derived depth of the 2ml/l dissolved oxygen concentration (Zox2) that defines limit conditions to vertical distribution. The Zox2 is deducted from temperature at depth data, using a correlation between temperature and oxygen. Such changes in habitat depth can potentially affect the catchability. There is a clear pattern of variability with out-of-phase fluctuations between East and West of the ocean. During the El Niño warm phase, there is a deepening of the thermocline and Zox2 in the West and a subsequent shoaling in the East. The largest anomalies takes place between 50°E and 70°E (Western Indian Ocean), where major yellowfin fishing

grounds for purse seine and longline are located. Two frequency domains are discernable in the time series of both parameters: a quasi-quadrennial oscillation that is likely to be linked to the ENSO dynamics, and a longer cycle around 25 years. No particularly trend is shown on the long-term; however the length of the series is still too short to address interdecadal fluctuations. The year-to-year changes in depth of limit conditions of the yellowfin habitat ranges between 5 and 50 meters.
The question of incorporating Z20 or Zox2 in the standardization procedure of CPUE from LL data was raised. It was indicated that although fluctuations of the thermocline and dissolved oxygen would affect catchability, they might also affect abundance, at least at a local level, and that it would be hard to discern between these two effects. Also, current fishing strategies of longline fishers take into account environment variability and could change the gear configuration to maximize catch under these situations. Finally, it was pointed out that Zox2 is a composed index computed from temperature, which is already included in the current standardized CPUE estimates.
Given the previous considerations, it was agreed that the inclusion of these parameters is not likely to substantially change the pattern of the estimated CPUE, however the question of their use in future analyses should still be evaluated.

Review of new data on predation by marine mammals

Document WPTT-02-34 summarizes the results of the predation survey conducted by the Japanese commercial tuna longline fisheries during September 2000-November 2001. Predation refers to attacks of hooked tuna and billfishes by false killer whales and killer whales (34% of the attacks) and sharks (64 %). Tuna species represent 89% of the predation. The overall predation rate represents around 3% of the catches, while predation rate on sets with predation represents around 13% of the catches. The document indicates that the reported predation rates are likely to be underestimated because not all longliners report predation records. There is a need to carry out more survey, to stratify the analysis spatially and to start implementing and testing mitigation methods.
It was remarked that the higher predation rates come from sharks rather than from killer (or false killer) whales. It was also argued that while shark populations have been reduced through fishing pressure, overall predation rates might remain high because toothed whales could be occupying the niche of the reduced shark populations.
Scientists from the Seychelles Fishing Authority indicated that they are currently collecting information about predation on longline. Analyses of logbook data from Seychelles domestic longliners (see document WPTT-02-08) indicate rates in the order of 15-20% of the overall tuna catches. It was observed that these rates are higher than those reported for the Japanese fleet in document WPTT-02-34.
It was emphasised that predation of fish caught in longlines deserved further studies and perhaps taken into account in the fishing mortality for stock assessment in the future.

General discussion on data related issues for tropical tunas

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

- Poor knowledge of the catches, effort and size-frequency from fresh tuna longline vessels, especially from Taiwan, China and several non-reporting fleets.
- Poor knowledge of the catches, effort and size-frequency from non-reporting fleets of deep-freezing tuna longliners, especially since the mid-eighties.
- Lack of accurate catch, effort and size-frequency data for the Indonesian longline fishery in recent years.
- Poor knowledge of the catches and lack of effort and size-frequency data for ex-Soviet purse seine boats flying flags of convenience in recent years.

A discrepancy between the nominal catches and catch/effort data has been detected in IOTC's database for the early years (1950's) of the Japanese longline fishery. The current figures in the nominal catches database are lower than those calculated from the catch and effort database. It has been recommended that the erroneous nominal catches (not only for yellowfin, but for all species) be replaced with corrected data provided by Japan.
For the analyses carried out by the WPTT, the data available at the Secretariat on catches of yellowfin tuna by Japanese longliners for the period 1952-1970 longliners were replaced by the series used in 1991 by the IPTP Working Group on Yellowfin Tuna Stock Assessment. The previous data, originated in FAO, were not used by the WPTT as it was evident that they represented a severe underestimation of the actual catches for this period by Japanese longliners.

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

1. **A better level of reporting**: NC, CE and SF information have been obtained for Omani vessels for some years and species. Sets of CE and SF statistics provided by Korea were integrated to the IOTC databases, although their quality is thought low.

2. **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 and to new series of NC data for some countries.
3. **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.
4. **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.
5. **Recovery of historical activity and size data from processing plants**: The collection of historical information from operators in different ports of the Indian Ocean has continued since last year. Some 200,000 individual fish weight records by species have been retrieved to date for 1998 to 2002.
6. **IOTC sampling programmes**: The collection of information on the activities of fresh tuna longliners landing in Phuket and Penang has continued during 2002. 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. Sampling is also carried out in Sri Lanka since March 2002; fresh tuna longliners have been operating in this country since the early nineties.
7. **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. The data retrieved during the first trips to Indonesia, in the scope of this cooperation, permitted to conduct more accurate estimates on the catches and crafts operating in this country since 1970. Sampling of landings of fresh tuna longliners operating in this country is scheduled to start by July this year and will allow raising more precise estimates.
8. **Korean CE and SF**: The series 1990-2000 of SF for yellowfin and bigeye tunas and 1999-2000 CE statistics reported last year by Korea was input to the corresponding IOTC databases after removal of inconsistent data.
9. **Oman CE and SF data**: Oman has submitted CE statistics of vessels operating gillnets from 1987 to 2000 and SF statistics of yellowfin tuna from 1986 to 1994. The recovery of more information is expected in the near future.
10. **Mauritius SF data**: New size frequency statistics retrieved for the Mauritius purse seine fleet were input to the database completing the series from 1989 to 2000.

The status of the current data situation for each of the species can be summarised as follows:

YELLOWFIN AND BIGEYE TUNA

NC data: Relatively well known for most purse-seine fisheries and the main longline fleets (Japan, Korea and Taiwan, China). Catches of non-reporting longline and purse seine fleets are still uncertain, although they are believed more accurate than past catches estimated. Artisanal catches are uncertain, although they are not considered large, with the possible exception of gillnet/longline and other coastal fleets where the catches are reported under “other species” groups, especially for early years. It has been recommended that apparently erroneous nominal catches (not only for yellowfin, but for all species) for the early (1950’s) Japanese longline fleet should be replaced with corrected data provided by Japan.
CE data: Well known in the purse-seine fisheries and the main longline operations (Japan, Korea and Taiwan, China). Nevertheless, the Korean data are thought inaccurate. No catch-and-effort statistics are available for non-reporting longline and purse seine vessels.
SF data: Data for the period 1997-2000 from the EU PS sampling is considered less accurate. Sampling coverage from Japan and Korea is low in recent years. The only data available regarding non-reporting fleets are from sampling in Phuket and Penang. No SF data are available from Taiwanese vessels since 1989. Little information is available on important artisanal catches (e.g. Oman, Pakistan, Yemen and Comoros).

SKIPJACK TUNA

NC, CE and SF data: Relatively well known for most purse-seine fisheries. Data are available for the important artisanal fishery in Maldives. Artisanal components (not well known) are important for this species. In several coastal countries the catches are not reported by gear.

Review of the Report of the Working Party on Methods

The WPTT was briefed about the conclusions and recommendations produced by the *ad hoc* Working Party on Methods (WPM), which met earlier. The briefing was documented by the report of the WPM, listed as IOTC-SC-02-04.

The main issues discussed by the WPM were (i) use and development of an operating model, (ii) review of stock status indicators, (iii) review of procedures for raising size frequency and catch effort data to total catch, (iv) methods for standardisation of catch and effort data[3] and (v) ecosystem management.

The WPM identified several stock status indicators; however no strong recommendations are possible until the robustness of these indicators can be tested.

The WPM indicated that it is clear that there are gaps in the data, and that important assumptions have been made during the process of raising catch and size frequency data to total catch at size. In this issue, the WPM recommends the construction of methods that fit existing data rather than the use of methods that estimate the missing data. It addition, not all the data available are being used in assessments, and there may be scope for considering what data could be incorporated (*e.g.* mean size data for bigeye tuna).

It was indicated that there is a strong pressure to adopt ecosystem-based approaches for management, although practical tools to achieve this are still missing, in particular for migratory pelagic species. It was agreed that IOTC should, at least, be aware of relevant initiatives in other commissions and fora, and that scientists involved in ecosystem studies should be encouraged to bring the results of any new research on this subject to the attention of IOTC.

The WPM recommended the development of an operating model for testing robustness of assessment and assessment-related methods and procedures. In addition, it was indicated that an operational model could also be used to asses how the raising of catch and size frequency data affects our perception of the stocks. This recommendation was endorsed by the Working Party in Tropical Tunas.

[3] Discussion of this item is deferred to a later section titled *Standardization of longline and purse seine CPUE data.*

Assessment of the stock of yellowfin tuna

Standardization of longline and purse seine CPUE data

The WPTT, recognizing the importance of agreeing on the indices of abundance to be used in the stock assessment, decided to assign to a small subgroup the task of looking at possible additional analyses of the datasets available. The purpose of these analyses was to better understand the trends of the different indices proposed and to improve the indices where possible.

Prior to the work of the subgroup, documents relevant to the calculation of indices of abundance were reviewed by the WPTT.

Document WPTT-02-14 presented a preliminary analysis of Chinese large longline vessels CPUE over 1999 - 2001. These vessels operate mostly in the western Indian Ocean. Nominal CPUE for bigeye and yellowfin tunas in 2001 were 4.39 and 2.83 fish/1000 hooks respectively. For bigeye tuna, the catch rate was comparable to the Japanese LL catch rates. For yellowfin tuna, it was lower than the Japanese CPUE.

Document WPTT-02-26 reported on the development of GLM to standardise fishing effort of the Spanish and French purse seine fleets. The models included year, country, vessel category and age as explanatory variables.

It was emphasized that the resulting standardized effort series should not be used just to calculate CPUE, but rather be considered a measure of nominal fishing effort. As it was explained in the document, due to the lack of data, the GLM cannot effectively describe effects in changes or improvements in vessels' technical equipment boat that can increase their efficiency.

Document WPTT-02-27 presented a new method for the standardization of yellowfin tuna CPUE of the Spanish purse seine free school. A Delta-Lognormal method was used in which separate models for the probability of non-zero sets (assumed to follow a Bernoulli distribution) and catch rate in non-zero sets (assumed to follow a lognormal distribution) were combined to give standardised CPUE.

One of the problems identified by the paper was the difficulty of obtaining good estimates of effort directed separately at free schools and FADs. Vessels use a combination of search patterns depending on area and time of year, and only report total effort. For instance, they may be searching for free schools but at the same time opportunistically fishing FADs whose location they know. In the analysis presented in document WPTT-02-27, the amount of effort directed at free schools was inferred using total purse seine effort and the proportion of catch that was taken from free schools.

The WPTT recognised that the analysis of CPUE for purse seine is a complex process, both in model design and in understanding which of the many factors involved in successful targeting of tuna by vessels is of importance. In the absence of complete information on the separation of FAD and free-school fishing, and considering the very rapid changes that are now occurring in the technology of fishing on FADs, it might be easier to interpret CPUE changes over time if the analysis was restricted to an area where fishing is predominantly on free schools.

Document WPTT-02-12 presented standardised CPUE for yellowfin tuna from the Japanese longline fishery. The final model included year, month, area, gear, and sea-surface temperature (SST) as explanatory variables, with year-area, month-area, month-gear, area-gear, and area-SST interactions. Data from the 1950s were omitted from the analyses because in these years catchability was quite variable and the fishing was more heterogeneous by area than in later years. Nevertheless, the WPTT suggested that it would be useful to see the series extended back to the start of the fishery (1952). It also considered useful to examine standardized CPUE trends for each of the individual Indian Ocean areas defined in the paper, a "tropical" area and the whole Indian Ocean to examine consistency of the CPUE series.

Additional factors which could be included in the model were identified as local fishing effort and the temperature at various depths. However, it was noted that despite the very complex GLM now being used, the trend in the standardised CPUE was very similar to the (non-standardized) nominal CPUE. The major effect of standardisation appears to have been to increase the overall size of the decline in CPUE (21 in 1960 to 2.5 in 2000) as compared with the nominal CPUE trend (14 to 2).

Japanese longline catch rates for yellowfin tuna in the Indian Ocean were standardised for the years 1960 to 2000 using generalized additive models (GAM) in document WPTT-02-11. Model terms included year, month, number of hooks between floats, sea surface temperature and the Southern Oscillation Index. GAM analyses were carried out using a logistic regression with a binomial response for the presence/absence data and a Gaussian response for the catch abundance data. The significance of the various model terms differed between the presence/absence and abundance models. The temporal trends estimated by the models suggest a decline in relative abundance in the early years between 1960 and 1980, thereafter remaining relatively stable at these lower levels in the 1980s and 1990s.

It was noted that latitude and sea surface temperature might be expected to be highly correlated, and therefore may not be mutually informative. However, the presentation of individual parameter effects in the GAM plots is very useful when interpreting these sorts of interaction effects within GAM models.

Document WPTT-02-19 presented a method for classifying Taiwanese longline sets as deep or shallow (in the absence of hooks-per-basket information). The results are discussed in the report of the WPM.

Document WPTT-02-30 reported a standardisation of the Taiwanese CPUE using year, quarter, area and the CPUE of albacore and bigeye tuna as explanatory variables. The Taiwanese and Japanese CPUE series agree in their general trends and in the timing of some of the peaks and troughs.

The WPTT suggested that it would be useful to agree on a common set of area definitions and re-run both models so that the results can be directly compared, especially since there are significant area effects in the Japanese GLM (see document WPTT-02-12).

Accordingly, the Taiwanese and Japanese data were re-analysed to produce four series, one for each of the fleets for the tropical area and the whole Indian Ocean, extended back to the earliest data in each series and using the same area definitions for each fleet (see Figure IV.1). Since the standardization described in WPTT-02-12 included a year-area interaction term but those in WPTT-02-30 did not, this term was included in all four new standardized series.

There is good agreement between the resulting standardised CPUE series (Figure IV.2) for the two fleets in both areas. However, the WPTT noted two features of the trends that were difficult to interpret. The first is the initial steep decline in CPUE, at a time when catches were relatively low and stable. Secondly, CPUE has been stable since the late 1970s, despite catches rising strongly (6-fold) during the 1980s. This pattern does not correspond well with the expected response of CPUE to changes in catch and biomass. There are a number of possible explanations, including changes in catchability or behaviour, or the population existing in two fractions of differential availability to purse seine and longline fishing, but there is no scientific information from which to judge which (if any) of these hypotheses is correct. Several additional features were noted (such as the wide variability in early CPUE between Areas 1, 5 and 2, and the apparent coincidence between the disturbance in the tropical series in the mid-1980s with the start of the purse seine fishery) but interpretation at this level of detail was not possible.

Review of stock assessment models

No new stock assessment methods were presented to the Working Party.

The Working Party agreed that it should attempt to undertake assessments during the meeting using a variety of different methods it has used in previous meetings. These involve use of a statistical catch-at-age analysis, the PROCEAN method (WPTT-02-23), sequential population analysis, ASPM (WPTT-02-13) and a multi-gear yield-per-recruit analysis. These methods are described in the following paragraphs.

Age-structured production models (ASPM) were used last year for the assessment of bigeye tuna stocks. This class of models lies between a simple biomass-based production model and the more data-demanding sequential age-structured population analyses. ASPMs are based on an age-structured representation of the population dynamics and directly estimate parameters of a stock-recruitment relationship. Their main advantage over simpler production models is that they can make use of age-specific indices of relative abundance and they can represent better the effects of changes in age-specific selectivities. The implementations of the APSM model available at the meeting assume that catchability remains constant over time.

Sequential population analysis is a VPA-based model that analyses catch-at-age data from all fisheries. The yearly catches at age are estimated using a catch-at-size table, assuming the growth curve and a simple slicing method. These catch-at-age data are analysed using a conventional catch equation and assuming known natural mortality at age and recruitments. The results obtained are the trend in biomass and the fishing mortality by age and by gear.

The multi-gear yield-per-recruit model allows yield-per-recruit to be calculated as a function of the fishing mortality exerted by both purse seine and longline (and assuming a constant fishing mortality for artisanal fisheries). The implementation is identical to that used during last year's meeting of the WPTT.

PROCEAN (PROduction Catch/Effort ANalysis) is a multifleet non-equilibrium Pella-Tomlinson model which includes both observation and process error on the carrying capacity of the considered stock and catchability for each fleet. The process error for catchabilities combines a random walk structure, which allows for slow trends in fishing power, and a robust error which allows for high frequency random variability of catchabilities. PROCEAN is designed in a Bayesian context which allows for using priors on r, m, K (or alternatively on MSY and FMSY) and the biomass at the beginning of the series (B_0). The objective of the model is not to propose a realistic representation of the fishery, but to serve as a tool to extract the maximum amount of information from the data set by structuring the information on a theoretical framework. Thus, modelling is used as a mean to explore data sets according to various hypotheses.

A multifleet statistical catch-at-age model (Maury, 2001) includes both observation error and process error in both catchabilities and selectivities for each fleet. The process error for catchabilities combines a random walk structure which allows for slow trends in fishing power with a robust error distribution which allows for high frequency random variability of catchabilities. The model is designed in a Bayesian context which allows for using priors on parameters such as natural mortality. A likelihood approach enables different levels of complexity of the model to be compared and allows extraction of the maximum amount of information from the data. A Monte Carlo Markov Chain (MCMC) algorithm can be used to integrate numerically the posterior distribution function of the model and to provide posterior probability distributions for each estimated parameter and variables of interest.

STOCK ASSESSMENT

Document WPTT-02-23 presented an application of the PROCEAN model to the yellowfin fishery of the Indian Ocean. Total yield for the fishery are used, as well as yields and nominal efforts for Japanese longliners, and French and Spanish purse seiners. Results for three different values of the shape parameter *m* are compared and discussed. The results from this analysis suggest that MSY level is likely to have been reached while there is more uncertainty on the situation relative to FMSY levels.

During the discussion, it was suggested that the priors (in particular those for MSY and FMSY) used in the analysis presented in the document may be too informative. It was agreed that additional runs with less informative priors and with different sets of priors should be done for the purpose of the current stock assessment.

Document WPTT-02-17 analyses the trend of yearly total catches of the Indian Ocean using Relative Rate of Catch Increase (RRCI), a modified version of the Grainger and Garcia's index. This index has been showing negative levels since 1996. WPTT-02-17 argues that the effective fishing effort by both purse seine and longline on yellowfin has been increasing during recent years, suggesting that the stock may have been overfished since 1996. Some simple simulations for a yellowfin-like species and fishery were performed that suggest that this index could provide reliable estimates of stock status.

It was suggested that a potential problem with this approach is that it does not account for the changes since the mid-1980's in selectivity patterns. The possible effect of this could be evaluated by simulation studies, but there was insufficient time available during the meeting for these to be carried out. It was noted, however, that this problem is not unique to this method and is shared by all models of this kind.

Document WPTT-02-13 presents an assessment of the yellowfin tuna resource using an age-structure production model (ASPM) and data for the period 1960-2000. The use of this approach was recommended for the tropical tuna stock assessments in the Indian Ocean at the first meeting of the WPM in 2001. The results presented in the paper indicate that it is likely that the current catch levels for yellowfin tuna are close to MSY level.

In discussion, queries were raised about the shape of the selectivity curves used for the purse seine catches. The need to omit the CPUE data for years earlier than 1967 in order to obtain convergence of the ASPM calculations was also cited as evidence that these data may not adequately reflect changes in yellowfin abundance (see also discussion on CPUE standardisation).

As noted in section 4.2, the WPTT agreed that it should attempt to undertake further assessment calculations during the meeting, using the PROCEAN method (WPTT-02-23), Sequential Population Analysis (SPA), ASPM (WPTT-02-13), a statistical catch-at-age analysis method (Maury, 2001) and the multi-species yield per recruit analysis carried out last year for bigeye tuna. Accordingly, the WPTT reviewed the input data and biological parameters to be used in these calculations.

STOCK STRUCTURE

While yellowfin tuna are distributed throughout the tropical and temperate waters of the Indian Ocean, the main fisheries for this species are concentrated in the Western Indian Ocean. In the absence of sufficient tagging and recovery data, the extent to which yellowfin tuna move between the various areas in the Indian Ocean, for instance between the eastern and western Indian Ocean, is largely unknown. However, it has been hypothesized by some scientists, based on analyses of fishery data, that there may be little intermixing between yellowfin tuna populations in the eastern and western Indian Ocean. As we have no direct information on the real movement patterns of yellowfin within the Indian Ocean, and since the limited genetic studies conducted have so far failed to identify more than one genetic stock of yellowfin in the Indian Ocean, the WPTT decided to do its assessments based on the hypothesis that there is a single yellowfin stock in the Indian Ocean., It should be kept in mind, however, that if yellowfin tuna do actually show a significant viscosity in movement, then even if the Indian Ocean stock as a whole is not currently overfished, there may be some geographical fractions of stocks that are locally overfished, and others that are only being lightly exploited.

CATCHES BY SIZE AND GEAR

While appreciating the difficulties inherent in developing annual estimates of yellowfin catches by size and gear identified by the WPM, the WPTT nevertheless agreed that it should attempt to estimate these for use in assessments during the meeting. The methods used for estimating the catches at size as well as the estimated values are presented in Appendix V.

Using the estimated annual catches of yellowfin by size and gear, it is possible to examine changes in the average weight of fish taken yearly by each gear and by the entire fishery. This is illustrated in Figure VII.3. Information on the mean weight of fish in the catches is of major interest as it can be compared with the optimal catch weight in terms of yield per recruit (assuming a known growth and a natural mortality pattern). Figure VII.3 shows that the mean weight of yellowfin caught in the longline fisheries declined substantially during the first 20 years of fishing activity, during a period when the total catches were still relatively low. There then followed a period of relative stability in average catch weight until 1995, after which the mean weight again declined. The recent decline in mean weight this decline is largely bought about by increasing numbers of small yellowfin being taken by purse seiners under FADs. The average weight taken by the combined yellowfin fisheries during the last 4 years was estimated to be at its lowest level in the history of the fishery (11.2 kg).

GROWTH CURVES

As described in the section on new biologic information of this report, considerable uncertainty remains about both the shape and parameter values that best describe growth in yellowfin tuna in the Indian Ocean. For the purposes of assessments during the meeting, it was agreed that two growth models would be used (Figure VII.5b). The first is a two-stanza growth curve (referred to as the Lumineau growth curve from now on), which is estimated using modal progression methods and based on pooled data of the purse seine and gillnet fisheries. This growth curve is presented in document WPTT-02-18 and described by the equation:

$$L_t = 34.77 + 15.35t + [152.07\text{-}(34.77 + 15.35t)].[1\text{-}\exp(\text{-}0.84t)]^{17.76}$$

where L_t is the fork-length in cm and t time in years

The second is the von Bertalanffy growth curve estimated by Stequert *et al.*(1995)[4], estimated from otoliths readings, according to the equation

$$L_t = 272.7(1 - \exp(-0.176(t + 0.266)))$$

The WPTT noted that the other growth curves discussed earlier generally lay between these two growth curves, and so in this sense use of these two should cover the range of possibilities.

CATCHES AT AGE

Using the two growth curves and the catch by size and gear information, two sets of total catches at age by gear and year were developed. These sets are presented in Appendix VI.

CATCH AND EFFORT DATA

The WPTT agreed that the revised tropical standardised Japanese and Taiwanese longline CPUE series as specified in the previous section should be used in further calculations using the ASPM method. Because the ASPM assessments in WPTT-02-12 failed to converge when CPUE data prior to 1968 were used as input, it was agreed that only series since 1968 should be used in the ASPM runs carried out during this meeting (Figure IV.2). Assessment models that do not assume constant catchability over time (i.e. all the other models in the assessment) used the complete series starting in 1952. In addition, the PROCEAN model uses nominal catches, while the statistical catch at age analysis used nominal catches for purse seine data and standardized CPUE for longliners.

NATURAL MORTALITY AT AGE

The WPTT agreed that a higher natural mortality rate should apply to the youngest age. Two natural mortality-at-age schedules were identified and used in the assessment models:

1) 0.8 for age 0, and 0.6 thereafter. This is similar to mortality vector used in ICCAT's assessments for yellowfin.
2) 0.8 for ages 0 and 1, and 0.6 thereafter.

MATURITY AT AGE

Two sets of values for age of maturity were used depending on the growth curve. For the Lumineau growth curve age at maturity was considered to be 3.41, while for the Stequert growth curve it was considered to be 2.67. The full vectors of maturity at age used by the assessment models are presented in Appendix VI.

Discussion of Yellowfin Stock Assessments

The results of the assessments carried out can be obtained upon request and are compiled in Addendum I[5] of this report. In reviewing these results, the WPTT noted that the different methods made a variety of different assumptions. For all methods used, it is likely that several of the assumptions are not met. The WPTT therefore agreed that the

[4] STÉQUERT, B., PANFILI, J., DEAN, J.M., 1995. Age and growth of yellowfin tuna, *Thunnus albacares*, from the western Indian Ocean, based on otolith microstructure. *Fish. Bull.* 94 : 124-134.

[5] The Addendum I to this Report is distributed as a separate document, due to its length. Please contact the Secretariat for a copy

results obtained should be considered as providing indications of likely stock status and should be considered with caution. Accordingly, the WP reviewed the suite of results (from all the methods) as a whole, looking in particular for any consistent indications of stock status across methods.

It is clear from the basic data that, during the early period of the fishery (from the 1950's to the start of the 1980's), the catches were relatively low and stable. Since the 1980's there has been a rapid increase in the longline and purse seine effort and catch. Since the mid-1990's there has also been an increase in purse seine fishing on floating objects which has led to a rapid increase in the catch of juvenile yellowfin. The rapid expansion, particularly on juvenile fish, is cause for concern, since it displays all the symptoms of a potentially risky situation. The WPTT also noted that the increases in catches in general has not been as a result of geographic expansion to previously unfished areas, but rather as a result of increased fishing pressure on existing fishing grounds.

There are some difficulties with the interpretation of the longline CPUE series (see section on CPUE, above), but for those methods that allow for changes in catchability over time, estimates of catchability are consistent between methods, for both the longline and the purse seine fleets. After an initial, rapid drop over the first 25 years of the fishery, catchability appears to have stabilised and then increased somewhat for longliners in recent years (Figure VII.9). For purse seiners, the estimated catchability has increased both steadily and substantially since their introduction to the fishery (Figure VII.8).

Although there are differences in the details of results from the different assessments, the overall picture is similar (Figures VII.6 and VII.7). While it is not currently possible to obtain a reliable estimate of MSY and FMSY, all the assessments and indicators suggest that current catches are close to, or possibly above, the MSY level. Even if current catches are below MSY, a continuation of the recent rapid increase in catches and effort would mean that the fishery could very soon reach or exceed MSY. It is also worth noting that, although total catch in biomass has been stable for several years, catches in numbers have continue to increase, as there has been more fishing effort directed towards smaller fish, as illustrated in Figure VII.10.

Technical Advice for Yellowfin tuna

Considering all the stock indicators and assessments, as well as the recent trends in effort and total catches of yellowfin, the WP considered that:

1. Total catches under current fishing patterns are close to, or possibly above MSY. Furthermore, while total catches appear to have stabilized in recent years, fishing effort and fishing mortality have increased continuously since 1990. Under these circumstances there should be no further increases in fishing effort or catches.
2. The current trend for increasing fishing pressure on juvenile yellowfin by purse seiners fishing on floating objects is likely to be detrimental to the stock if it continues, as fish of these sizes are well below the optimum size for maximum yield per recruit.

Other species

Review of bigeye tuna

Document WPTT-02-35 presented updated standardized Japanese longline CPUE and additional ASPM analyses for bigeye tuna, following up on the ASPM results used by the WPTT in its 2001 assessment. Bootstrap confidence intervals for the estimate of MSY were calculated and bootstrapped future projections under constant catches and constant fishing mortality rate are presented. From these new analyses, it was concluded that the bigeye tuna stock is seriously overfished, and that catches need to be reduced by at least 20%.

Document WPTT-02-07 presented the results of applying two implementations of ASPMs to the assessment of bigeye tuna. The first of these was the model used by the WPTT in 2001. The lack of convergence of some of the runs in the 2001 assessment was explored and resolved. Some limited sensitivity analyses were also performed, particularly with regard to the deterministic versus stochastic assumption about recruitment and the choice of input parameters governing the recruitment deviations. An alternative ASPM implementation in AD Model Builder was also applied to the bigeye tuna data, combined with different assumptions and input parameters. The results show a wide range of possible outcomes depending on the input parameters and assumptions. Estimates of steepness suggest that there is very little information about the stock-recruit relationship in the data.

The WPTT agreed that the results from these two papers confirmed and reinforced the assessment of bigeye tuna developed at last year's meeting.

An executive summary of the status of bigeye tuna in the Indian Ocean was reviewed during the process of adopting the report.

Technical Advice for Bigeye tuna

The results of further assessments of the bigeye tuna stock using age-structured production models presented to the WPTT (WPTT-02-07 and WPTT-02-35) confirmed and reinforced the assessment agreed at the 2001 meeting of the WPTT (IOTC-SC-01-05). The WPTT therefore reiterates the technical advice on bigeye tuna given last year, and quoted below:

1. "The WPTT had already noted with concern the rapid increase of catches of bigeye tuna at its meeting in 1999. Since then, catches have continued to increase. Taking into account the results of the current assessment, which represents the best effort to date to analyse the available data in a formal context, it is likely that current catches are well above MSY".
2. "Bearing in mind those considerations and the need for a precautionary approach, the WPTT recommended that a reduction in catches of bigeye tuna from all gears should be effected as soon as possible."

It is noted that one of the participants in this session of the WPTT abstained from endorsing these recommendations.

Review of skipjack tuna

No papers containing new information on skipjack tuna were presented to the WPTT. It was noted, however, that considerable amounts of new information on skipjack tuna have been submitted to the IOTC since the WPTT last reviewed the status of this species.

The WPTT agreed that this information should be reviewed at its next meeting. A preliminary executive summary for skipjack tuna was drafted during the meeting and reviewed during the process of adopting the report.

Technical Advice for Skipjack tuna

The WPTT developed no technical advice for skipjack tuna

Technical advice on optimal fishing capacity

The Working Party agreed that for the reasons given in its report in 2001, it was unable to provide substantive advice on the optimal fishing capacity for tropical tunas.

However, the WPTT noted that there is convergence in terms of the assessments and technical advice for bigeye and yellowfin tuna. In particular, the advice that there should be a reduction in catches of bigeye tuna by all gears and, at least, no further increase in catches of yellowfin tuna, implies that there should be no further increases in effective effort directed at two of the three main tropical tuna species. Furthermore, the advice regarding the need to reduce catches of juvenile bigeye and yellowfin tuna on floating objects is also consistent. It is noted that measures to achieve this reduction are also likely to affect catches of skipjack tunas.

Research Recommendations and Priorities

The WP reiterated the research recommendations and priorities identified at its last meeting that have not yet been fully implemented. In addition, it made the following recommendations:

- The tagging project should be strongly supported in order to obtain reliable estimates of tropical tuna growth rates, stock structure and mixing, natural mortality and catchability. Any realistic modeling of the Indian Ocean stocks and subsequent reliable assessments will not be possible without setting up a large-scale tagging program.
- Scientists are encouraged to undertake further research on interpretation of longline CPUEs for yellowfin tunas, and in particular on the possible causes of the substantial important decreasing trend in the early years of the fishery and the apparent stability on recent years. Possible approaches include incorporation of behavioural models and/or vertical stock stratification into the operational models.
- Further research needs be done on differentiating regular and deep longlines and other aspects of targeting.
- Where possible, ecosystem components should be incorporated into stock status evaluations. As a starting point, information on the condition factors was considered a possible indicator of the status of the ecosystem. Information on condition factors should be obtained for the purse seine as well as for the longline fisheries.
- Scientists are encouraged to continue collection of information on predation and to incorporate the effects of the predation into stock assessments.
- An important potential problem in the skipjack fisheries is interaction between industrial and artisanal fisheries. Countries with artisanal fisheries for skipjack tuna should make a special effort to submit data on these fisheries to the IOTC before next year's WPTT meeting.
- Reiterating the suggestions made by the WPM, the development of an operating model is recommended.

Recommendations on organization of future work

The WPTT agreed that priority should be given to skipjack tuna stock assessments at its next meeting. The Working Party also agreed that it should be interesting to obtain standardized stock indicators for skipjack tuna.

If this is the only topic considered, then the length of the meeting might be reduced. Alternatively, other topics could also be considered in a seven-day meeting. Possible such topics identified include:

- Reviewing the assessment of bigeye tuna
- More extensive consideration of executive summaries for species
- Further consideration and application of operating models, possibly in a joint meeting of WPM and WPTT.

Any other business

Executive Summary and Permanent Report on the Status of Bigeye tuna

The Working Party reviewed and adopted with amendments a draft Executive Summary for bigeye tuna prepared by the Secretariat. This is attached as Appendix VII.

A draft of a Permanent Report on the Status of Bigeye Tuna also prepared by the Secretariat was distributed to participants. It was agreed that comments and suggested amendments to this report should be forwarded to the Secretariat.

Executive Summary on the Status of Yellowfin tuna and Executive Summary on the Status of Skipjack tuna

The concept of producing Executive Summaries for these species was agreed and adopted by the Working Party. It was agreed that these summaries should contain only information that explicitly appears on the Working Party reports, and that draft versions of these executive summaries will be circulated for amendments and final adoption by the participants of the Working Party before the next meeting of the Scientific Committee

Adoption of the Report and Arrangement for next meeting

The report of the WPTT was adopted on June 11th , 2002. It was agreed that next meeting of the Working Party on Tropical Tunas should be held in June of 2003. The details of dates and place and venue are to be arranged by the Secretariat.

On behalf of the WPTT, the Chairman expressed his deep appreciation to the Bureau of Fisheries and the Shanghai Fisheries University for the superb organisation and facilities arranged for the WPTT meeting. He also thanked the Secretariat and particularly the students of Shanghai Fisheries University for their assistance.

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APPENDIX II – Agenda for the 4th Meeting of the Working Party on Tropical Tunas

1. *Review the statistical data for the tropical tuna species and the situation in reporting countries on data acquisition, for reporting to the WPDCS.*
2. *Review new information on the biology and stock structure of tropical tunas, their fisheries and related environmental data.*
3. *Review report and recommendations of WPM*
4. *Undertake stock assessment for yellowfin tuna.*
   - *4.1. Standardization of CPUE data*
   - *4.2. Review stock assessment models*
   - *4.3. Stock assessment*
   - *4.4. 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 yellowfin tuna.*
6. *Review new information on skipjack and bigeye tunas.*
7. *Consider the question of the optimum fishing capacity of the fishing fleet.*
8. *Identify research priorities, and specify data and information requirements, necessary for the Working Party to fulfill its responsibilities.*
9. *Any other business*
10. *Adoption of the Report*

APPENDIX III – List of documents

WPTT-02-01	Status of the IOTC databases for Tropical Tunas. *IOTC Secretariat*
WPTT-02-02	Catches of Artisanal and Induatrial Fleets in Indonesia: an update. *M.A. Herrera*
WPTT-02-03	Catches of industrial fleets operating under flags of non-reporting countries in the IOTC Area of Competence: an update. *M.A. Herrera*
WPTT-02-04	French purse-seine tuna fisheries statistics in the Indian Ocean, 1981-2001. *R.Pianet and V. Nordstrom*
WPTT-02-05	Memorandum on regulatory measures for purse seine fisheries in the western tropical Indian Ocean. *Z.Suzuki*
WPTT-02-06	Statistics of the main purse seine fleets fishing in the Indian Ocean (1981-2001). *P.Pallares, R.Pianet, A.Delgado,J.Ariz,V.Nordstrom,R.Bargain,A.Thomas*
WPTT-02-07	Application of an age-structured production model (ASPM) to theIndian Ocean bigeye tuna (Thunnus obesus) resource. *D.Ricard & M. Basson*
WPTT-02-08	Trends in the Longline and Purse Seine Fishery in the Seychelles waters. *R.M. Bargain, A. Thomas, V. Lucas*
WPTT-02-09	Incidental Yellowfin catch with swordfish longline fisheries in the Seychelles, Preliminary results of an experimental longline fishing program. *B. Wendling, R.M Bargain*
WPTT-02-10	A Brief Report on Taiwanese Tuna Longline Fisheries Operate in the Indian Ocean.. *Shyh-Bin Wang and Shui-Hei Wang*
WPTT-02-11	Standardization of Japanese longline catch rates for yellowfin tuna in the Indian Ocean using GAM analyses.. *B.Wise,A.Bugg,H.Shono,S.Barry,T.Nishida,D.Barratt and J.Kalish*
WPTT-02-12	Standardized CPUE for yellowfin tuna (Thunnus albacares) of the Japanese longline fishery in the Indian Ocean by Generalized Linear Models (GLM) (1960-2000).. *H.Shono, H.Okamoto and T.Nishida*
WPTT-02-13	Stock assessment of yellowfin tuna (Thunnus albacares) resources in the Indian Ocean by the age structured production model (ASPM) analyses.. *T.Nishida and H.Shono*
WPTT-02-14	Preliminary analysis of the Nominal CPUE and fishing effort in the China longline fishery in the Indian Ocean. *DAI Xiaojie, XU Liu-xiong and SONG Li-ming*
WPTT-02-15	Estimated sex ratio of large yellowfin taken by purse seiners in the Indian Ocean; comparison with other oceans. *Alain Fonteneau*
WPTT-02-16	Atlas of Indian ocean purse seine fisheries 1982-2001 with a special emphasis for yellowfin tuna taken on FAD and free schools.. *Alain Fonteneau, R.M. Bargain, V. Nordstrom et P. Pallares*
WPTT-02-17	Analysis of trend of total yearly catches of yellowfin tuna (Thunnus albacares) in the Indian Ocean and status of stock. *Alain Fonteneau & Daniel Gaertner*
WPTT-02-18	Study of the growth of yellowfin tuna (thunnus albacares) in the Western Indian Ocean based on length frequency data.. *Olivier Lumineau*
WPTT-02-19	Some considerations to separate Taiwanese regular and deep longliners. *Ying-Chou Lee*

WPTT-02-20	Some aspects on the FAD fishery in the Indian Ocean from observers data analysis.. *X.Mina,J.Ariz,R.Prellezo,A.Delgado,I.Artetxe,P.Pallares,H.Arrizabalaga*
WPTT-02-21	Updated analysis of observers data analysis from the 1998-1999 moratorium in the Indian Ocean.. *X.Mina,I.Artetxe and H.Arrizabalaga*
WPTT-02-22	The use of MULTIFAN to estimate growth parameters of yellowfin tuna (Thunnus albacares) in the Indian Ocean.. *H.Arrizabalaga & X.Mina*
WPTT-02-23	Application of the procean model to the Indian Ocean Yellowfin Tuna (Thunnus Albacares) fishery. *Olivier Maury*
WPTT-02-24	On-going research activities on trophic ecology of tuna in equatorial ecosystems of the Indian Ocean. *M.Potier, F.Marsac, V.Lucas, R.Sabatie & F.Menard*
WPTT-02-25	Analysis of the catches by weight category of yellowfin tuna (Thunnus albacares) undertaken by the purse seine fleets in the Indian Ocean from 1991 to 2000.. *J.Ariz,P.Pallares,A.Delgado,A.Fonteneau,JC.Santana*
WPTT-02-26	Standardization of tropical purse seine fishing effort by generalized linear model (GLM). *M.Soto,P.Pallares,D.Gaertner,A.Delgado,A.Fonteneau,J.Ariz*
WPTT-02-27	A new approach to standardize catch rates for yellowfin (Thunnus albacares) for the Spanish purse seine fleet (1984-1995).. *M.Soto,J.Morón,P.Pallares*
WPTT-02-28	Statistics of the purse seine spanish fleet in the Indian Ocean (1984-2001). *A.Delgado,P.Pallares,JJ.Areso and J.Ariz*
WPTT-02-29	Review of biological aspects of yellowfin tuna (thunnus albacares) from the Indian Ocean. *V.Somvanshi*
WPTT-02-30	Update on standardization of CPUE for yellowfin tuna caught by Taiwanese distant-water tuna longline fishery operate in the Indian Ocean.. *Shu-Hui Wang and Shyh-Bin Wang*
WPTT-02-31	Tuna Purse Seine Landings in Phuket, Thailand, from 1993 to 2001.. *P. Nootmorn, S. Panjarat, S.Hoimuk, U.Augsornpa-ob,W.Singtongyam and D.Keawkaew, Chijaroon Tantivala*
WPTT-02-32	Tuna Longline Landings in Phuket, Thailand, from 1994 to 2002.. *P. Nootmorn, S.Panjarat, W. Singtongyam,,S. Roopradit, K. Kawises and T.Intharasuwan*
WPTT-02-33	Changes in depth of yellowfin tuna habitat in the Indian Ocean:an historical perspective 1955-2001.. *F. Marsac*
WPTT-02-34	Report of the predation survey by the Japanese commercial tuna longline fisheries (September 2000 - November 2001).. *T. Nishida and Y. Shiba*
WPTT-02-35	Updated bigeye tuna (Thunnus obesus) resource analyses in the Indian Ocean - CPUE, ASPM (MSY) and projections -.. *T.Nishida, H. Shono, H. Okamoto and Z. Suzuki*
WPTT-02-36	Status of oceanic tuna landings form Indian Ocean at Penang port, Malaysia.. *Mahyam Mohammad-Isa and Khairul-Anuar Ismail*
WPTT-02-37	Statistics and status of Japanese tuna fisheries in the Indian Ocean up to 2000.. *H.Okamoto and N.Miyabe*
WPTT-02-38	Atlas for the major industrial longline fleets in the Indian Ocean (preliminary version).. *IOTC Secretariat*

APPENDIX IV - CPUE Standardization Results

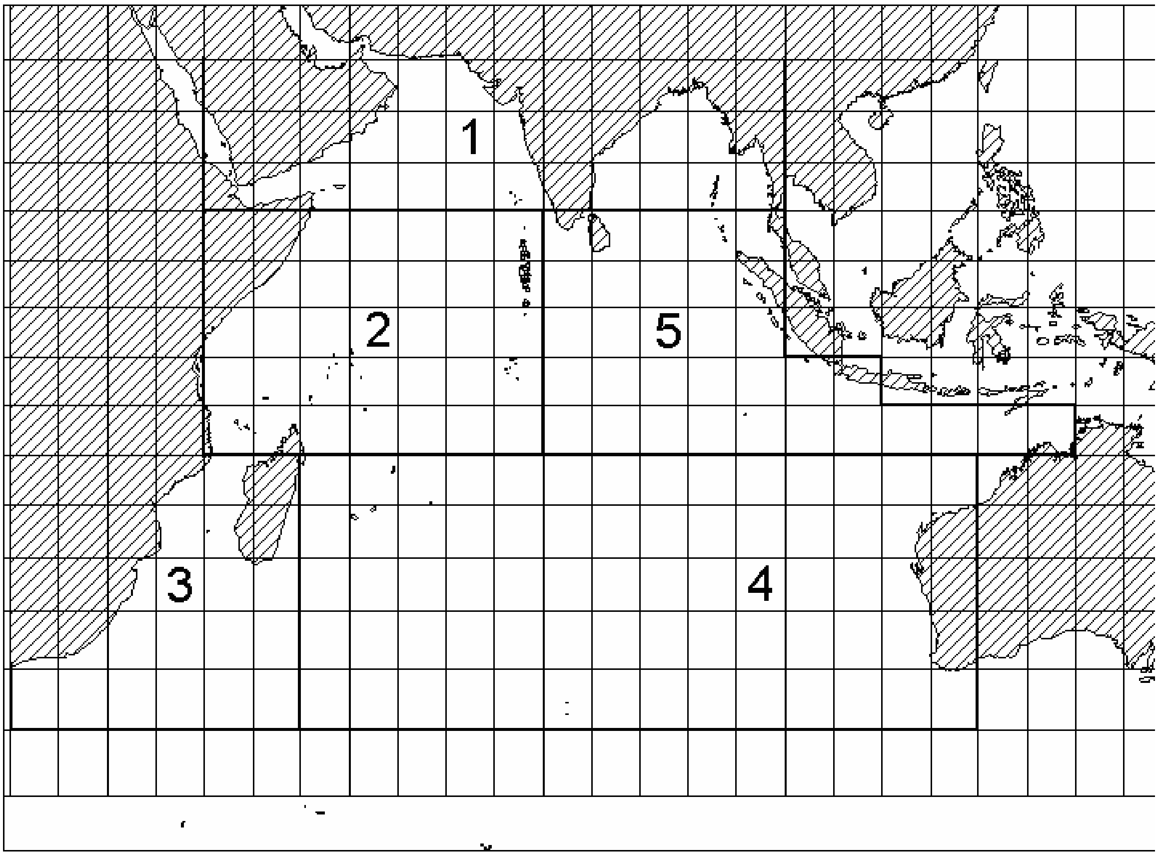
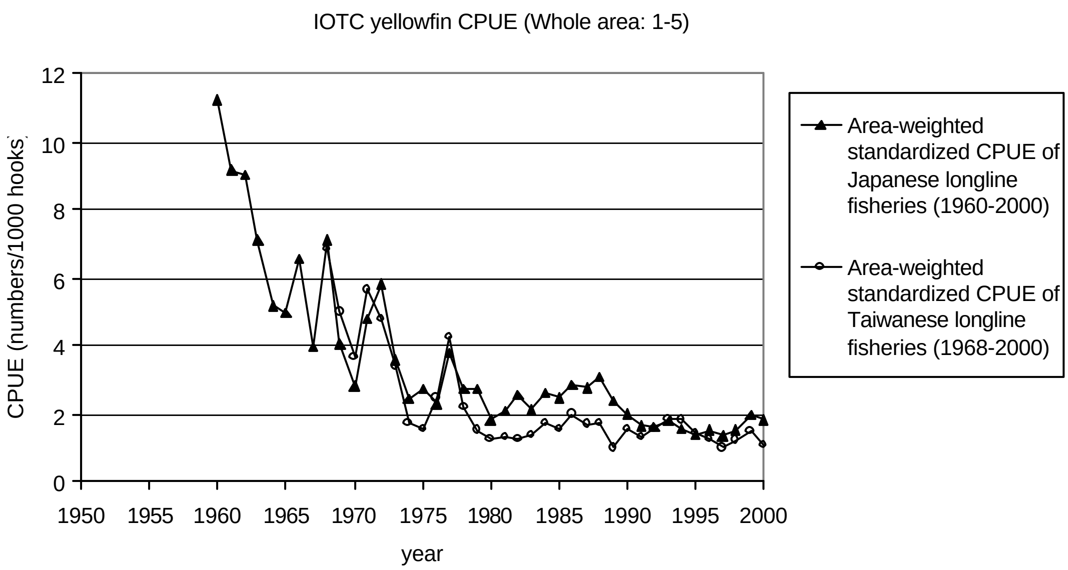


Figure 1. Areas used for standardized CPUE estimates. Tropical Areas include sections 2 and 5.



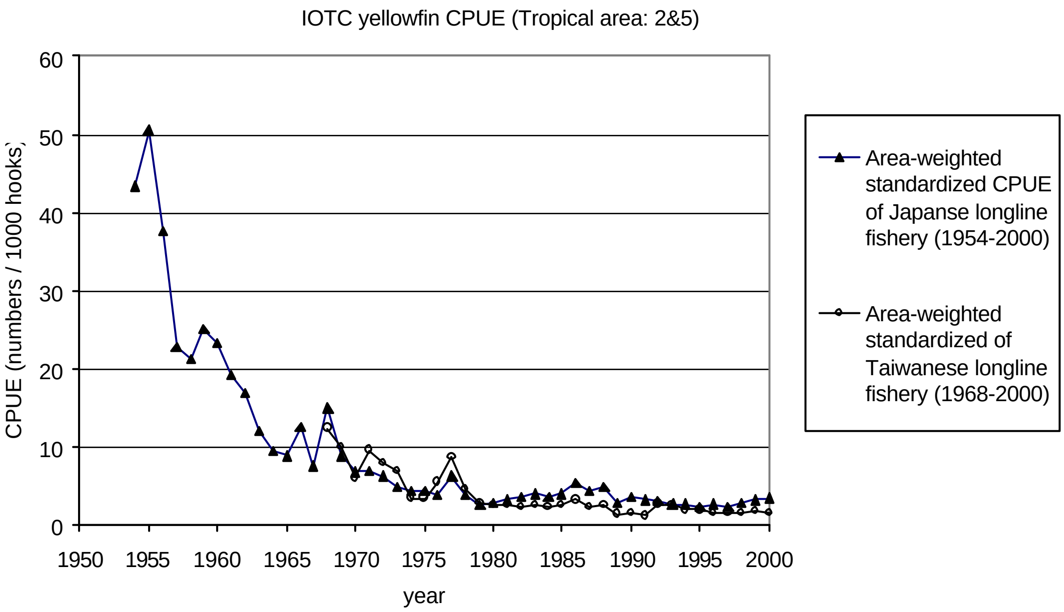


Figure 2. Standardized CPUE series for Japanese and Taiwanese longline fleets.

APPENDIX V – Estimation of Catch at Size for Yellowfin

Longline

In order to be raised to the total catch, catches expressed as number were converted into weight, using mean weights estimated from the Japanese longline size frequencies data within 10x20 degree quarterly time area strata.
Fleets having catch and effort (C/E) and size data were raised on a quarterly basis to their nominal catches, and assessed a size frequency according to the Japanese ones for missing periods. The Taiwanese size frequency data were used for Taiwan from 1985 to 1988.
Fleets with no sizes or C/E data were assigned a quarterly profile from their nominal catch using the Japanese size frequencies, and the NEI-ICE fleets catches were assign a size frequency based on the NEI-ICE size data from 1998 to 2000.
When data were missing in some strata, cumulated data in large strata (NE, NW, SE, SW, N, S, W, E or total, east-west limit being set at 80°E) were used, and then size frequencies were weighted by the number of fish caught in each strata.
Finally, all size frequencies data were cumulated by country, year and quarter. Details of the process for the longline fishery is reported in Table 1.

Purse seine

In the eastern Indian Ocean, the only size data available were those from Japan from 1995 to 2000; these data have been used for the eastern Japanese purse seine catches for all years using the 1995 profile for previous years.
In the western Indian Ocean, size data from the EU purse seiners by school type (log, free and unknown) were used and then cumulated by quarter and the 10 large areas used for this fleet.
Fleets having catch and effort (C/E) data were raised on a quarterly basis to their nominal catches, and assessed a size frequency according to the EU purse seine ones for missing periods.
Fleets with no sizes or C/E data were assigned a quarterly profile from their nominal catch using the EU purse seine size frequencies, using the first year profile for previous years when necessary.
When data were missing in some strata, cumulated data in large strata (NE, NW, SE, SW, N, S, W, E or total, east-west limit being set at 80°E) were used.
Finally, all size frequencies data were cumulated by country, year and quarter. Details of the process for the purse seine fishery is reported in Table 2.

Artisanal

BAITBOATS

Even if some other size data probably exist, only those from the Maldivian fishery from 1983 to 1998 are available and were used for all fisheries for this period. Years previous to 1985 were assigned the size distribution from 1985.
Details of the process for the baitboat fishery are reported in Table 3.

GILLNET

Several size data sets are available :

- From Sri Lanka for the period 1992-1998, for a combination of gillnet and longline,
- From Iran (1992-2000), Indonesia (1984-1986), Oman (1987-1994) and Pakistan (1887-1994), for gillnets.

For the eastern Indian Ocean, the Indonesian size data set was raised to its total nominal catch; the mean profile was used for missing years. Australian catches were raised using these Indonesian size frequencies.
For the western Indian Ocean, the combined gillnet-longline size data set was raised to the total nominal catch of Sri Lanka for the available period. For other gillnet fisheries, size frequencies from 1987 to 2000 were built from a combination of Iranese, Omanese and Pakistanese data sets; these individual data sets were first raised to their respective country nominal catch, and then combined into a cumulated data set. Pakistanese data previous to 1987 were assigned the mean 1987-1989 size frequency. All other gillnet catches were raised using these combined sizes frequencies.
This assumes that, due to their strong selectivity, the gillnet size frequency remains relatively stable. Details of the process for the gillnet fishery are reported in Table 3.

OTHERS

This category is made of catches from handline, lines, trolling and others non identified, and no size data are available; however, these catches are relatively negligible (average of 5000 tons before 1990, 9000 tons after).
These catches were raised to the total others “Artisanal” fisheries, *i.e.* baitboat+gillnet.
Details of the process for the other artisanal fisheries are reported in Table 3.

Table 1 : Longline

Country	Years	C/E	Size	Use for missing	Comments NC: mean (min-max)
AUS	1989-2000	Yes (w)	No	JPN SE	NC: 235 (14-642)
CHN	1985-1998 1999-2000	No Yes (w)	No No	JPN IO JPN 10x20	NC: 1080 (137-2361)
ESP	1993-2000	No	No	JPN W	NC: 35 (8-108)
FRA-MAY	1998	No	No	JPN W	NC: 194
FRA-RUN	1991-2000	Yes (n)	No	JPN 10x20	NC: 175 (18-360)
IDN	1973-2000	No	No	JPN IO	NC: 9175 (114-40445)
IND	1983-1990 1991 1992-1993 1994-1997 1998-2000	No Yes (w) No Yes (w) No	No No No No No	JPN N JPN N JPN N JPN N JPN N	NC: 140 (5-645)
IRN	1976-2000	No	No	JPN NW	NC: 1057 (25-4980)
JPN	1952-2000	Yes (n)	Yes		NC: 12201 (2023-38100)
KEN	1980-1983	No	No	JPN IO	NC: 220 (77-370)
KOR	1966-1974 1975-1990 1991-1993 1994-2000	No Yes (n) Yes (n) Yes (w)	No No Yes Yes	JPN IO JPN 10x20 JPN 10x20 JPN 10x20	Few size data, not used NC: 9107 (100-31383)
LKA	1982-2000	No	No	JPN IO	NC: 588 (204-1138)
MDV	1988-1998	No	No	JPN IO	NC: 5 (1-19)
MUS	1978-1998	No	No	JPN IO	NC: 50 (1-219)
NEI-DFRZ	1985-1989 1990-1991 1992-2000	No Yes (w) No	No No No	JPN IO JPN IO JPN IO	NC: 7936 (56-22272)
NEI-ICE	1989-1997 1998-2000	No No	No Yes	JPN SE	NC: 18975 (10615-27614) used
NEI-IDN	1986-1999	No	No	JPN IO	NC: 7564 (42-16099)
OMN	1991	Yes (w)	No	JPN 10x20	NC: 1069
PAK	1991-2000	No	No	JPN NW	NC: 5769 (133-28188)
PHL	1998-2000	No	No	JPN SE	NC: 514 (299-623)
PRT	1998-2000	No	No	JPN IO	NC: 8 (4-10)
SUN	1988-1989	No	No	JPN IO	NC: 5 (2-8)
SYC	1983-1985 1995-2000	Yes (w) Yes (w)	No No	JPN 10x20 JPN 10x20	NC: 73 (5-170)
THA	2000	No	No	JPN IO	NC: 227
TWN	1966-1984 1985-1988 1989-2000	Yes (n & w) Yes (n & w) Yes (n & w)	No Yes No	JPN 10x20 JPN 10x20	NC: 17406 (3355-88026) TWN used

Table 2 : Purse seine

Country	Years	C/E	Size	Use for missing	Comments NC: mean (min-max)
AUS	1981-1988	No	No	JPN East?	NC: 28 (8-43)
ESP	1983-2001	Yes (w)	Yes	PS-EUR	NC: 41903 (11453-65143)
FRA	1981-2001	Yes (w)	Yes	PS-EUR	NC: 33900 (199-59913)
IDN	1974-2000	No	Some	JPN East?	1986-1988 NC: 325 (21-814)
IND	1998	No	No	PS-EUR?	NC: 14
IRN	1992-1995 1996-2000	No Yes (w)	No Yes	PS-EUR	NC: 2676 (1607-4300) except 1996
JPN	1977-1988 1989-1994 1995-2000	No Yes (w) Yes (w)	No No Yes	 JPN West JPN East	NC: 2180 (32-11882) Eastern IO
LKA	1993	No	No	PS-EUR?	NC: 1
MUS	1983-1987 1988-2000	No Yes (w)	No Some	PS-EUR	NC: 1319 (109-2621) 1989-1990
NEI-EUR	1983-2000	Yes (w)	Yes	PS-EUR	NC: 13732 (661-27049)
NEI-SUN	1990-2000	Some	No	PS-EUR	1992-1993 NC: 9494 (804-17002)
SUN	1963-1965 1983-1984 1985-1991	No No Yes (w)	No No No	PS-EUR	NC: 1693 (5-4153)
SYC	1991-2001	Yes (w)	Yes	PS-EUR	NC: 6306 (221-12007)
THA	2000	No	No	PS-EUR	NC: 250

Table 3 : Artisanal

Country	Years	C/E	Size	Use for missing	Comments NC: mean (min-max)
Baitboat					
AUS	1989-1996	No	No	MDV 1983-2000	NC: 4 (1-11)
ESP	1981-1982	No	No	MDV 1983-1985	NC: 209 (55-363)
IDN	1985-1987	No	No	MDV 1983-2000	NC: 122 (4-256)
IND	1976-1991 1999-2000	Yes (w) No	No No	MDV 1983-1985 MDV 1983-2000	NC: 366 (25-1214)
LKA	1982-1988	No	No	MDV 1983-2000	NC: 167 (4-452)
MDG	1973-1975	No	No	MDV 1983-2000	NC: 630 (180-1160)
MDV	1950-1969 1970-1982 1983-1998	No Yes (w) Yes (w)	No No Yes	MDV 1983-1985 MDV 1983-1985 MDV 1983-2000	NC: 4874 (1000-12994) Size 1983-84 not used
Gillnet					
AUS	1995-2000	No	No	IDN 1986	NC: 1 (1-1)
IDN	1982-1983 1984-1986 1987-2000	No Yes (w) No	No Yes No	IDN 1984 IDN 1984-1986 IDN 1986	NC: 251 (29-526)
IND	1979-1981 1998-2000	Yes (w) No	No No	Combined (IRN+OMN+PAK)	NC: 630 (4-1969)
IRN	1989-1992 1993-1995 1996-2000	No Yes (w) No	No Yes Yes	Combined (IRN+OMN+PAK)	NC: 13634 (980-28465)
LKA-GILL&LL LKA-GILL	1992-1998 1982-2000	Yes (w) No	Yes No	Combined (IRN+OMN+PAK	NC: 11048 (5151-27139)
OMN	1985-1986 1987-1994 1995-2000	No No No	No Yes No	Combined (IRN+OMN+PAK)	NC: 11076 (2237-21276) Some C/E 1996 & 2000
PAK	1950-1986 1987-1991 1992-1994 1995-2000	No Yes (w) No No	No Yes Yes No	Combined (IRN+OMN+PAK)	NC: 2436 (351-8747)
TWN	1986-1991	Yes (n & w)	No	Combined (IRN+OMN+PAK)	NC: 36 (1-88)

Table 3 : Artisanal (continued)

Country	Years	C/E	Size	Use for missing	Comments NC: mean (min-max)
Others					
AUS-Hand AUS-Troll AUS-Others	1990-2000 1989-2000 1977-1980	No	No	Combined BB+Gillnet	NC: 9 (1-34)
COM-Hand COM-Troll COM-Others	1989-2000 1989-2000 1970-2000	No	No	Combined BB+Gillnet	NC: 1927 (100-5609)
F/RUN-Hand F/RUN-Troll	1993-2000 1950-1992	No	No	Combined BB+Gillnet	NC: 207 (79-416)
IDN-Troll IDN-Others	1985-1987 1950-2000	No	No	Combined BB+Gillnet	Some information (troll) NC: 639 (44-2915)
IND-Hand IND-Line IND-Troll IND-Others	1979 1998-2000 1976-1991 1996-1998	No	No	Combined BB+Gillnet	NC: 655 (2-7155)
JPN-Others	1981	No	No	Combined BB+Gillnet	NC: 2
KEN-Troll	1984-2000	No	No	Combined BB+Gillnet	NC: 59 (19-80)
LKA-Hand LKA-Troll LKA-Others	1986-2000 1982-2000 1956-2000	No	No	Combined BB+Gillnet	NC: 3216 (2-9000)
MDV-Hand MDV-Troll MDV-Others	1985-2000 1970-2000 1990-2000	No	No	Combined BB+Gillnet	NC: 389 (150-1591)
MOZ-Others	1983-1985	No	No	Combined BB+Gillnet	NC: 73 (15-188)
MUS-Troll	1984-2000	No	No	Combined BB+Gillnet	NC: 78 (8-249)
SYC-Hand SYC-Troll SYC-Others	1986-2000 1985-1991 1970-1983	No	No	Combined BB+Gillnet	NC: 122 (1-949)
TMP-Line	1999-2000	No	No	Combined BB+Gillnet	NC: 2 (1-3)
TZA-Others	1999-2000	No	No	Combined BB+Gillnet	NC: 525 (300-700)
YEM-Others	1980-2000	No	No	Combined BB+Gillnet	NC: 716 (5-2367)
ZAF-Hand	1983-1995	No	No	Combined BB+Gillnet	NC: 35 (1-166)

APPENDIX VI – Catch at Age and Maturity at Age

Maturity at age vectors

Age	Maturity % (Lumineau)	Maturity % (Stequert)
1	0	0
2	0	0.33
3	0.59	1
4	1	1
5	1	1
6+	1	1

Catch at age

			Age			
Year	1	2	3	4	5	6
1952	259	69	33	46	85	49
1953	257	66	42	80	117	69
1954	260	73	65	222	210	79
1955	341	88	81	430	372	143
1956	377	162	130	575	513	208
1957	435	287	183	317	254	157
1958	401	214	176	262	182	81
1959	407	223	163	390	128	41
1960	266	243	247	582	235	60
1961	359	288	263	465	215	58
1962	408	385	473	846	219	64
1963	502	607	426	481	176	40
1964	430	434	270	375	173	38
1965	369	479	524	356	147	44
1966	446	481	550	779	232	54
1967	561	648	627	620	177	33
1968	581	720	1825	848	265	86
1969	544	587	911	889	155	31
1970	585	551	438	528	182	41
1971	413	472	783	343	144	29
1972	663	609	777	470	77	23
1973	1414	636	310	331	131	53
1974	1239	667	372	344	148	48
1975	1004	644	577	351	101	33
1976	1104	661	424	393	103	45
1977	1046	625	518	528	281	101
1978	887	590	606	520	147	75
1979	1032	727	424	518	137	24
1980	1046	746	406	337	138	59
1981	1299	781	528	377	118	57
1982	1249	802	795	506	127	46
1983	2325	930	589	564	155	72
1984	3804	1002	676	694	288	145
1985	6624	1904	741	807	335	127
1986	2878	1569	946	1359	308	111
1987	3558	2163	1494	1265	310	127
1988	6695	2540	1333	1517	496	183
1989	5479	3369	2224	1271	480	165
1990	4678	3394	1644	2069	589	254
1991	4374	1536	1761	2269	680	168
1992	5821	2370	2680	2601	1013	375
1993	6781	1982	3383	2906	1402	595
1994	10545	2506	2581	2072	1064	536
1995	10895	3878	3359	2778	725	290
1996	13247	4333	2856	2755	824	444
1997	19006	4222	2633	2608	715	325
1998	12105	4416	3835	2216	644	270
1999	22177	5365	3147	2587	763	204
2000	14961	3512	2429	3138	665	158

Catch at Age x 1000
(Lumineau Growth Curve)

			Age			
Year	1	2	3	4	5	6
1952	310	45	43	134	5	0
1953	305	50	75	181	14	0
1954	312	59	211	309	13	0
1955	403	80	388	547	32	0
1956	494	134	534	752	45	0
1957	646	218	312	406	45	0
1958	557	188	274	276	16	0
1959	572	169	406	190	8	0
1960	446	223	610	333	14	0
1961	569	254	506	303	10	0
1962	693	358	1006	317	14	0
1963	936	500	534	249	6	0
1964	755	301	416	237	5	0
1965	726	497	476	207	8	0
1966	806	469	929	325	8	0
1967	1046	584	779	246	5	0
1968	1101	1552	1261	386	19	0
1969	974	570	1341	220	5	0
1970	991	438	635	247	8	0
1971	757	745	474	196	4	0
1972	1114	700	683	110	6	0
1973	1881	408	372	197	9	0
1974	1735	470	389	210	10	0
1975	1474	601	473	150	5	0
1976	1599	489	477	145	15	0
1977	1511	465	652	444	22	0
1978	1331	615	621	233	19	0
1979	1579	490	617	166	5	0
1980	1608	510	399	195	14	0
1981	1881	614	474	165	21	0
1982	1847	767	704	184	16	0
1983	3036	692	637	241	24	0
1984	4615	690	807	454	38	1
1985	8184	881	934	503	29	0
1986	4133	988	1546	467	31	0
1987	5319	1492	1590	475	34	0
1988	8743	1475	1747	748	45	0
1989	8014	2582	1634	706	46	0
1990	7546	1710	2376	923	66	0
1991	5320	1791	2629	1004	40	0
1992	7562	2522	3183	1498	89	0
1993	8341	2761	3715	2040	182	2
1994	12424	2396	2683	1592	200	4
1995	13379	3579	3818	1032	111	1
1996	16679	2905	3424	1260	175	7
1997	22180	3021	3122	1051	129	0
1998	15435	3690	3306	936	113	2
1999	26871	2940	3273	1116	38	1
2000	17844	2370	3646	962	34	0

Catch at Age x 1000
(Stequert Growth Curve)

APPENDIX VII – Additional tables and figures on yellowfin tuna summarizing results of the assessments conducted during the meeting.

Table 1. Catches of yellowfin tuna by area, country and gear for the period 1950-1975.

Area/Country	Gear	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Total Indian Ocean		2030	2230	11130	15735	27431	49548	68614	42951	30865	29765	45515	40632	59767	37641	34843	38034	59809	52508	92637	66842	45475	40955	42756	35620	37615	37359
IO_All	Baitboat	1500	1500	1500	1500	1500	2000	2000	2000	2000	2000	1000	1500	1500	1500	1500	1000	1500	1700	1700	1800	2282	1381	2511	7401	6159	4732
	Gill net	351	351	351	535	552	569	535	1372	686	686	836	753	1188	1757	2442	2643	3530	3429	3446	3112	2827	2306	2750	2162	2965	3272
	Hand line																										
	Hand line and Troll																										
	Longline			8800	13300	24900	46500	64400	36000	25700	24400	40300	34600	51700	25900	24800	27600	48200	38021	77554	54093	33435	31194	29220	19135	20675	21729
	Unclassified	100	300	400	400	400	400	1600	3500	2400	2600	3300	3700	5300	8400	6000	6700	6500	9200	9700	7600	6600	5500	7700	6286	7070	6955
	Purse seine														5	22	12									21	39
	Troll line	79	79	79		79	79	79	79	79	79	79	79	79	79	79	79	79	158	237	237	331	573	575	636	725	632
Somme IO_Eastern		100	300	3640	6357	9208	7326	11156	13457	9225	8369	12164	9721	18725	13627	10800	12000	11000	16921	19644	19298	19509	12645	13861	10735	12268	15875
IO_Eastern	Baitboat																										
	Gill net																										
	Hand line																										
	Hand line and Troll																										
	Longline			3240	5957	8808	6926	9556	9957	6825	5769	8864	6021	13425	5227	4800	5300	4500	7721	9944	11698	13109	7345	6361	4649	5427	9081
	Unclassified	100	300	400	400	400	400	1600	3500	2400	2600	3300	3700	5300	8400	6000	6700	6500	9200	9700	7600	6400	5300	7500	6086	6820	6755
	Purse seine																									21	39
	Troll line																										
Somme IO_Western		1930	1930	1930	2035	5016	19825	23927	11553	9717	11832	16847	17873	22348	14025	16543	19334	31909	31787	60593	45044	22266	28310	28895	24884	25348	21484
IO_Western	Baitboat	1500	1500	1500	1500	1500	2000	2000	2000	2000	2000	1000	1500	1500	1500	1500	1000	1500	1700	1700	1800	2282	1381	2511	7401	6159	4732
	Gill net	351	351	351	535	552	569	535	1372	686	686	836	753	1188	1757	2442	2643	3530	3429	3446	3112	2827	2306	2750	2162	2965	3272
	Hand line																										
	Hand line and Troll																										
	Longline					2885	17177	21313	8102	6952	9067	14932	15541	19581	10684	12500	15600	26800	26500	55210	39895	16626	23849	22859	14486	15248	12648
	Unclassified																					200	200	200	200	250	200
	Purse seine														5	22	12										
	Troll line	79	79	79		79	79	79	79	79	79	79	79	79	79	79	79	79	158	237	237	331	573	575	636	725	632
Countries																											
Comoros																						100	100	100	100	100	100
France-Reunion		79	79	79		79	79	79	79	79	79	79	79	79	79	79	79	79	158	237	237	79	395	395	316	381	284
Indonesia		100	300	400	400	400	400	400	400	400	400	400	500	600	600	600	700	700	700	700	800	600	600	1000	1100	1071	869
Japan *				8800	13300	24900	46500	64400	36000	25700	24400	40300	34600	51700	25900	24800	27600	44100	31600	50500	25200	14500	12900	7800	3400	4415	4719
Korea, Republic of																		100	200	4638	7977	4068	6454	9580	9919	11563	11694
Madagascar																									550	1160	180
Maldives		1500	1500	1500	1500	1500	2000	2000	2000	2000	2000	1000	1500	1500	1500	1500	1000	1500	1700	1700	1800	2534	1560	2691	7170	5344	4900
Pakistan		351	351	351	535	552	569	535	1372	686	686	836	753	1188	1757	2442	2643	3530	3429	3446	3112	2827	2306	2750	2162	2965	3272
Seychelles																						100	100	100	100	150	100
Soviet Union															5	22	12										
Sri Lanka								1200	3100	2000	2200	2900	3200	4700	7800	5400	6000	5800	8500	9000	6800	5800	4700	6500	5100	6070	6611
Taiwan,China																		4000	6221	22416	20916	14867	11840	11840	5702	4397	4630

Table 1 (cont). Catches of yellowfin tuna by area and gear for the period 1976-2000.

Area/Country	Gear	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Total Indian Ocean		37339	58848	48287	42326	38230	41400	51587	61321	99693	120714	141179	154780	210168	199574	231226	226342	306047	379087	308497	323282	331595	313384	293198	328640	303954
IO_Al	Baitboat	5218	4897	3822	4396	4368	5946	5000	8120	8482	6961	6206	7378	5944	5526	4932	7028	8029	9275	12383	11768	11501	12167	12994	13594	10773
	Gill net	3070	2743	1598	2762	1275	1958	9183	8138	6126	9902	12006	14982	27390	34931	26952	28260	39709	38068	52196	54076	55953	48631	54747	68946	48356
	Hand line	0	0	0	0	0	0	0	5	1	2	44	44	49	2118	2251	2132	1348	1720	1988	1904	2019	1926	1780	1779	1938
	Hand & Troll line	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	287	485	592
	Longline	20834	43543	34796	25348	22221	23366	33517	30109	24799	29946	45079	45594	54248	64647	85787	80420	139002	196990	121738	97778	118255	107644	112470	101654	87792
	Unclassified	7359	6874	6976	8589	9182	8876	1691	1224	956	4289	3879	2357	3238	711	764	889	867	951	962	952	8153	5013	2229	1397	1747
	Purse seine	56	107	289	187	211	342	1301	12777	58437	68904	73566	83951	118728	89875	108811	105786	112928	128185	114816	152348	131318	133531	104027	136136	146934
	Troll line	802	684	806	1044	974	912	895	948	891	709	398	474	571	1766	1728	1828	4164	3897	4415	4456	4396	4472	4664	4648	5823
Somme IO_Eastern		16842	18901	18556	20105	20746	16549	16863	17926	16296	18596	19294	17699	23292	47537	49266	50378	58687	62830	86288	71279	83384	90532	104086	98965	77710
IO_Eastern	Baitboat							418	452	258	27	4	4	5	1	11						1				
	Gill net							6733	7311	5233	6178	6941	6759	8171	9391	7428	11246	10273	10773	11398	8195	13132	15999	20202	27764	22350
	Hand line											37	36	43	2	52	1	3	44	11	23	9	12	13	15	15
	Hand & Troll line																							57	334	437
	Longline	9577	12100	11491	11557	11826	8601	7963	8732	9667	10025	9128	8825	13319	37814	41432	38344	47956	50447	70582	57832	64045	68819	66692	67431	53490
	Unclassified	7209	6694	6776	8361	8709	7805	1058	770	416	1767	2915	1698	1460	44	68	117	117	143	139	150	1619	1003	450	225	225
	Purse seine	56	107	289	187	211	143	273	209	336	277	221	330	238	255	270	611	338	1418	4153	5076	4572	4694	16662	3183	1179
	Troll line							418	452	386	322	48	47	56	30	5	59		6	5	3	6	6	9	13	14
Somme IO_Western		20497	39947	29731	22221	17485	24851	34724	43395	83396	102118	121885	137081	186876	152037	181960	175964	247360	316257	222209	235001	235523	212378	180946	217348	211824
IO_Western	Baitboat	5218	4897	3822	4396	4368	5946	4582	7668	8224	6934	6202	7374	5939	5525	4921	7028	8029	9275	12383	11768	11500	12167	12994	13594	10773
	Gill net	3070	2743	1598	2762	1275	1958	2450	827	893	3724	5065	8223	19219	25540	19524	17014	29436	27295	40798	45881	42821	32632	34545	41182	26006
	Hand line								5	1	2	7	8	6	2116	2199	2131	1345	1676	1977	1881	2010	1914	1767	1764	1923
	Hand & Troll line																							230	151	155
	Longline	11257	31443	23305	13791	10395	14765	25554	21377	15132	19922	35951	36769	40929	26833	44356	42076	91046	146544	51156	39946	54210	38826	45777	34222	34301
	Unclassified	150	180	200	228	473	1071	633	454	540	2522	964	659	1778	667	696	772	750	808	823	802	6534	4010	1779	1172	1522
	Purse seine						199	1028	12568	58101	68627	73345	83621	118490	89620	108541	105175	112590	126767	110662	130270	114057	118363	79199	120627	131335
	Troll line	802	684	806	1044	974	912	477	496	505	387	350	427	515	1736	1723	1769	4164	3891	4410	4453	4390	4466	4655	4635	5809

Table 1 (cont). Catches of yellowfin tuna by country for the period 1976-2000.

Area/Country	Gear	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Countries																										
Australia			3	15	28	34	20	8	18	41	43	42	40	12	216	80	23	14	91	647	263	107	305	275	478	395
China																					138	494	750	402	2335	2361
Comoros		100	100	100	100	100	110	110	120	130	140	140	140	150	3321	3321	3321	4742	4742	5609	5609	5520	5310	5310	5200	5600
East Timor																									1	3
France							199	1028	10505	36735	39143	43301	46801	59913	38375	45323	38135	45282	39539	35819	39635	35577	31227	22382	30799	37694
France-Reunion		303	255	352	312	260	244	190	183	174	144	151	170	209	198	198	262	388	410	492	402	628	636	609	534	656
France-Territories																								194		
India									14	42	115	645	240	133	31	17	49	40	228	185	194	7327	4106	3618	2073	2158
Indonesia		1317	2345	2811	3692	3984	2823	3980	1823	1520	2795	3779	3194	3932	4142	5015	6380	9819	13037	16471	18047	30713	36843	35558	41998	
Iran, Islamic Republic		920	719		392	370									980	2280	3238	14565	21636	27162	27175	30233	21250	21530	26871	15743
Japan		2744	2095	4239	2126	3426	4733	6475	7237	7709	9338	11115	7813	8944	4451	9165	8901	15725	14323	12304	12705	15929	16078	18483	16427	15018
Kenya						77	197	235	370	20	26	36	19	27	39	50	71	75	80	80	80	80	80	80	80	80
Korea, Republic of		12848	31383	25165	17788	12537	11777	18654	15337	9895	12017	14891	12575	13428	8103	7006	3004	4091	4681	3622	2444	3443	3642	2265	908	1064
Maldives		5717	5326	4276	5128	5082	6251	4814	7981	8486	7136	6353	7595	6218	5776	5140	7227	8309	9605	12621	12031	11811	12489	13566	13664	11713
Mauritius				17		1	1		1057	1284	925	890	1694	1352	1848	1434	2741	2285	2537	1858	1725	713	1095	1443	742	226
Mozambique									15	188	15															
NEI-Deep-freezing											58	1060	1195	4003	3612	6728	7458	13421	22273	8993	7941	13719	6599	11494	8672	9769
NEI-European									661	8370	9375	6324	5233	7909	4485	11945	11930	8053	15483	19676	19319	16741	21898	20283	25827	27051
NEI-Ex-Soviet Union																804		5149	8079	5836	17002	12689	10474	8165	12327	14420
NEI-Fresh Tuna															11860	16646	14382	16718	19547	27614	25690	24315	24222	21559	14538	10616
NEI-Indonesia Fresh Tuna												74		2630	10151	12374	12671	15301	12341	16100	8726	3679	3926	325	43	
Oman											2237	2520	5842	15485	15998	14084	8996	13419	11366	18922	21276	11590	9782	11307	7377	7016
Pakistan		3070	2743	1598	2762	1275	1958	2450	827	893	1487	2517	2336	3733	8560	3156	6480	23394	30817	4604	5140	5250	3838	3795	8884	4946
Philippines																								623	619	300
Portugal																								5	11	9
Seychelles		50	80	100	128	357	949	518	157	131	177	10	8	3		15	372	225			5	67	2878	7451	9921	11603
South Africa									166				1	1		70	7	13	24	6	26					
Soviet Union									180	148	720	2882	3578	4161	3130	2428	3059									
Spain							363	55		11453	18420	20017	26258	44928	41070	43711	44023	37836	47802	43149	65143	59431	60986	38588	51919	52179
Sri Lanka		6915	5720	5369	6166	6906	7662	8350	9046	6439	6716	7359	7163	8604	10134	7903	12130	10446	11616	11939	8696	12889	15756	19651	27538	22091
Taiwan,China		3355	8079	4245	3704	3806	4101	4715	5580	5812	7321	16249	22365	22765	22425	31638	30713	55988	88026	33984	23069	27850	18374	23416	17686	17367
Tanzania																									350	700
Thailand																										478
Yemen						16	12	5	44	222	2367	824	519	1628	667	695	771	748	804	804	800	800	840	820	820	820

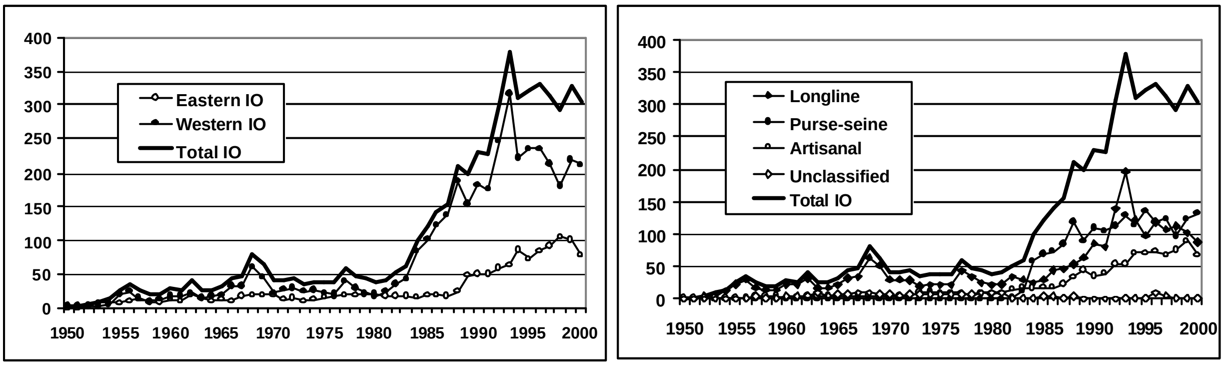


Figure VII.1 – Yearly catches (thousand of metric tons) of yellowfin by area (Eastern and Western Indian Ocean, left) and by gear (longline, purse-seine, artisanal and unclassified, right) from 1950 to 2000.

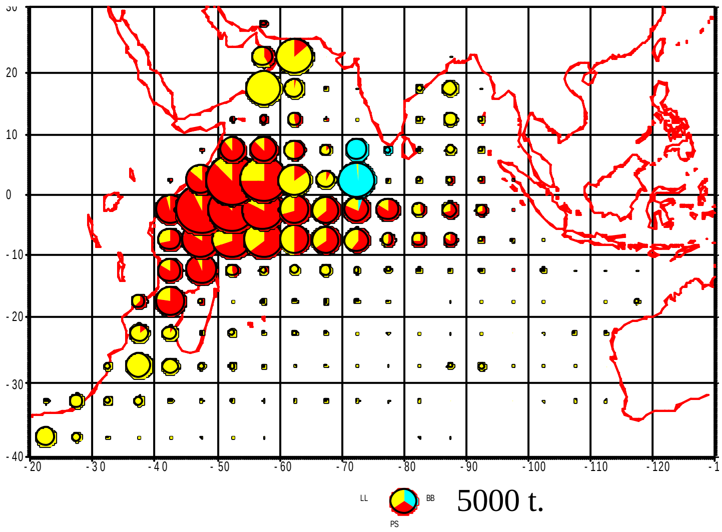


Figure VII.2 – Average (1995-1999) geographical distribution of yellowfin catches according to the gear (longline, purse-seine and artisanal).

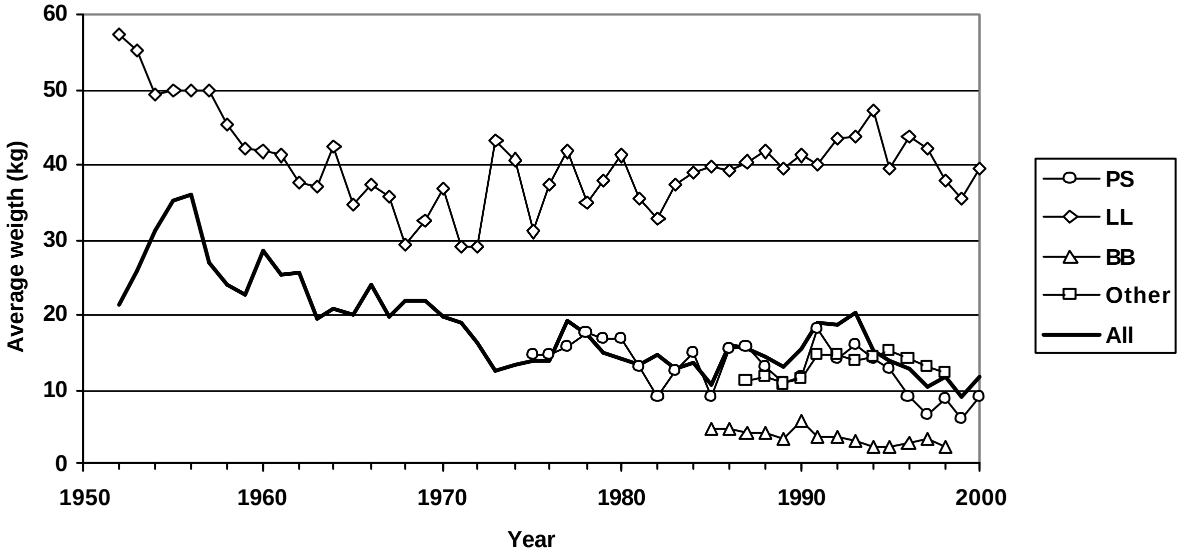


Figure VII.3 – Yellowfin average weight in the catch by gear (from size-frequency data) and for the whole fishery (estimated from the total catch at size).

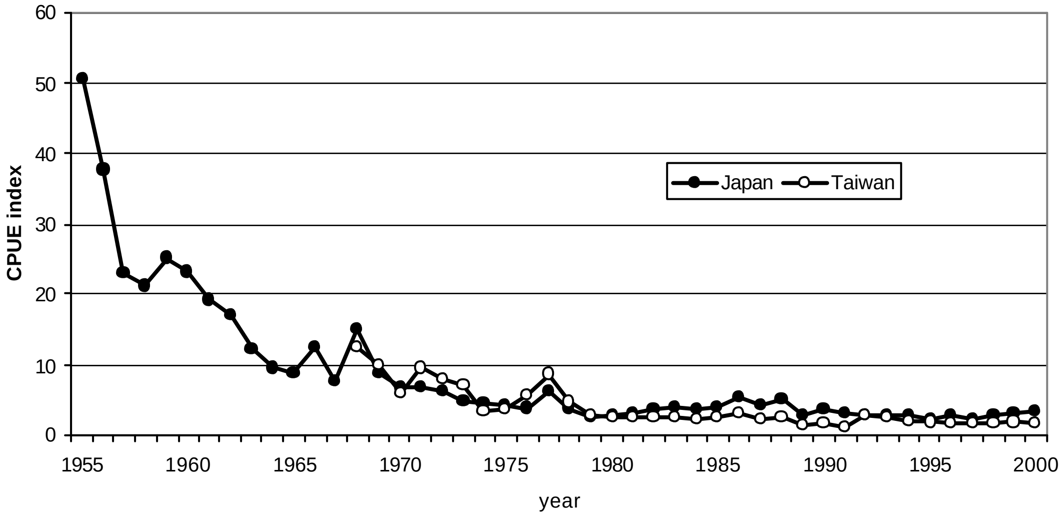


Figure VII.4 – Yearly abundance indices based on the Japanese and Taiwan, China longline yellowfin CPUE's in the tropical area (10°N-15°S).

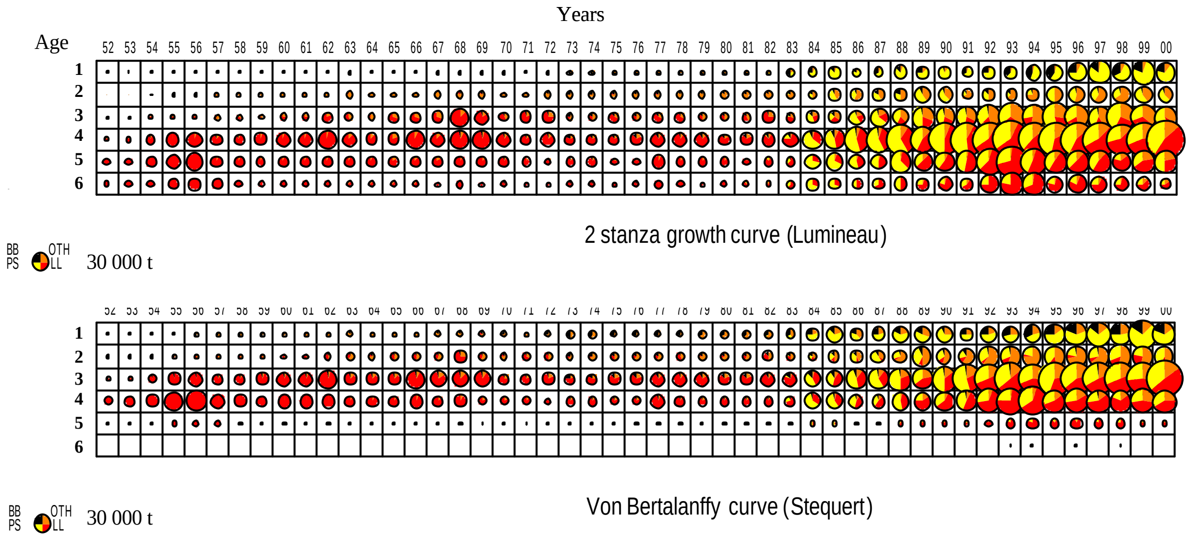


Figure VII.5a – Catch at age by gear (in weight) according to the two growth hypothesis used by the WPTT: "slow", assuming a two stanzas growth curve (above) and "fast", assuming a constant growth rate (below).

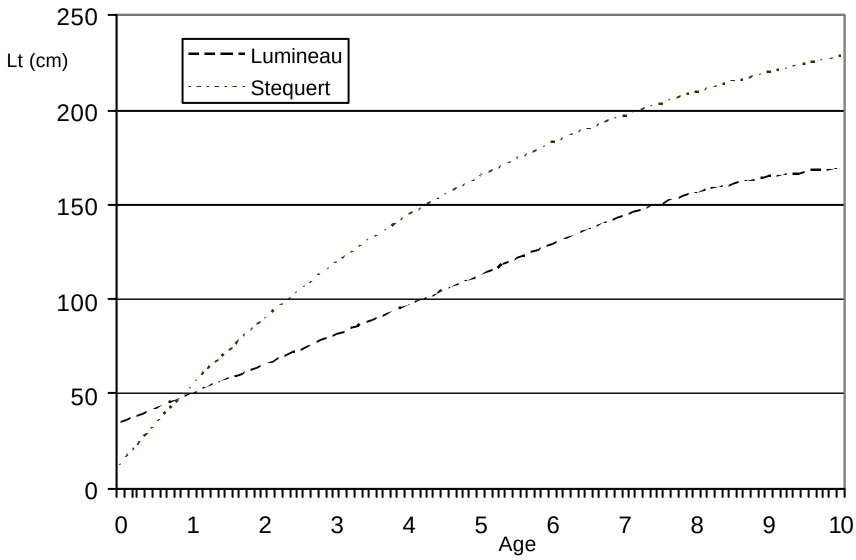
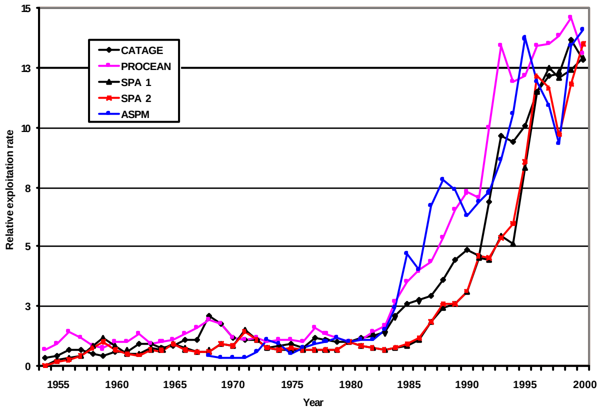


Figure VII.5b – Comparison between the two growth models used in the assessments



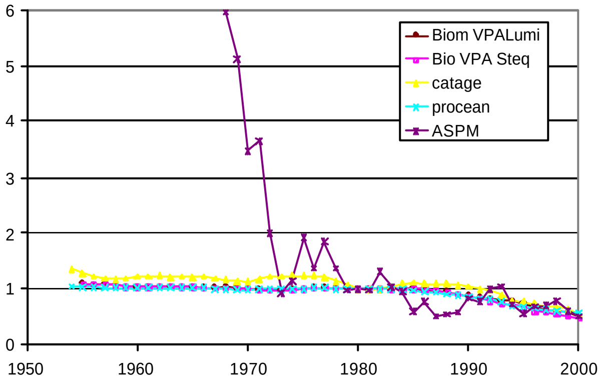


Figure VII.6 – Relative exploitation rates estimated from the five assessments ran by the WPTT (all have been set at 1 in 1980selected as the reference).

Figure VII.7 – Trend of the relative biomass estimated from the five assessments ran by the WPTT.

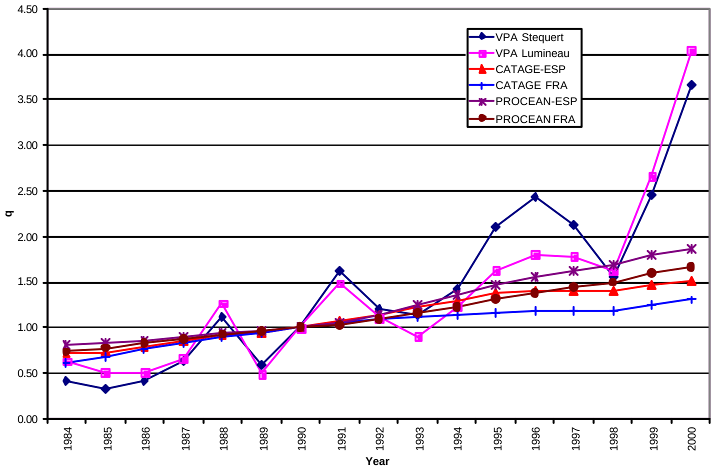


Figure VII.8 – Average yearly relative catchability coefficients for purse seine fleets estimated from the assessments ran during the meeting; all have been set at 1 in 1985 (first year of activity of the major purse-seine fleets) selected as the reference year.

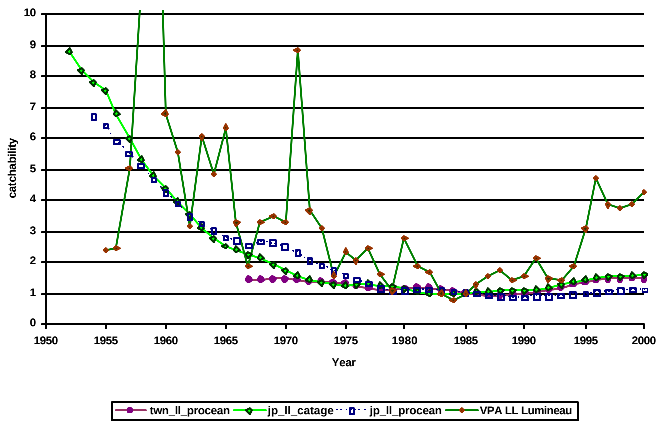


Figure VII.9 – Average yearly relative catchability coefficients for longline fleets estimated from the assessments ran during the meeting; all have been set at 1 in 1985, selected as the reference year.

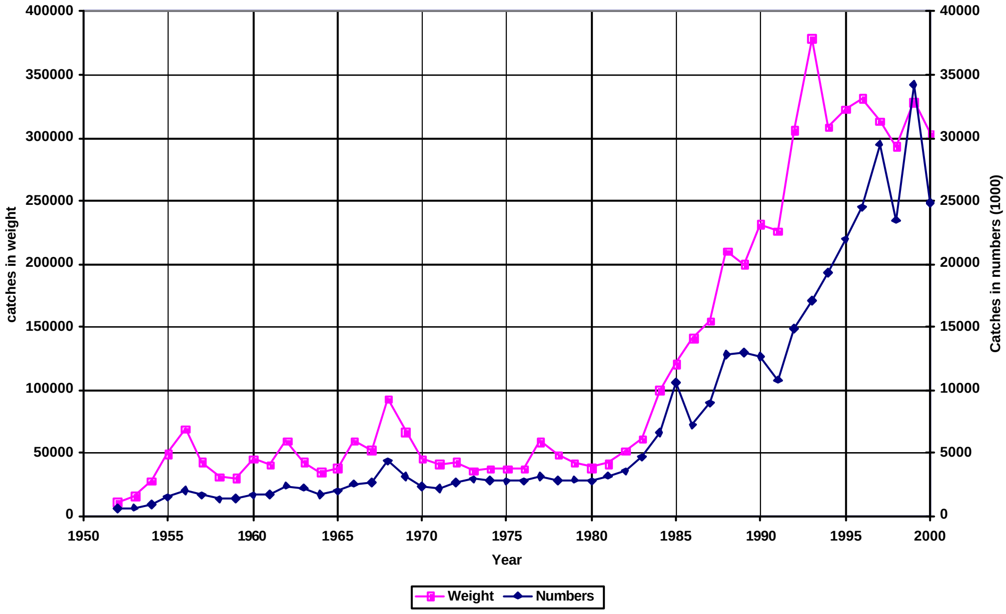


Figure VII.10 –Total catch of yellowfin tuna in weight and numbers.