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Commission des Thons de l'Océan Indien

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

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Executive Summary

The First Meeting of the Working Party on Tropical Tunas (WPTT) was held in Mahé, Seychelles from 4 to 8 September 1999, involving 26 participants from 12 countries or organizations. Dr. Geoff Kirkwood was elected Chairperson for the Meeting and subsequently for the coming biennium.

The emphasis of the meeting was placed on bigeye tuna, but a number of the conclusions and recommendations reached apply equally to all tropical tunas.

A review of fisheries and available data confirmed that both longline and purse seine fisheries for bigeye tuna have been expanding rapidly over the current decade. There are however major gaps in catch and effort data available, in particular major longline fleets operating from Indonesia and several eastern Indian Ocean ports and some which are engaged in illegal, unregulated and unreported (IUU) fishing. Furthermore, size data for most longline fisheries are generally missing or of doubtful quality.

A number of recommendations on research were formulated, dealing with improvements in fisheries and biological data collection and diffusion and with stock assessment. In particular, the process for estimating IUU catches through a vessel registry, landings database and port sampling proposed by the Permanent Working Party on Data Collection and Statistics was endorsed.

The lack of reliable data limited the possibilities of conducting rigorous stock assessments; however, a number of indices were examined which, taken together, led to the conclusion that bigeye tuna stocks might be fully- or overexploited.

The WPTT therefore recommended an immediate halt to the increase in catches from all gears. In addition, it was deemed necessary to cut short the increased catches juvenile bigeye tuna by purse seines fishing on FADs. A number of ways of achieving this were proposed, the most promising being suggested as time and area closures on log fishing.

Some indices of skipjack catches led to the conclusion that there may also be signs of at least localised overfishing, with possibilities of interactions between the central Indian Ocean purse seine fishery and the Maldivian pole-and-line fishery.

Finally, the WPTT discussed and proposed Terms of Reference of the Working Party on Tagging. Wide-scale tagging of tropical tunas is seen as an urgent priority and a number of immediate actions were identified. The Working Party on Tagging is seen to have a functional relationship with the WPTT and it was proposed that, initially at least, the two groups should meet together.

1. OPENING OF THE MEETING, ELECTION OF THE CHAIRPERSON AND ADOPTION OF THE AGENDA

The First Meeting of the Working Party on Tropical Tunas (WPTT) opened on 4 September 1999 in Mahé, Seychelles. The participants (*Appendix I*) elected Dr. Geoff Kirkwood, from Imperial College, London, as Chairperson for the Meeting. The Agenda (*Appendix II*) was adopted. The documents available for discussion are listed in Appendix III.

Based on the Terms of Reference for the WPTT (*Appendix IV*) the Working Party recognised the following activities as priorities:

- Develop a preliminary stock assessment of bigeye tuna as a priority. However, if time allows, the assessment might be extended to include yellowfin tuna and skipjack tuna.

- Examine the Terms of Reference for a future Working Party on Tagging. In particular, consider the objectives and requirements of a tagging programme that will meet the most important information needs for the assessment activities.

- Examine the question of excess fishing capacity in the Indian Ocean in the light of the results of the assessment.

2. REVIEW OF FISHERIES AND AVAILABLE DATA

Summary of current knowledge concerning bigeye tuna in the Indian Ocean

The biology and fisheries for bigeye tuna (*Thunnus obesus*) in the Indian Ocean are presented in the document WPTT/99/inf 03 and the major points are summarised here. Bigeye tuna are broadly distributed in oceanic waters throughout the Indian Ocean at latitudes north of 40°S. Young bigeye tuna of less than 80 cm in length are found predominantly in equatorial waters and appear most abundant under floating objects where they are captured by purse seines. Low oxygen levels (less than 2.0 ml/l for juveniles and less than 1.0 ml/l for adult fish) constitute the principal limitation to their distribution in some sectors bordering the Asian continent. Large bigeye tuna found in equatorial waters of the Indian Ocean have mature gonads. Spawning takes place throughout the year, but peaks around the fourth to first quarter of the year. Bigeye tuna mature at a length of about 100 cm and an age of between two and three years. According to research carried out in the western Pacific Ocean, growth of bigeye tuna is slow for a tropical tuna species and longevity may be on the order of 10 to 15 years. There are no direct estimates of natural mortality for bigeye tuna in the Indian Ocean. The bigeye tuna population in the Indian Ocean is assumed to constitute a single stock. However, there has been little evidence to support this assumption, partly because there have been no tagging experiments involving bigeye tuna.

Limitations of data on bigeye tuna

The Secretariat reported on recent trends in the fishery and on the availability of data for the assessment of bigeye tuna.

Fisheries data

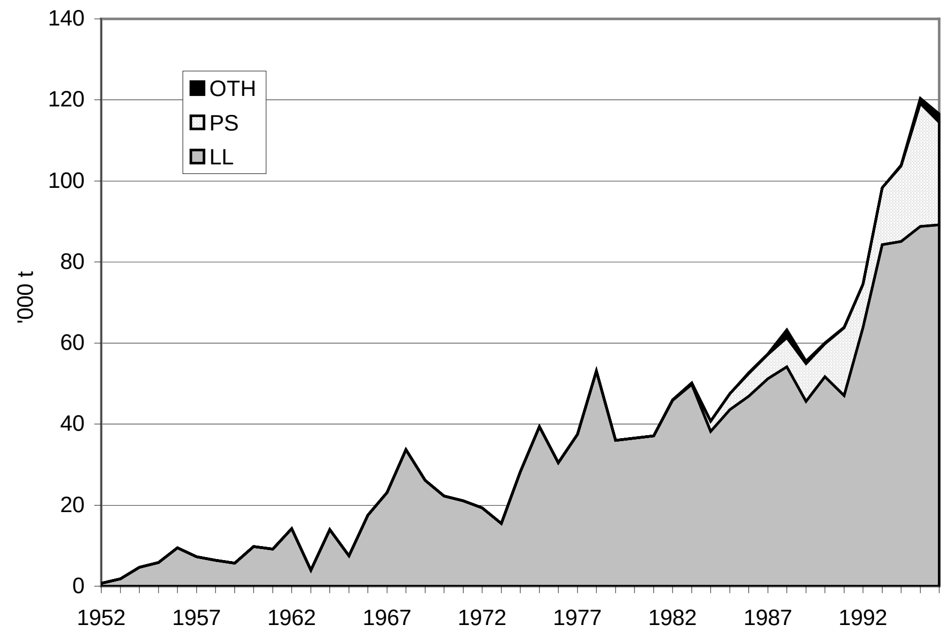
Data reporting of bigeye tuna catches is very poor for some segments of the fishery and even total catches are only partially known (Table 1.). Catch data are largely missing from longline and artisanal vessels flying flags of convenience, as well as from Indonesia and Taiwan Province of

China, which land their catch in both the eastern and western Indian Ocean. It was estimated that there were up to 1,200 vessels in these fleets. Unconfirmed reports indicate that these vessels are active for at least six months of the year in the Indian Ocean, each catching approximately 15 t of tuna per month, half of which is bigeye tuna. If these reports are correct, the magnitude of the catch from this fleet was estimated to be around one half of the total reported longline catch of bigeye in the Indian Ocean.

Table 1. *Catches of bigeye tuna in the Indian Ocean in 1996 in tonnes.*

Country	*GILL*	*HAND*	*LL*	*PS*	*TROL*	*UNCL*	*Grand Total*
Australia			25		1		26
China			453				453
Comoros		18			12		30
France		5	94	8,777			8,876
Honduras			39				39
India						1650	1,650
Indonesia			26,456				26,456
Japan			15,340	1,335			16,675
Korea			12,403				12,403
Mauritius			4	257	10		271
Seychelles						39	39
Spain				13,312			13,312
Sri Lanka	301		190				491
Taiwan (Province of China)			29,820				29,820
Not elsewhere identified			4,348	1,690			6,038
Grand Total	301	23	89,172	25,371	23	1,689	116,579

Figure 1 *Catches of bigeye tuna in the Indian Ocean in tonnes, by gear.*

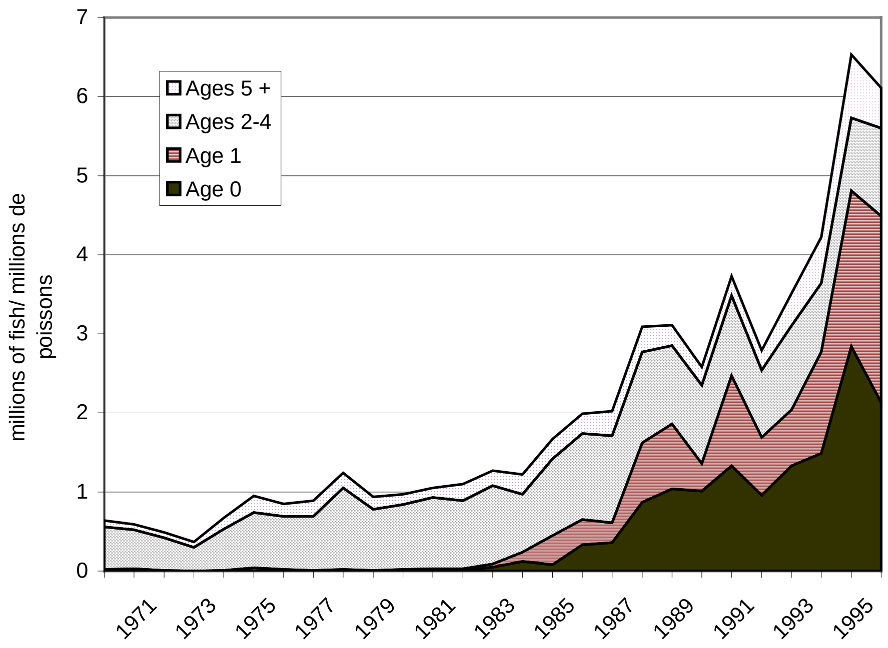


There has been no reporting of Indonesian catches since 1994 and, since that time, catches have been assumed to be the same as the 1994 catch. This is likely to be an underestimate of the true catch. Furthermore, catch data are not available from Taiwan Province of China since 1997.

The Working Party noted that much of the basic fisheries statistics for bigeye tuna (as well as other tropical tunas) are missing. These include, but are not limited to:

- Catch, effort and size-frequency data for the Indonesian longline fishery in recent years.
- Size-frequency data for the whole period of operations for the Korean longline fishery.
- Catch (since 1997), effort (since 1994) and size-frequency (since 1988) data for the Taiwanese longline fishery.

Figure 2. *Catches of bigeye tuna (in millions of fish) by age categories, for all gears (from document WPTT/99/08)*



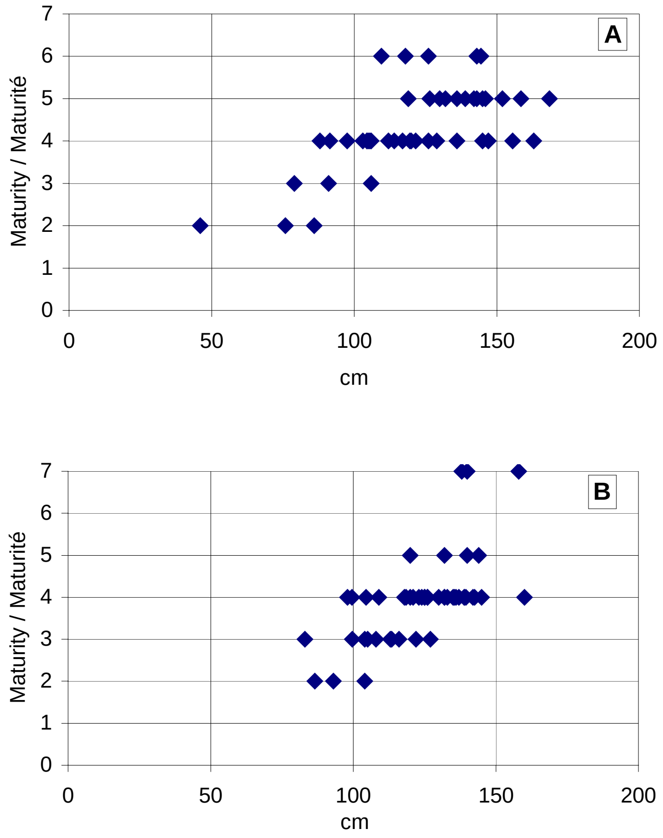
Poor reporting of size structure data from Indian Ocean bigeye catches is a further impediment to stock assessment. The most complete data set is from Japan, which has provided size-frequency data for catches from 1952 to 1997. No size data are available from Korea or Indonesia. It appears that these data have never been collected in Korea. There is a window of five years (1984-1988) of size-frequency data from Taiwan Province of China. France and Spain recently provided a new series of size-frequency data from their purse seine fleets. The 'Not-Elsewhere-Included' (NEI) purse seine fleet, essentially French and Spanish vessels operating under flag-of-convenience arrangements, has provided good size data since the beginning of its operations in the Indian Ocean. These data are not currently available for the NEI longline vessels from various countries.

Trends in the fishery

There are clear trends in the estimated catches of bigeye tuna by both purse seine and longline gear (*Figure 1. and 2.*). Purse seine catches more than doubled since 1993. The great increase in the use of FADs (often referred to as logs) in the purse seine fishery was noted. This, combined with the use of deep nets and electronic equipment such as sonar, has led to an increase in bigeye tuna catches and catch rates.

Catches of bigeye tuna in the Indian Ocean by longline have more than doubled since 1987. The majority of this increase was attributed to a change in targeting practices in the longline fleet based primarily in Indonesia, which increased dramatically its catch of bigeye tuna around 1992. It is believed that there have been important further increases in the Indonesian longline catch after 1994, but these cannot be confirmed due to the lack of data reporting.

***Figure 3.** Maturity scale in bigeye tuna as a function of fork length, by sex. Scale values above 3 indicate sexually mature fish.* A*: Males;* B*: Females.*



General Discussion

The Working Party discussed the prospects for completing a successful stock assessment with incomplete catch and size data as well as an extremely limited biological understanding of bigeye tuna. It was recognised that, until reasonable stock assessments were feasible, there would be value in seeking to identify indicators that are symptomatic of overfishing. Suitable indicators might include, for example, a decrease in the average weight of catches, declines in CPUE, and changes in the surface area fished. Further investigation of these indicators was recommended.

Without basic fishery information, stock assessment using even simple production models is difficult if not impossible. The lack of even catch data from the longline fleets of Indonesia and Taiwan Province of China is particularly worrying, as these vessels are thought to be taking at least 40-70% of the total Indian Ocean catch (in weight) of bigeye tuna in the 1990’s.

This problem is confounded by the many developments in fishing vessel operations and gear technology (particularly but not exclusively for the purse seine fleets), which make standardisation of fishing effort all but impossible. Studies are needed to address this problem. It was noted that the EU is undertaking such a study of its purse seine fleets, starting in 1999.

It was also noted that the biology of bigeye tuna in the Indian Ocean was still poorly known. Basic information such as length-weight relationships and growth parameters are not well known. Without such information, stock assessment using age-structured models is impossible. Some new information on size-at-maturity, available from data collected by observers participating in the programme put in place by the BIOT authorities was made available to the Working Party

(*Figure 3*) The new data are consistent with the assumption that the length-at-maturity is about 100 cm.

3. PROGRESS IN RESEARCH ON FISHERIES, BIOLOGY AND OCEANOGRAPHY

Stock structure

In Document WPTT/99/09, the progress on the collection of tissue samples for the DNA analysis of yellowfin stock structure in the Indian Ocean is reviewed. The National Research Institute for Far Seas Fisheries (NRIFSF) of Japan has undertaken to investigate the genetic stock structure of Indian Ocean yellowfin tuna. It was noted that ten countries had agreed to supply tissue samples for this study and that samples might be available from another two or three countries. It was anticipated that the analyses should be completed in 2000 and preliminary results should be available for presentation at the next meeting of the WPTT.

The Working Party noted that CSIRO is currently undertaking a study of the genetic stock structure of bigeye tuna and swordfish in Australian waters and other areas in the Pacific and the Indian Oceans. It was also noted that it would be feasible to conduct a similar study of the stock structure of Indian Ocean skipjack tuna in the near future.

Relationship with the environment

The latest 1997-98 warming event, a consequence of one of the strongest ENSO events in the century, has caused dramatic temperature and wind stress anomalies in the equatorial Indian Ocean. These events are described in document WPTT/99/03. These anomalies are likely to be the strongest ever recorded in the Indian Ocean. This document focused on their impact on the purse seine fishery (European Union and NEI vessels). The geographic distribution of the purse seine catches was drastically modified, especially at the beginning of 1998, at the peak phase of the El Niño phenomenon. The usual fishing grounds of the western Indian Ocean basin were deserted and the fleets started a massive shift to the eastern basin, as far as 100°E, a longitude never reached before by the EU fleet. This change may be explained by a significant decrease of catchability by purse seines of free-swimming schools (that are usually exploited during the first quarter of the year in the western Indian Ocean). The tuna habitat was deepened by an unusually deep thermocline as a consequence of the tilt of the slope of the ocean due to the ENSO. Piling up of warm water in the western Indian Ocean resulted from anomalous strong easterly winds; at the same time, cool conditions prevailed in the eastern Indian Ocean.

Fleets reacted very quickly to the environmental anomaly. The changes in fishing strategy are not well accounted for in the CPUE indices currently used to relate to the environment. The development of tools for more reliable quantitative analyses needs to be promoted, including multispecific simulation models of the distribution of tuna, forced by the environment and incorporating simultaneously the behavioural response of the species and the fishing strategy changes. This type of model involves an underlying physical model that is used to force the movements of tunas and their catchability. The most powerful physical models, such as coupled models, are complex to use. As a first step, simple shallow-water models can be used to estimate environmentally-related catchability indices on a large scale. At a later stage, the coupling with more complex bio-geochemical models should be attempted for process-oriented studies, such as the effect of environmental anomalies on recruitment and forage availability for tuna.

The Working Party noted that the study demonstrated the importance of understanding the link between tuna behaviour (e.g. horizontal and vertical distribution) and climate change, as well as the response of fishing fleets. The purse seine fleets make large-scale movements (in the order of thousands of kilometres) based on changes in catchability of the target species and these movements are directed with the aid of environmental data (e.g. sea surface temperature data from satellites). The response of the fleet still only occurs over short time scales since they do not plan future large-scale movements on the basis of probable ocean conditions associated with the development of climatic phenomena such as El Niño. 'Bio-geochemical' models, which relate physical processes to biological production, have already been used successfully to predict the distribution of tunas in the Pacific. These models are extremely complex and in a relatively early stage of development. However, in the near future models of this type will be developed for the Indian Ocean.

In document WPTT/99/10, the seasonal changes in bigeye tuna fishing areas in relation to oceanographic parameters in the Indian Ocean are analysed, based on historical Japanese longline catch and oceanographic data. Within the Indian Ocean, there are three main longline fishing areas for bigeye tuna: a western tropical area (Arabian Sea to Madagascar), an eastern tropical area (Java Island to Sri Lanka) and a southern high latitude area (western Australia to South Africa). Bigeye tuna are relatively scarce in longline catches in the zone 10°S-20ºS. Adult and subadult bigeye tuna are found most frequently in waters of 10-16ºC. Therefore, they are caught by longlines at depths of about 150-300 m in the tropics, but at depths of about 90-270 m in more southerly latitudes. Sexually mature bigeye tuna are only found in the tropical areas. Furthermore, these mature fish are only found in areas where the sea-surface temperature exceeds 26ºC. This warm tropical area is considered to be a breeding and nursery zone. It contracts during the southwest monsoon (June to September), largely as a result of upwelling off the coast of Somalia, at the same time that the southern 'feeding' area, where subadult bigeye is found, expands.

The Working Party noted that the distribution of mature bigeye tuna in the tropical Indian Ocean corresponded very closely to the 'Monsoon Area', as described by Longhurst (1998)[1], while the distribution of younger fish in more southerly latitudes corresponded very closely to the southern part of Longhurst's 'Southern Gyre Area'. This emphasises the importance of an ecosystem approach to tuna fisheries analysis. The absence of adult bigeye tuna from the Somali coast during the southwest monsoon was thought to reflect particularly low oxygen levels at depth during the upwelling season. However, juveniles (swimming in the surface layers) are able to take advantage of the seasonal productivity associated with the upwelling and are targeted there by the purse seine fleet.

Document (WPTT/99/11) also discussed the distribution of bigeye tuna and its relationship to the environmental conditions in the Indian Ocean, based on Japanese longline fisheries information. Longline bigeye tuna hooking rates are very low at depths less than 100 m and highest at depths greater than 200m. Mature females are found mostly in tropical waters, between 15ºN-15ºS. Mature bigeye are found year-round in the western and central tropical Indian Ocean, but are relatively scarce in the eastern tropical Indian Ocean from April to September. The optimum temperature for adult and subadult bigeye is 10-16ºC. The minimum dissolved oxygen requirement for bigeye is 1 ml/l. This explains low catch rates in the northern Bay of Bengal, where dissolved oxygen levels below about 100m are very low.

In the ensuing discussion, the estimation of hook depth from longline catenaries was questioned. However, in this case it was felt that hook depths were estimated fairly accurately: some depths were actually measured and longlines were not normally deployed in high currents.

The relationship between environment and tuna fisheries in Maldives was discussed in document (WPTT/99/07). Maldivian tuna catches are affected by changes in oceanographic conditions, including those associated with ENSO events and with decadal-scale oscillations. Three types of variability were considered in this document. On inter-annual time scales, catch rates of skipjack tuna tend to go down during El Niño events, while catch rates of yellowfin tuna, frigate tuna and

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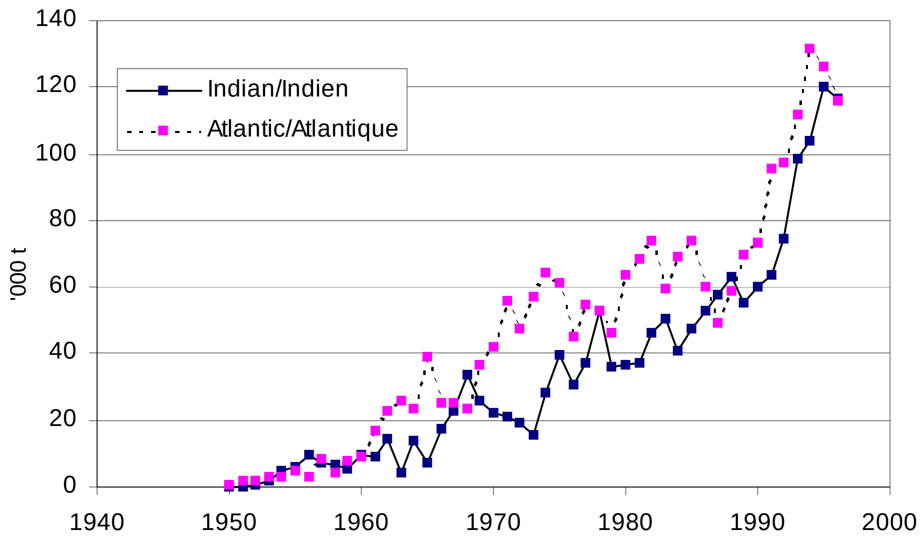
[1] Longhurst, A.E. (1998). Ecological Geography of the Sea. Academic Press, 398 pp.

kawakawa tend to go up. The opposite is seen during La Niña events. Over decadal scales, skipjack catches were higher and yellowfin tuna catches were lower than average during 1970-72 and 1985-92, but the opposite was seen during 1973-84 and 1993-98. This is interpreted as evidence for a decadal-scale oscillation in Indian Ocean oceanographic conditions, with a period of about 20 years. Thirdly, over still longer periods, frigate tuna catches have decreased while kawakawa catches have increased. This was interpreted by the author as possible evidence for a decadal-scale oscillation in Indian Ocean oceanographic conditions, with a period of perhaps 60 years or longer. The lack of understanding of Indian Ocean variability is a hindrance to a full understanding of Indian Ocean tuna dynamics.

The Working Party concluded that it would be important to determine if the trends observed for the Maldivian tuna catches are the result of effects at a local scale or if these are representative of interactions across the entire Indian Ocean. Identification of the spatial scale of the observed effects would require analysis of many more data sets. There was some speculation on the reasons behind the observed increases and declines in catches of different tuna species in the Maldives. Among the mechanisms suggested were declines in larval survival due to oceanographic variability or habitat shifts by the fished species that would affect catchability. Extreme values of turbulence might be linked to higher rates of survival in yellowfin tuna larvae. It was unclear how these effects would relate to survival of larvae of the different tuna species. In the past year, Maldivian catches of large skipjack are among the greatest recorded. Changes in the nature of catch could be associated with a range of oceanographic phenomena. These could include the Pacific Decadal Oscillation (PDO), El Niño/La Niña, the Indonesian through-flow and the Antarctic Circumpolar Wave. Further research should identify trends in catch of various tuna species; particularly from regions such as the Maldives with good time series of catches and determine if there are links with various ocean phenomena.

Figure 4*. Comparison of total catches of bigeye tuna in the Indian and Atlantic Oceans*



Fishery studies

A comparative analysis of the exploitation of bigeye tuna in the Indian Ocean and eastern Atlantic Oceans, with emphasis on purse seine fisheries was presented in document WPTT/99/04. The major increase of bigeye catches in both the Indian and Atlantic oceans since 1990 (*Figure 4.*) came from an increase of juveniles catches by the surface fisheries in the recent years, combined with higher adult catches by the longline fisheries. Although purse seiners do not primarily target bigeye, the extensive use of FADs is assumed to be one of the main causes of the increase in juvenile bigeye catches. However, increases in fishing power due to the introduction of numerous changes to purse seine fishing equipment and operations, make it difficult to estimate meaningful indices of abundance. In the absence of detailed information on the time of introduction of these changes, the authors proposed: 1) the use of non-traditional indices and 2) a comparison between the Indian and Atlantic Ocean fisheries in order to assess the likelihood of the different assumptions proposed in explaining changes in bigeye catch. The analysis of the differences between the area visited and the area fished and the catch per log set by time of day both suggest an increase in bigeye catchability. Changes over time of some indices, such as the proportion of bigeye in log catches, the catch per successful log set and the spatial distribution of log catches by species suggest to the authors that bigeye tuna were less affected by FAD fishing than skipjack tuna (at least in the Atlantic).

It was widely agreed by the Working Party that there are great difficulties in accounting for changes in catchability of bigeye (and other tunas) associated with increases in fishing power of the purse seine fleet in the Indian Ocean. It was also agreed that there are some similarities between the Atlantic bigeye purse seine fishery and the Indian Ocean fishery. Comparative studies such as this one were therefore felt to be particularly useful in providing some insights into developments within the Indian Ocean fishery. It was further noted that a recent increase in the use of FADs in the eastern tropical Pacific fishery had also led to an increase in bigeye catches, with the sizes caught being similar to those in the Atlantic and Indian Oceans. Yield-per-recruit analyses from all three oceans might therefore be expected to provide comparable results. Within the Indian Ocean, very large numbers of floating FADs are now being deployed by the purse seine fleets, which is having a major impact on catches and on catch composition in particular. The recent decrease in skipjack catches on FADs by purse seines was noted; the reason for this decline was not known but it could reflect a decrease in skipjack abundance rather than a change in the fishing pattern of the purse seiners. It was suggested that analysis of Mauritian purse seine catch and effort data might shed some light on the changing catch composition of the EU purse seine fleet, since the Mauritian vessels were believed to have concentrated on FAD fishing with deep nets since the beginning of their operations.

In document WPTT/99/13, the fishery, distribution and abundance of bigeye tuna in the seas around India were discussed. Commercial exploitation of bigeye tuna in India was initiated by chartered vessels during the 1980s and later continued by chartered, joint venture and Indian-owned vessels. Chartered vessels initially targeted yellowfin tuna using surface longline. As a result, bigeye tuna comprised only a small portion of the catches. Operations of Indian-owned vessels during 1993-94 produced high hook rates for bigeye tuna throughout the year, in waters north of the equator. Catches comprise three size groups by weight. The largest component is of large (40+kg) fish, followed by the smallest size group (15-25kg). All bigeye caught are exported. The main bait varieties used are Pacific saury and Indian mackerel.

Document WPTT/99/12 describes the activities of the sampling programme carried out by scientists from the Andaman Sea Fisheries Development Center to monitor the activities of the foreign fleets landing in Phuket, Thailand. The foreign fleets covered by this programme, which started in 1993, include purse seine fleets from the EU and Japan and longline fleets from different countries, particularly from Taiwan Province of China.

The importance of the sampling program in Thailand was noted by the Working Party. Phuket is a major transhipment point for tuna caught by purse seiners and longliners from several fleets operating in the eastern Indian Ocean. Data are often not available directly from the vessels and the port sampling outlined in the paper is a valuable source of data. In addition to sampling for species composition, length and weight, it was also possible to obtain biological samples from the catch. The programme has been obtaining samples of otoliths from skipjack, yellowfin and bigeye tuna and a study of age and growth is in its early phases. Continuation of this research was encouraged.

Document WPTT/99/02 presents the results of a tuna purse seining survey in the eastern Indian Ocean conducted by Thai scientists during May and June 1998. The survey area covered 3°S-8°S and 89°E–96°E, where ten tuna purse seine sets were carried out. The results showed poor catches, with an average catch rate of 2.58 t/haul. Yellowfin tuna was the dominant species in the catch, comprising of 44% in weight. Fork length ranged from 27 cm to 135 cm, with a predominance of large fish. Skipjack tuna was also prominent; comprising 43% of the catch, with a size range of 28.5-92.0 cm. Catches of bigeye tuna, not a target species for tuna purse seine, were negligible.

The Working Party noted that no mature bigeye tuna were reported in the study, but the number of bigeye tuna caught in the survey was extremely small, so it is not possible to draw a conclusion on the presence of mature fish in the area. Similarly, other existing biological parameters for the species could not be verified. Catch rates from the purse seine survey have not been compared with catch rates from the Japanese purse fleet operating in a similar area.

Fishery statistics

The statistics for the main segments of the purse seine fleet operating in the Indian Ocean are described in several documents. Document WPTT/99/14 presented the statistics of the Spanish purse seine fleet. The number of Spanish purse seiners operating in the Indian Ocean decreased from 23 in 1997 to 19 in 1998. The number of fishing days also decreased, from 6,054 to 5,303. The total tuna catch has decreased from 141,000 t in 1994 to 103,000 t in 1998. In 1998, 73% of the total tuna catch was from 'log' schools. The increase in fishing on log schools since 1994 has led to an increase in bigeye tuna catch rates. There has been a concurrent decrease in skipjack and yellowfin catch rates. The mean weight of yellowfin in free schools also declined in 1997-98, due to the failure of the fishery near Seychelles.

Document WPTT/99/15 covered statistics from those purse seiners operating under flags of convenience (most of which are effectively Spanish or French vessels) plus a few others not included elsewhere. The number of such vessels operating in the Indian Ocean decreased from 12 in 1997 to 11 in 1998, although the number of fishing days increased from 2,292 to 4,068. The total catch of these vessels also increased substantially in 1998, to 85,334 t, some 72% of which was from log schools. Data collection and sampling procedures for this fleet are the same as for the Spanish and French purse seine fleets.

The general statistics of the French purse seine fishery in the Indian Ocean were presented in document WPTT/99/16. The number of fishing days by French purse seiners operating in the Indian Ocean increased from 84 in 1981 to 4,268 in 1998. The number of fishing days was about 14,600 in both 1997 and 1998. The total tuna catch decreased from 95,924 t in 1995 to 59,578 t in 1998. In 1998, 73 % of the total tuna catch was from floating object schools. Length-frequency data were summarized.

Document WPTT/99/17 presents a brief summary of the main general activities of the European purse seine fishery (France, Italy, Spain and other European flags) in the Indian Ocean since the beginning of their fishery in 1981. Data on catch by species and fishing type (log and free-swimming schools), effort, species composition and size-frequency are presented. The description of the procedures used for gathering statistics, sampling and processing the data are reported in a document (WPDCS/99/09) presented at the meeting of the Working Party on Data Collection and Statistics. Total effort in fishing days has increased from 84 days in 1981 to 14,576 days in 1998 and the total catch of yellowfin, skipjack, bigeye and albacore has increased from 372 t to 247,617 t over the same time period.

4. PROGRESS IN STOCK ASSESSMENT

Bigeye Tuna

Review of Papers Submitted on Bigeye Tuna Stock Assessment

Production models

Document WPTT/99/05 presented a new approach to production modelling. Recognising the lack of data to assess tuna stocks in the Indian Ocean, there is a need for developing new statistical approaches explicitly dealing with uncertainties. Production models have proved to be very useful assessment tools because of their flexibility and low data requirements, but two main problems make their use difficult for investigating the status of tropical tuna stocks. The first lies in the calculation of effective fishing effort (i.e. an effort proportional to the fishing mortality) when, often, many different fleets with heterogeneous and changing fishing power (in general showing an increasing efficiency) are exploiting the same stock. The second lies in the fluctuation of the overall size of the exploited area (most often its increase). Indeed, it is known for tuna fisheries that the estimated production curve and its associated MSY are closely linked to the area exploited. In this document, both categories of problem were addressed by formulating a multi-fleet non-equilibrium production model incorporating the fished surface area. A maximum likelihood approach is used to estimate the model parameters in a Bayesian context, allowing the stock carrying capacity and catchability by fleet to vary each year following a random walk. Once parameters have been estimated, the model can be used to estimate the catchability trends by fleet, the overall effective fishing effort and the stock status.

In the ensuing discussion, some details of the model were questioned (e.g. the assumption that virgin biomass per unit area was uniform throughout the population range), and the lack even of catch data from the important longline fisheries of Indonesia and Taiwan Province of China was reiterated. It was also suggested that it might be useful to test this model using data from a well-characterised Atlantic or Pacific tuna fishery. Nevertheless, it was agreed that a production model that could incorporate data from many disparate fleets, as well as increases in area fished, could prove most useful and should be applied to the Indian Ocean bigeye fishery.

Indices of Abundance

A standardized CPUE of bigeye caught by the Japanese longline fishery in the Indian Ocean up to 1998 was presented in document WPTT/99/06. The method used to standardise longline effort was the application of a GLM, taking into account the considerable change in numbers of hooks per basket during 1952-98. In the southern part of the Indian Ocean, bigeye tuna CPUE fluctuated erratically, probably because of changes in fishing activity by Japanese fishermen in response to quota restrictions and time-space regulation on southern bluefin tuna catch. In the western and eastern tropical Indian Ocean, CPUE patterns were similar, both showing a general downward trend. These were thought to reflect a general decline in bigeye tuna abundance. In the tropical area, standardized bigeye CPUE in 1998 was about 36 % of that in 1954.

The Working Party noted the considerable jump in both nominal and standardized bigeye CPUE between 1976 and 1977 that appears to reflect an increase in Japanese longline catchability in the western tropical Indian Ocean at that time. This effect is also seen in yellowfin tuna and striped marlin nominal CPUE data, but not in data for other species. The effects of changes in materials used in longline construction are not yet known, but they will be investigated. The substantial decrease in standardized longline CPUE for bigeye tuna from 1954 to 1998 was noted with concern.

Age-structured modelling

Document WPTT/99/01 describes the estimation of the catch-at-age matrix of bigeye tuna fisheries for the period 1970-96. An age-length-weight key was constructed using published length-weight relationships and growth equations. Catches at age were estimated for longline (substituting Japanese size-frequency data for other fleets), purse seine and other gears separately and summed. The resultant catch-at-age matrix was presented, together with graphs summarising the major trends in bigeye tuna catch by age in the Indian Ocean. While ages 2 to 6+ dominated the predominantly longline catches from 1970-85, ages 0 and 1 have dominated catches since then as a result of the growth of the purse seine fishery.

During discussion, the use of MULTIFAN to partition size distributions into age distributions was questioned and it was suggested that the results of alternative approaches could be compared. The recent submission of revised size-frequency data from the European purse seine fleet was not thought to necessitate immediate recalculation of the catch-at-age matrix. The lack of size data from major longline fleets was noted with concern. The Working Party noted that the estimation of the catch-at-age matrix was a complex and time-consuming task. It was suggested that this work might in future be undertaken by the IOTC secretariat in collaboration with interested scientists.

A stock assessment of bigeye tuna in the Indian Ocean based on an age-structured analysis was presented in document WPTT/99/08. The catch-at-age method of analysis known as ADAPT was used to estimate the age-specific population numbers using a catch-at-age matrix and an age-specific abundance index based on the Japanese longline CPUE. Under a given M vector (0.8 for age 0-1 and 0.4 for age 2+), results show that the total population (biomass) has been gradually increasing from 2.7 million t (1970) to 4.5 million t (1990). After 1990, the total biomass sharply decreased to 3.3 million t (1994). Recruitment had been gradually increasing from 20 million (1970) to 40 million fish (1988). However, the recruitment has been sharply decreasing from 40 million (1988) to 15 million fish (1992), but showed an increase to 21-23 million in 1993-94. Spawning biomass has been gradually increasing from 174,000 t to 327,000 t during 1970-92 and then from 1992, it decreased sharply to 114,000 t in 1994. Exploitation rate has been gradually increasing from 5.1 % to 13.9 % during 1970-91 and then as from 1991, it sharply increased to 31 % in 1994. It was noted that population estimates were comparable to those in the Atlantic Ocean, and they are likely to be reasonable estimates.

In discussing the results presented in this document, the Working Party recognized the efforts of the Japanese scientists in carrying out an assessment using the methods recommended by the 7th Expert Consultation on Indian Ocean Tunas. However, the Working Party decided that the existing uncertainties were too large and agreed that the results of these analyses would not be used on this occasion.

There was concern about the reliability of the results of the catch-at-age analysis employed due to the quality of the data available for the analysis and the nature of the results. For example, from about 1976 to 1991 an increase in spawning biomass was predicted despite the fact that the standardised CPUE index (WPTT/99/06) over this time period showed a decreasing trend. Several possible reasons were advanced for these results. Further investigation is needed to clarify this issue.

It was also noted that problems with the ADAPT framework used for the analysis have been recognised by ICCAT. Among these problems is the tendency to overestimate the most recent values of fishing mortality. This problem can be seen in the bigeye tuna VPA, with several unrealistically large values of F in the most recent years, in excess of 2 for older age classes.

In addition to problems with the method used, there were concerns about the data available for the analysis. Size data for longline caught fish were only available from the Japanese longline fleet. Therefore, this size distribution had to be assumed to apply to catches from other longline fleets, while it is not clear at this time if they operated in the same areas and seasons as the Japanese fleet. Further research is needed to clarify this issue. Coverage for the younger purse seine caught age classes was less likely to be a problem. Another problem is that the only index of abundance available for tuning is based on the Japanese longline CPUE.

For future meetings, there was a suggestion to employ a length-based catch-at-age analysis, such as MULTIFAN-CL. Use of alternative forms of VPA, such as the modifications to the ADAPT method currently used by ICCAT, or XSA, used by ICES, might also be explored. These had been tested and altered to be more suitable for analysis of tuna data. The ICCAT and ICES methods are already available at the IOTC Secretariat, which could use them to undertake standard assessments for future meetings as required. A group such as the WPTT should guide such work.

The time taken to complete these assessments can be substantial. Active collaboration between involved scientists and the Secretariat would facilitate future analyses.

General Discussion

Standardisation of bigeye tuna CPUE

There was further discussion of methods to standardise CPUE for longline data, as this was seen as a critical issue. It was concluded that further data should be incorporated into the standardisation, particularly environmental data. The Secretariat for the Pacific Community (SPC) has introduced sea surface temperature, dissolved oxygen and thermocline depth into their standardisations. If these data, or indices based on them, could be incorporated into the IOTC Secretariat's database they could be made available for standardisations and assessments. Similarly, the interpretation of the purse seine CPUE could benefit from taking into account the vertical thermal structure (such as the depth of the thermocline or the depth of the 20° isotherm).

Rising market prices for bigeye tuna were put forward as a possible reason for some increase in CPUE for this species. The price of bigeye tuna increased fourfold in the mid-1970s at Tsukiji fish market. Over the same period, the price of yellowfin tuna increased only slightly and the value of albacore was constant. The increased value of bigeye may have provided an incentive to fishers to fine tune methods for the capture of bigeye. It was suggested that the market price of fish could be incorporated into the standardisation of longline CPUE.

Figure 5. *Average weight of bigeye tuna caught in the Japanese longline fishery, in the northern (N) and southern (S) areas.*

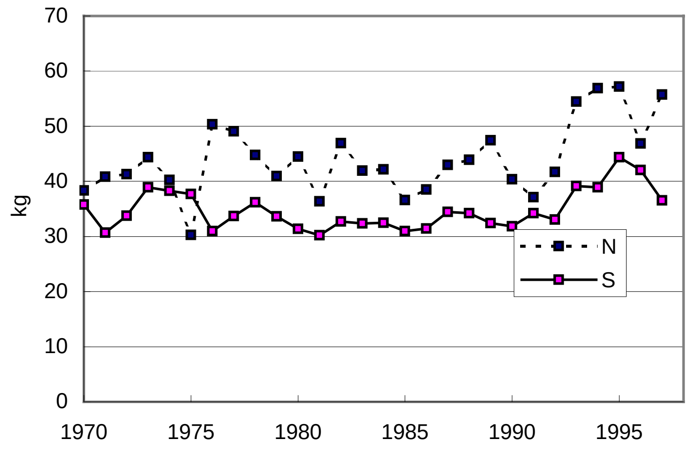
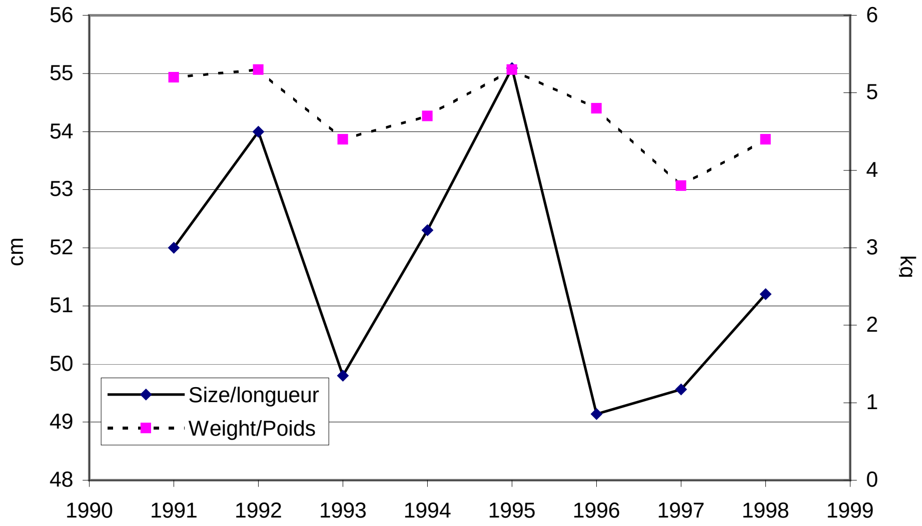


Figure 6. *Average size of bigeye tuna in the purse seine catches.*



Stock status indicators

In the absence of a reliable stock assessment, the Working Party agreed to consider the following potential indicators of stock status.

1. Average weight in the catch.

In theory, if stock abundance is declining under fishing, then the average weight of fish in the catch might be expected to decline, given stable selectivities at age. In the case of the Japanese longline fishery, average weights of fish in both the southern (i.e. mainly subadult fish) and the tropical (i.e. mainly mature fish) fishing zones have been remarkably stable for many years (see *Figure 5*.). If anything, average weights in both fishing zones have increased slightly since 1992. In the case of the purse seine fishery, however, there was a slight decrease in the mean weight of bigeye tuna caught in log sets since 1992 (*Figure 6*.). These trends do not provide clear evidence of overexploitation.

2. Catch trends.

Total bigeye tuna catches increased fairly steadily up until about 1990, since when there has been a big increase in both purse seine and longline catches (*Figure 1*.). Purse seine fishing effort increased fairly steadily from 1984 to 1998; bigeye catches increased erratically but not substantially from 1984 to about 1994, since when they have increased radically. This spectacular growth in purse seine catches is a result of the increased use of FADs. In the Atlantic bigeye fishery, a significant drop in catches and catch rates in 1997-98 followed a similar increase in longline and purse seine catches associated with the use of FADs.

3. Tentative abundance indices.

Nominal purse seine catch rates for bigeye from free schools have remained relatively stable, varying without obvious trend since the start of the fishery in the early 1980s. Purse seine catches per fishing day have increased considerably since about 1992. This is in large part a result of the increasing use of FADs as catches of bigeye tuna on free schools are minimal. However, bigeye catches per set on FADs have also increased. This is believed to be the result of improvements in fishing gear and operations (e.g. the use of deeper-setting nets which can catch more bigeye and the practice of setting more than once on a FAD which often results in a catch of larger bigeye from the subsequent sets). The high and increasing catches and catch rates of bigeye by purse seiners on FADs suggest that, at least up to the last few years, recruitment overfishing has not occurred, however they provide no evidence that this may not occur in the future.

Standardized Japanese longline CPUE shows a large unexplained increase in 1977 (*Figure 7.*). Given that there are several cohorts in the longline catch, a jump in biomass of such a magnitude seems unlikely; a change in fishing efficiency, which has not been fully accounted for in the standardization procedure, seems a more likely explanation. Tentative adjustments were applied to the CPUE series by reducing the post-1976 figures by the amount that the average value for 1977-1979 exceeded the average for 1974-76. In the standardized CPUE time series, CPUE in 1998 is some 36% of the CPUE in 1954. In the adjusted CPUE time series, CPUE in 1998 is some 25% of the CPUE in 1954.

Figure 7. *Trends in CPUE from the Japanese longline fleet. Darker ovals indicate the trend after ad-hoc adjusting as detailed in the text.*

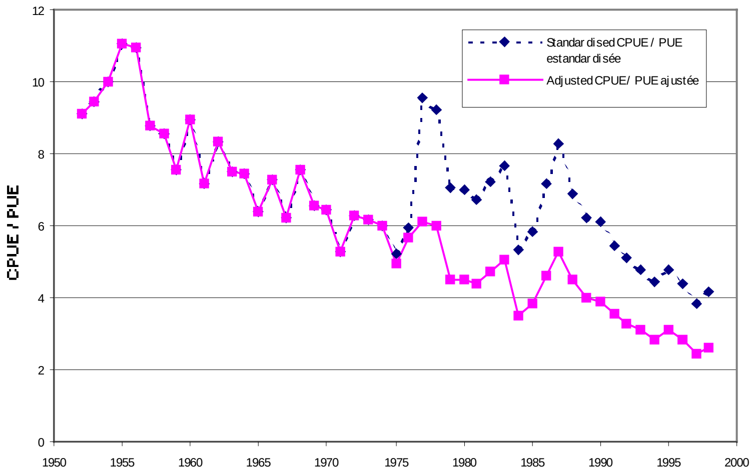
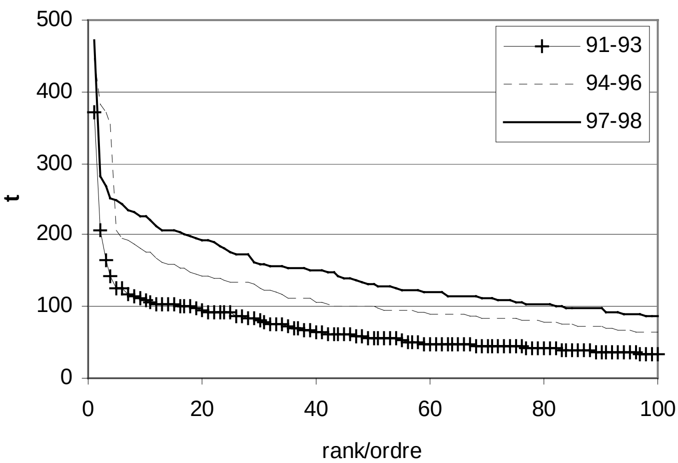


Figure 8. *Average catch of bigeye tuna by European purse seiners per one-degree square as a function of the rank of the square.*



4. Catch per unit area fished.

Ranked catches per unit area fished (*Figure 8*.) show a steady increase during the period 1991-98. For example, only about fifteen 1° square areas yielded bigeye catches in excess of 100 t during 1991-93, compared to over 40 in 1994-96 and about 80 in 1997-98. This is believed to be almost entirely due to increases in fishing effort of the purse seine fleet and in particular to the use of FADs, combined with an expansion of the fishery and other improvements in fishing operations and technology. It was suggested that a similar analysis might be attempted for the longline fishery, but this might not be a fruitful exercise because of the aggregation of Japanese data by 5° squares and the lack of recent data from Taiwanese vessels.

Figure 9. *Size frequency of bigeye tuna in the Indian Ocean.*

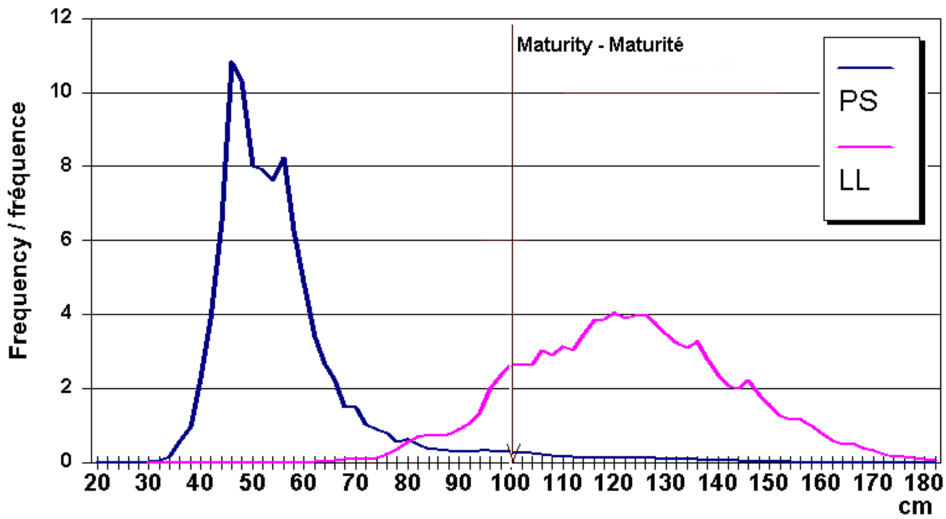
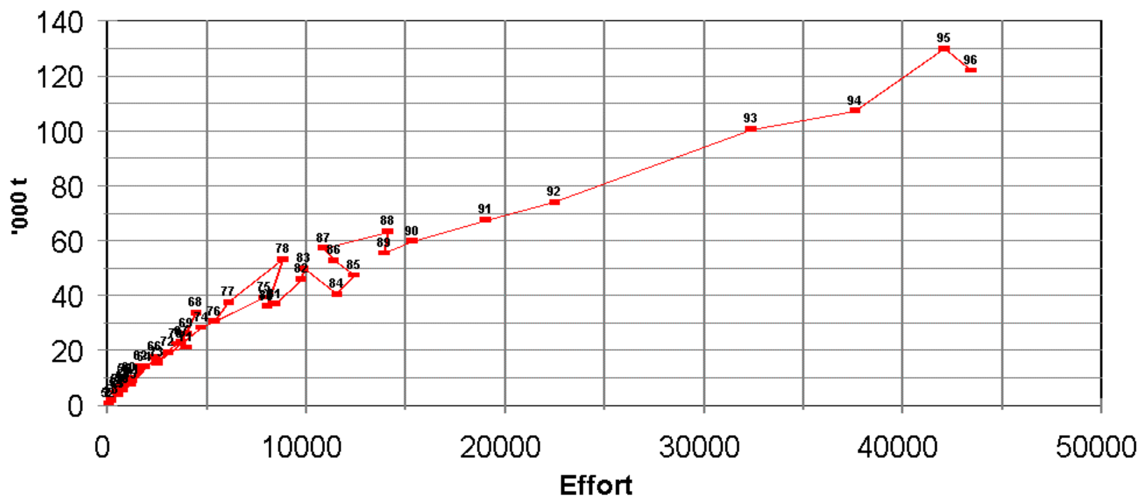


Figure 10. *Catch (in thousands of tonnes) as a function of estimated effective effort. See text for details.*



5. Size distributions.

The purse seine catch consists almost entirely of immature bigeye of about 40-70 cm FL (*Figure 9*.). In contrast, the longline fishery catches bigeye tuna that are mainly 90-160+ cm FL, most of which are mature. There is very little overlap in the sizes caught by the two fisheries. Bigeye caught in the purse seine fishery may be about 1 to 2.5 yrs old and about 2.5 to 6+ yrs old in the longline fishery. The age of the largest fish is not well known and may be very much more than 6 years. Accurate estimation of ages (i.e. accurate estimation of growth parameters) will be vital for understanding the likely impact of high levels of purse seine catches on the longline catch. If growth rates are slow, there may be many age classes in the longline catch and it may take many years for the effects of growth overfishing to become apparent. Accurate estimation of natural mortality rates, particularly in young fish, is another key to understanding likely interactions between the fisheries. If natural mortality rates in young bigeye are high, then even high levels of purse seine catch may have little impact on the longline fishery.

6. Apparent catch and effort relationship.

A catch and effective effort relationship for the entire fishery can be plotted using standardized Japanese longline CPUE as an index of abundance for the entire bigeye stock (*Figure 10*.). It is very clear from this plot that both catch and effective effort for both longlines and purse seines have increased dramatically since 1990. Total catch and effort in 1995-96 were so much higher than catch and effort before 1990 that it was suggested that they must be above equilibrium levels. If this is the case, a fall in catches might be expected; the lack of complete catch data for 1997-98 is therefore particularly unfortunate.

Status of Bigeye Tuna

There has been a remarkable increase in total bigeye tuna catches by both longline and purse seine fleets over the past ten years. While longline catch rates have declined steadily over time, catch rates by purse seiners have increased in recent years. However, the Working Party recognized that this should not be taken as an indication that the stock was necessarily in a healthy condition. Rather, the increase in purse seine catch rates was most likely due to an increase in fishing efficiency resulting from many operational changes in the fishery and associated developments in gear technology, and particularly to the increased use of FADs.

The Working Party noted that it was impossible to make a rigorous stock assessment for bigeye tuna because of a lack of recent fishery (catch and effort) data from the important longline fleets of Taiwan Province of China and Indonesia, and of biological information (size frequencies from several fleets and estimates of basic biological parameters) for Indian Ocean bigeye tuna (section "*Limitations of data in bigeye tuna*"). This limited the ability of the Working Party to provide detailed scientific advice for the management of Indian Ocean bigeye tuna.

However, it was noted with concern that there were a number of indicators which, taken together, suggest that there may be problems with the status of the stock:

1. Japanese longline CPUE data show a clear long-term decline, with standardized longline CPUE reduced to 25-36 % of the CPUE at the beginning of the fishery.

2. If longline CPUE reflects trends in adult biomass, these data suggest that recruitment overfishing could occur in the near future. In other words, there is a very real danger that severe reductions in spawning biomass may occur, which could result in a subsequent failure of recruitment and collapse of the stock. However, the Working Party noted that the large catch of juvenile bigeye tuna taken until 1998 suggested that this has not happened yet.

3. As a result of the large increases in the catch of juvenile bigeye tuna by purse seiners in recent years, small bigeye tuna (ages 0 and 1) now account for about 70 % of the total number of bigeye tuna caught. The Working Party noted that there were no unequivocal indications that this significant juvenile catch had yet had a direct impact on the catch of adult bigeye tuna by longline fleets. However, there are some possible indications that there might be some interaction between the fisheries:

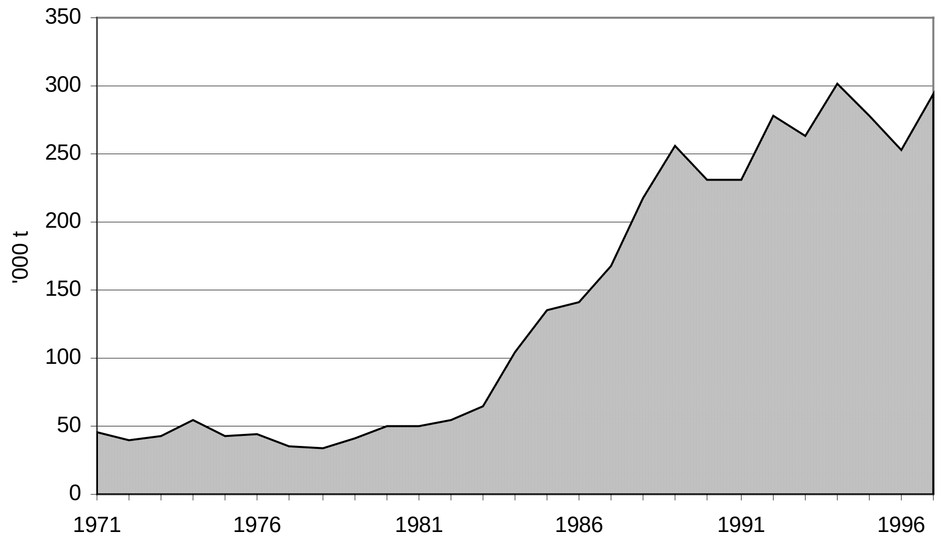
- The heavier than normal average weight of bigeye tuna in Japanese longline catches since 1993, which could be interpreted as being the result of increased catches of small fish (however, it was recognized that another explanation for this observation could be the increased deployment of deep longlines by the Japanese fleet.).

- The Indian Ocean-wide Japanese longline CPUE is relatively stable during 1978-87 and then declines.

- The decline in Japanese longline CPUE in the western Indian Ocean (i.e. in the main purse seine fishery area) since 1987 in the north and 1994 in the south. The latter decline, in particular, could be related to the large increase in catches of bigeye tuna by both longliners and purse seiners.

It is clear that there are alternative explanations for all these observations that do not involve interactions between the purse seine and longline fisheries. However, it is also clear that there is potential for future negative impact on the longline fishery from the substantial and increasing catch of juvenile bigeye tuna.

Figure 11. *Catches of skipjack tuna in the Indian Ocean by all gears, in thousands of tonnes.*



4. Bigeye tuna is a relatively long-lived species (possibly with a lifespan in the range 10-15 years) and consequently the productivity of the stock is likely to be less than that of skipjack or yellowfin tuna. Therefore, any effects of overfishing would take longer to become apparent and subsequently to rectify than in the case of other tropical tunas.

5. Comparison with bigeye tuna fisheries in other oceans (where other tuna commissions have recognized signs of overfishing of bigeye tuna stocks and taken management action) may shed some light on developments within the Indian Ocean. In the eastern Atlantic Ocean bigeye tuna fishery, which shared similar catch patterns with the Indian Ocean fishery up until 1996 (Figure 4), catches and catch rates fell significantly in 1997-98, as a possible result of overfishing. In the eastern tropical Pacific bigeye tuna fishery, a decline in longline catches coincided with the development of a large-scale purse-seine fishery on FADs that catches juvenile bigeye tuna.

The Working Party was unable to conclude whether the bigeye tuna stock in the Indian Ocean is currently fully or overexploited. However, in light of these indications and if catches continue at current high levels, the stock is likely to become overexploited in the very near future. It therefore agreed that immediate management action is needed.

Skipjack Tuna

Recent trends in the fishery

Skipjack tuna catches in the Indian Ocean increased from 105,000 t in 1984 to a record level of 301,000 t in 1994. Since then, catches have decreased slightly, varying in the range of 253,000 to 294,000 t per year (*Figure 11.*). The major fishing gears used are purse seine (mainly France and Spain), pole and line (mainly Maldives) and gillnet (mainly Sri Lanka). Other important fishing nations include Indonesia, India and Japan.

Table 2. *Catches of skipjack tuna in 1996 in tonnes.*

Country	*BB*	*GILL*	*HAND*	*LL*	*PS*	*TROL*	*UNCL*	*Grand Tot*
Australia			1		210			211
Comoros			46			2,104		2,150
France			96		32,018			32,114
Honduras				9				9
India				8,400			250	8,650
Indonesia		2,597			1,528		19,475	23,600
Iran		5						5
Japan				7	7,025			7,032
Kenya						108	108	
Maldives	66,174	2	13	14		299		66,502
Mauritius					1,858	40		1,898
Oman						606	606	
Pakistan		4,140						4,140
Spain					53,220			53,220
Sri Lanka	4	22,718	1			21	10	22,754
Taiwan				59				59
Yemen							88	88
NEI					29,625			29,625
Grand Total	66,178	29,462	157	8,489	125,484	2,464	20,537	252,771

Status Indicators

The Working party briefly reviewed some information pertaining to the stock status of skipjack tuna. No formal stock assessment was presented, but the following indicators were considered:

1. Purse seine CPUE for skipjack caught on logs has declined in recent years. Catch per successful set on floating objects declined by nearly 50 % between 1992 and 1997 despite an increase in bigeye tuna CPUE. The reasons for this decline are not fully understood, but it is thought to reflect a real decrease in skipjack tuna abundance under logs (perhaps associated with a dilution effect resulting from the greater use of FADs). Note that skipjack is the main target of this FAD fishery, with bigeye being a minor, albeit increasing, component.

2. The average weight of skipjack caught on logs by purse seiners has also declined in recent years (by about 23 % between 1992 and 1997) (*Figure 12.*). Again, the reasons for this decline are not fully understood.

3. Skipjack catch rates by the Maldivian pole and line fleet have declined in recent years. In particular, Maldivian catch rates have declined ever since total Indian Ocean catches exceeded 200,000 t in 1989 (*Figure 12.*). At the same time, decreases in average sizes of skipjack caught in the Maldivian fishery have been reported. Although other explanations could not be excluded, these observations do suggest a negative impact of the wider Indian Ocean skipjack fishery (notably the western Indian Ocean purse seine fishery) on the Maldivian pole and line fishery.

Figure 12. *Average weight of skipjack tuna caught by European purse seiners in the Indian Ocean.*

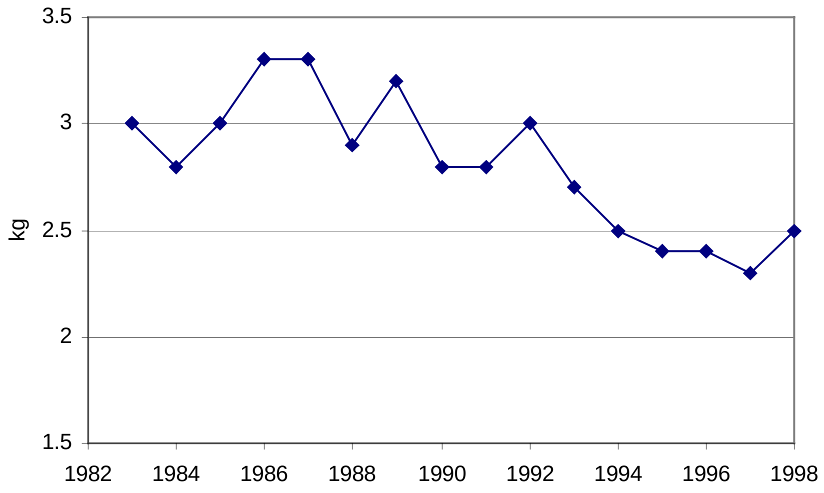
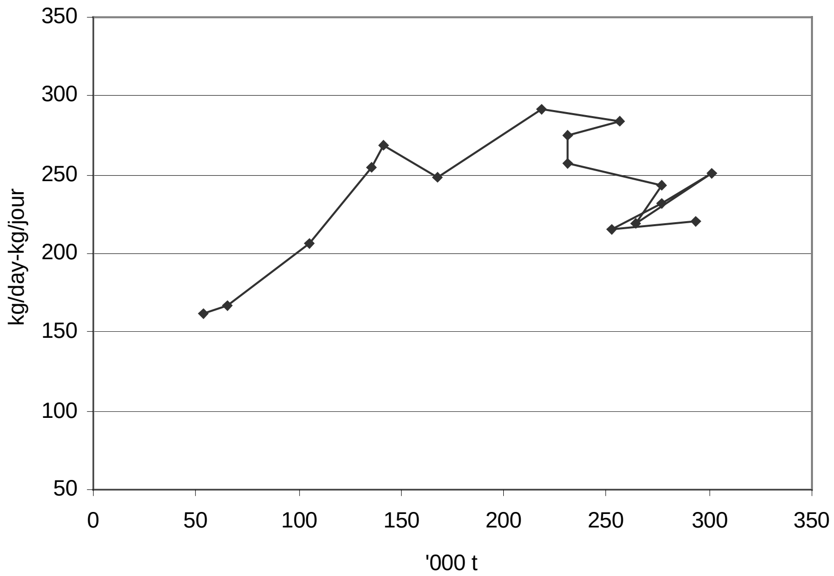


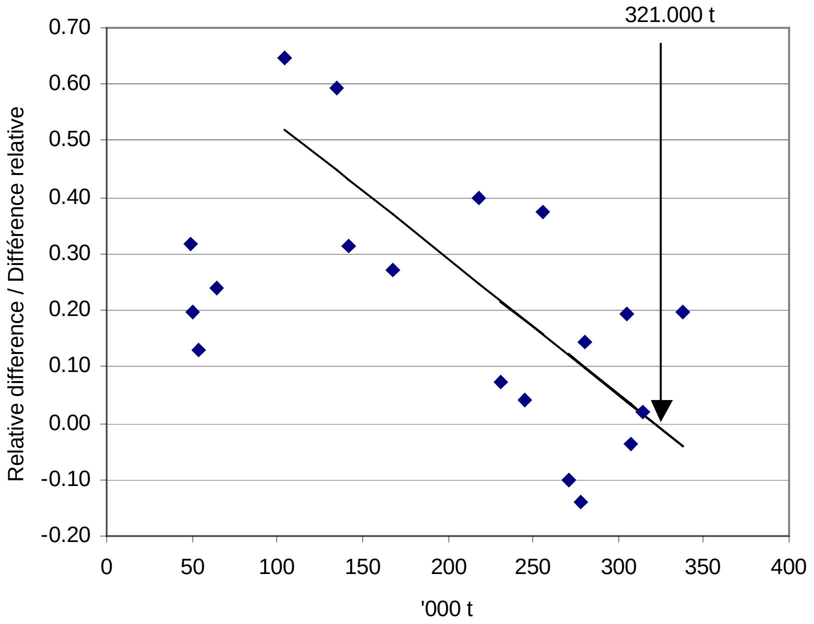
Figure 13. *Skipjack CPUE in the Maldivian pole-and-line fishery as a function of the total catch of skipjack in the Indian Ocean.*



4. A plot of the relative differences in catches for consecutive years indicated that total Indian Ocean skipjack catches has been declining during the last few years (*Figure 14*.). Taking into account the increasing effective fishing effort on skipjack, this could be taken to indicate that local yield maximum had been reached.

The significance of these observations was difficult for the Working Party to assess with the information available. However, it was recognized that these observations could indicate possible negative interactions, both within and between fisheries. During 1994-98, the number of purse seine sets on logs increased by about 30 %, but skipjack catches unexpectedly decreased by about 30 %; this is suggestive of local overfishing. There is clearly an urgent need for research to clarify the situation.

Figure 14. Relative differences in catch for consecutive years as a function of the catch for the skipjack tuna in the Indian Ocean.



5. Recommendations

Research Recommendations

General

1. Developments in fishing practice and gear technology need to be fully documented and their effects on fishing power need to be assessed for all major fleets.

2. Size-frequency data from the Korean longline fishery during 1974-90, if they exist, should be made available to IOTC.

3. Catch, effort and size-frequency data from the longline fishery of Taiwan Province of China in recent years, if they exist, should be made available to IOTC.

4. Catch, effort and size-frequency data from the Indonesian longline fishery in recent years, if they exist, should be made available to IOTC.

Stock Assessment

A small group met to discuss ways of improving the stock assessment process on tropical tunas in the Indian Ocean. The group also discussed types of analyses that should be undertaken. The WPTT agreed on the following recommendations proposed by the group:

1. In order to facilitate the calculation of indices of apparent biomass, the IOTC Secretariat should approach Japan requesting that the catch-and-effort data for the Japanese longline fleet be provided, aggregated by the number of hooks between floats. These data, together with the already available size data, will then be provided through the IOTC to scientists willing to undertake the calculation of the required indices (in particular, age-

specific indices). Scientists undertaking this work should make their results available through the IOTC website.

2. Scientists should include environmental data in the calculation of indices of apparent biomass.

3. The IOTC Secretariat is to coordinate further work with interested scientists to facilitate the calculation and provision of the necessary catch-at-age data sets required for stock assessment purposes. Once calculated, these data sets should be posted on the IOTC website.

4. The IOTC Secretariat is to list recommended biological parameters to be used for stock assessment purposes on the IOTC website. A list of recommended methods, models and programs (drawing on the work of other tuna commissions such as ICCAT and IATTC) should also be made available through the IOTC website.

5. The IOTC Secretariat will assist in the dissemination of environmental data useful for stock assessment purposes. The Secretariat will provide through its Web site a list of contacts and Internet addresses of primary sources for this type of data. Scientists are invited to send to the Secretariat information about such sources, together with a short summary of the data available from the sites.

6. Scientists from the various organisations with an interest in undertaking stock assessments on the tropical tunas in the Indian Ocean are encouraged to make use of the data and methods which will be posted on the IOTC website. Scientists undertaking such work are also encouraged to make their results available through the IOTC website and seek comments back on their work. In this manner, much of the preliminary work required to undertake stock assessments could be undertaken before the annual meeting of the WPTT.

7. Scientists are encouraged to explore and develop the use of new methods and models applicable to the assessment of tropical tunas in the Indian Ocean. Such models should explicitly incorporate uncertainty in the data and model structure and include consideration of spatial and environmental structure and interactions between species.

8. Individual scientists are encouraged to assist the IOTC Secretariat to achieve each of the above recommendations.

The Working Party had insufficient time to consider carefully the status of the stocks of yellowfin and skipjack tunas. However, it noted that many of the issues raised in relation to bigeye tuna are equally applicable to those two species. During discussions, the following points were noted:

Comments on the report from the WPDCS

The port-sampling program suggested by the WPDCS was strongly endorsed by the WPTT as being the approach most likely to solve the critical problem associated with the lack of catch and size-frequency data from both IOTC member countries and non-members.

The WPTT agreed that it would include examination of the data and statistics for tropical tunas as part of its regular agenda as recommended by the WPDCS.

Bigeye Tuna

1. Countries and fisheries scientists should support the Australian CSIRO initiative to investigate genetic stock structure of Indian Ocean bigeye tuna by supplying appropriate tissue samples.

2. Comparative studies of bigeye tuna fisheries in the Indian Ocean and those in other oceans may shed light on developments within the Indian Ocean and are therefore encouraged.

3. Catch and effort data from Mauritian purse seiners (which are believed to have concentrated on FAD fishing with deep nets since the beginning of their operations) should be analysed to provide comparative information on the changing catch composition of the EU purse seine fleet, which has engaged more recently on such fishing.

4. A major Indian-Ocean-wide tagging experiment is required in order to address the stock structure of bigeye tuna in the Indian Ocean and to estimate levels of mixing of tuna between the western and eastern parts of the ocean.

5. Tagging experiments and otolith studies are also thought to be the best ways to estimate bigeye tuna growth rates.

6. Many basic biological parameters are poorly known and further study is required in order to refine estimates of:

    - Growth rates, particularly of large fish

    - Length-weight relationships

    - Natural mortality rates

    - Age (and/or size) at first maturity

7. Some data relating to biological parameters are available with national or other agencies (e.g. maturity data from BIOT and gonad index data from the Japanese longline fishery). Any such data not already submitted to the IOTC should be submitted as soon as possible.

8. Port sampling of bigeye catches will be necessary in order to obtain the size-frequency data required for stock assessment. In order to determine the optimum disposition of sampling sites, it is recommended that heterogeneity analysis be carried out. In considering the adoption of statistical units, it would be appropriate to adopt ecologically meaningful sub-areas (e.g. based on Longhurst’s areas).

9. VPA by size, rather than age, may be useful, especially if it reduces assumptions about growth parameters and addresses the problem of missing size compositions.

10. It is necessary to obtain data on the sex ratio by size in the catch. In the future, this information could be used to carry out stock assessments by sex.

Yellowfin Tuna

1. Countries and fisheries scientists from the region should support the Japanese NRIFSF initiative to investigate the stock structure of Indian Ocean yellowfin tuna by supplying appropriate tissue samples.

2. Tagging is necessary to investigate stock structure, migrations, fishery interactions and growth and mortality parameters.

Skipjack Tuna

1. The stock structure of Indian Ocean skipjack tuna should be investigated as soon as possible.

2. Tagging is necessary to investigate stock structure, migrations, fishery interactions and growth and mortality parameters.

3. The cause(s) of the recent decline in skipjack catches on FADs by purse seiners should be investigated.

4. The possibility of interactions between fisheries for skipjack tuna and, in particular, between the western Indian Ocean purse-seine fishery and the Maldivian artisanal fishery should be investigated.

Management Recommendations

Bigeye Tuna

Taking into account the observations made in the previous sections, in particular bearing in mind the need for a precautionary approach, the Working Party recommended that:

1. The increase in catches of bigeye tuna from all gears should be halted immediately.

2. The increase in catches of small bigeye tuna by purse seiners deploying FADs should be halted, if not reversed, immediately.

The Working Party discussed some of the actions that could achieve these goals. Enforcing measures to reduce longline catches is necessary, even if it is difficult. The Commission should look at all possible measures to achieve such reduction.

A number of possible management actions potentially leading to a reduction of the fishing mortality of small bigeye tuna were discussed. Management actions adopted by other Tuna Commissions to reduce catches of small bigeye on floating objects by purse seiners have included:

1. *Introduction of quotas for bigeye tuna fished on logs*. However, quotas are difficult to monitor and certainly require the use of observers on board fishing vessels, in particular because of the difficulties in discriminating between small individuals of yellowfin and bigeye tunas.

2. *Restrictions on the use of auxiliary supply vessels*, specifically on their use to deploy and monitor FADs. The biological and economic effects of these measures would need to be investigated.

3. *Introduction of a minimum size for bigeye tuna*. However, as small bigeye tuna are taken as part of a multispecific fishery, this would be difficult to monitor and would certainly lead to an increase in discards. This option has not worked in other oceans.

4. *Area and seasonal closure of fishing grounds to log fishing* . For maximum effectiveness, the areas and seasons to be closed will require careful scientific design. Enforcement would require the use of VMS or observers on board fishing vessels. Nevertheless, the Working Party felt that this was the best available option.

Yellowfin Tuna

No management recommendations were made.

Skipjack Tuna

No management recommendations were made.

6. Terms Of Reference For The Working Party On Tagging

The Working Party on Tropical Tunas (WPTT) was instructed by the Scientific Committee to propose terms of reference for a Working Party on Tagging (WPT).

The WPTT agreed that priority should be given to tagging of tropical tunas. As a consequence there is a functional link between the WPTT and the proposed WPT. This link is strengthened by the fact that the WPDCS is delegating, to the individual species working parties, the responsibility of reporting the status of data collection and statistics for the species groups under their responsibility.

The WPTT recommended that the WPT, at least in the initial stages, should meet in association with the WPTT.

The following terms of reference are proposed for the Working Party on Tagging.

1. Review and identify the objectives and scope (e.g. which species and spatial scales) of any proposed tagging experiment.

2. Propose aims, designs and methods for pilot studies that might assist in the successful execution of the tagging programme.

3. Identify impediments to achieving the desired objectives and where possible identify measures for overcoming these impediments.

4. Determine the most appropriate design of a tagging experiment (e.g. temporal and spatial coverage, number of tags, types of tags) needed to achieve the identified objectives.

5. Review and identify the best means of implementing a tagging experiment (e.g. platform, logistic arrangements) and identify possible logistical difficulties (e.g. availability of boats, bait) and how these may be best overcome.

6. Determine the types and levels of publicity required to maximize the return of tags and assess the utility of supplementary tag seeding experiments for the estimation of reporting rates.

7. Determine the budget for a tagging experiment and identify possible funding sources.

8. Provide coordination to ensure the successful implementation for a tagging experiment, identify and coordinate on-going work and analyses required to achieve the program objectives.

The Chairman of the Scientific Committee requested that the WPT meet as soon as possible. It was suggested that an *ad hoc* meeting might be convened of those participants who will be attending the meeting of the Scientific Committee in Kyoto.

The discussion group recognized that some activities that had no financial implications to the Commission could be undertaken immediately and elected Dr. Alain Fonteneau to act as Coordinator, pending the first formal meeting of the WPT. Participants in the group undertook to conduct simulation studies, to update information available on bait resources in the Indian Ocean and to assess the possibilities and financial implications of pilot tagging studies which could be undertaken at low cost using available research vessels.

7. Any Other Matters

The issue of poor attendance by scientists from Indian Ocean coastal states at Working Party meetings was considered to be an area of major concern. This problem must be addressed in order to facilitate cooperation in scientific research, which will lead to improved data collection, analyses and management of tunas and tuna-like species.

It was noted that participation of coastal country tuna scientists in the WPTT, which now has increased responsibilities for the examination of data and statistics for tropical tunas (section on WPDCS), should lead to facilitation of data collection and interpretation. Furthermore, the Working Party felt strongly that the active participation tuna scientists from coastal countries would lead to increased research capabilities in those countries in the longer term.

The Working Party noted that one of the issues that it was asked initially to examine was the question of excess fishing capacity in the Indian Ocean (*Appendix 3*). In the time available, the Working Party was not able to address this issue in detail. However, it noted that its assessment of the status of the bigeye tuna stock and the management recommendations flowing from that assessment did have relevance to that issue.

8. Election of Chairperson and Arrangement for Next Meeting

The Working Party elected unanimously the current Chairperson, Dr Geoff Kirkwood, to continue in this post for the coming biennium. It was agreed that the next meeting would take place in Seychelles at a date to be specified later.

APPENDIX I: LIST OF PARTICIPANTS

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APPENDIX II: AGENDA FOR THE MEETING

1. *Election of Chairperson and Arrangements for the Meeting*
2. *Review of Fisheries and Available Data*
3. *Progress in Research*
4. *Progress in Stock Assessment*
5. *Recommendations*
    a. *Research Recommendations*
    b. *Management options*
6. *Terms of Reference for the Working Party on Tagging*
7. *Any Other Matters*
8. *Adoption of Report*

Appendix III: Terms of Reference for the Working Party on Tropical Tunas

1) Review new information on the biology of species of tropical tunas (bigeye, yellowfin and skipjack tunas), their fisheries and relevant environmental data.
2) Coordinate and promote collaborative research on the species and their fisheries.
3) Develop and identify agreed models and procedures for the assessment of stock status of each species.
4) Conduct stock assessments for each of each species or stock.
5) Provide technical advice on management options, the implications of management measures and other issues.
6) Identify research priorities, and specify data and information requirements that are necessary for the Working Party to meet its responsibilities.

Initially, the Working Party should:

1) Develop a preliminary stock assessment of bigeye tuna as a priority. However, if time allows it, the assessment might be extended to include yellowfin tuna and skipjack tuna.
2) Examine the Terms of Reference for a future Working Party on Tagging. In particular, consider the objectives and requirements of a tagging programme that will meet the most important information needs for the assessment activities.
3) Examine the question of excess fishing capacity in the Indian Ocean, in the light of the results of the assessment.

APPENDIX IV: LIST OF DOCUMENTS

WPTT-99-AG	Provisional Agenda
WPTT-99-LP	List of Participants
WPTT-99-01	Estimation of catch-at-age of BET fisheries in the Indian Ocean. *T.Nishida*
WPTT-99-02	Tuna caught by purse seining in the Eastern Indian Ocean. *W. Pokapunt, V. Sornvijit and N. Thongyou*
WPTT-99-03	Oceanographic effects of El Niño and La Niña events in the Indian Ocean. *F. Marsac*
WPTT-99-04	Comparative analysis of the exploitation of bigeye tuna in the Indian and Eastern Atlantic oceans with emphasis on purse seine fisheries. *F. Marsac and D. Gaertner*
WPTT-99-05	A multi-fleet non-equilibrium production model including surface to assess tuna stocks dynamics. *O. Maury*
WPTT-99-06	Standardized CPUE of the bigeye caught by the Japanese longline fishery in the Indian Ocean, up to 1998. *H. Okamoto and N. Miyabe*
WPTT-99-07	The Maldivian Tuna Fishery and Indo-Pacific Ocean Variability. *C. Anderson*
WPTT-99-08	BET stock assessment by the VPA. *T. Nishida and Y. Takeuchi*
WPTT-99-09	Progress of collection of tissue samples for the DNA analyses of the YFT stock structure in the Indian Ocean. *T. Nishida and S. Chow*
WPTT-99-10	Seasonal Changes in Bigeye Tuna Fishing Areas in Relation to the Oceanographic Parameters in the Indian Ocean. *M. Mohri and T. Nishida*
WPTT-99-11	Vertical distribution of bigeye tuna fishing in the Indian Ocean. *M. Mohri and T. Nishida*
WPTT-99-12	Preliminary Results on Fisheries and Biology of Bigeye Tuna (*Thunnus obesus*) in the Eastern Indian Ocean. *P. Chantawong, S. Panjarat and W. Singtongyam*
WPTT-99-13	Fishery, Distribution and Abundance of Bigeye Tuna in the Seas around India. *V.S.Somvanshi and A.K. Bhargava*
WPTT-99-inf01	Terms of Reference for the Working Party.
WPTT-99-inf02	Report of the 1995 Working Group on Tuna Tagging**.**
WPTT-99-inf03	A Review of the Biology of Bigeye Tuna, *Thunnus obesus*, and the Fisheries for this Species in the Indian Ocean. *K.A .Stobberup, F. Marsac, and A. Anganuzzi*
WPTT-99-inf04	Summary of Projects Related to the Assessment of Tropical Tuna and Billfish in the Indian Ocean. *CSIRO, Australia*