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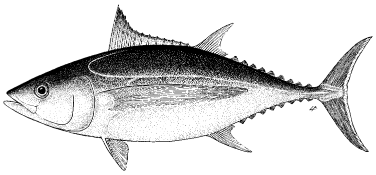

EXECUTIVE SUMMARY: STATUS OF THE INDIAN OCEAN ALBACORE TUNA RESOURCE (*THUNNUS ALALUNGA*)

TABLE 1. Status of albacore (*Thunnus alalunga*) in the Indian Ocean.

Area[1]	**Indicators – 2011 assessment**		**2011 stock status determination 2010**[2]
Indian Ocean	Catch 2010:	43,711 t	
	Average catch 2006–2010:	41,074 t	
	MSY (1 model):	29,900 t (21,500–33,100 t)	
	F_{2010}/F_{MSY} (1 model):	>1	
	SB_{2010}/SB_{MSY} (1 model):	≈ 1	
	SB_{2010}/SB_{1980} (1 model):	0.39	

[1]Boundaries for the Indian Ocean stock assessment are defined as the IOTC area of competence.
[2]The stock status refers to the most recent years' data used for the assessment.

Colour key	Stock overfished($SB_{year}/SB_{MSY}< 1$)	Stock not overfished ($SB_{year}/SB_{MSY}\geq 1$)
Stock subject to overfishing($F_{year}/F_{MSY}> 1$)		
Stock not subject to overfishing ($F_{year}/F_{MSY}\leq 1$)		

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

The WPTmT **RECOMMENDED** the following management advice for albacore in the Indian Ocean, for the consideration of the Scientific Committee, noting that there remains considerable uncertainty about the relationship between abundance and the standardized CPUE series, and about the total catches over the past decade.

Stock status. Trends in the Taiwan,China CPUE series suggest that the longline vulnerable biomass has declined to about 39% of the level observed in 1980. There were 20 years of moderate fishing before 1980, and the catch has more than doubled since 1980. Catches have increased substantially since the previous albacore assessment when there was considered to be a risk that $SB<SB_{MSY}$, so the risk will have increased further. It is considered likely that recent catches have been above MSY, recent fishing mortality exceeds F_{MSY} ($F_{2010}/F_{MSY} > 1$). There is a moderate risk that total biomass is below B_{MSY} ($B_{2010}/B_{MSY} \approx 1$) (Table 1, Fig. 1).

Outlook. Maintaining or increasing effort will probably result in further declines in biomass, productivity and CPUE. The impacts of piracy in the western Indian Ocean has resulted in the displacement of a substantial portion of longline fishing effort into the traditional albacore fishing areas in the southern and eastern Indian Ocean. It is therefore unlikely that catch and effort on albacore will decline in the near future.

The WPTmT **RECOMMENDED** that the Scientific Committee consider the following:

- The available evidence indicates considerable risk to the stock status at current effort levels.
- The two primary sources of data that drive the assessment, total catches and CPUE are highly uncertain and should be investigated further as a priority.
- Current catches (average ~41,000 t over the last five years, ~44,000 t in 2010) likely exceed MSY (29,900 t, range: 21,500–33,100 t). Maintaining or increasing effort will probably result in further declines in biomass, productivity and CPUE.
- A Kobe 2 Strategy matrix was calculated to quantify the risk of different future catch scenarios. However, a number of inconsistencies between the model and data were noted for future investigation (matrix not presented here as a result).

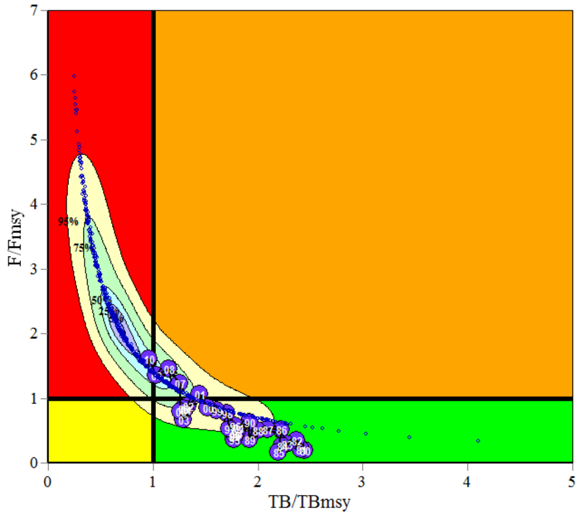

Fig. 1. ASPIC Aggregated Indian Ocean assessment Kobe plot (95% Confidence surfaces shown around 2010 estimate). Fixed B/K=0.9. Blue circles indicate the trajectory of the point estimates for the TB ratio and F ratio for each year 1980–2010 (Note: at this time the WPTmT had limited confidence in the assessment results (refer to paragraphs 71–77 in the report of the WPTmT03 (IOTC–2011–WPTmT03–R) for further clarification).

SUPPORTING INFORMATION

(Information collated from reports of the Working Party on Temperate Tunas and other sources as cited)

CONSERVATION AND MANAGEMENT MEASURES

Albacore (*Thunnus alalunga*) in the Indian Ocean are currently subject to a number of conservation and management measures adopted by the Commission, although none are species specific:

- Resolution 08/04 *concerning the recording of catch by longline fishing vessels in the IOTC area*.
- Resolution 09/02 *On the implementation of a limitation of fishing capacity of contracting parties and cooperating non-contracting parties*.
- Resolution 10/02 *mandatory statistical requirements for IOTC Members and Cooperating non-Contracting Parties (CPC's)*.
- Resolution 10/03 *concerning the recording of catch by fishing vessels in the IOTC area*.
- Resolution 10/07 *concerning a record of licensed foreign vessels fishing for tunas and swordfish in the IOTC area*.
- Resolution 10/08 *concerning a record of active vessels fishing for tunas and swordfish in the IOTC area.*
- Recommendation 11/06 *Concerning the Recording of Catch by Fishing Vessels in the IOTC Area of Competence*.

FISHERIES INDICATORS

General

Overall, the biology of albacore stock in the Indian Ocean is not well known and there is relatively little new information on albacore stocks. Albacore (*Thunnus alalunga*) life history characteristics, including a relatively late maturity, long life and sexual dimorphism, make the species vulnerable to over exploitation. Table 2 outlines some of the key life history traits of albacore specific to the Indian Ocean.

Catch trends

Albacore are currently caught almost exclusively using drifting longlines (98%), and between 20°S and 40°S, with remaining catches recorded using purse seines and other gears (Fig. 2). Between 1983 and 1992, a large portion of albacore catches were taken by the Taiwan,China fleet using drifting gillnets (Fig. 2; Table 3) which targeted juvenile albacore in the southern Indian Ocean (30°S to 40°S). In 1992 the United Nations worldwide ban on the use of drifting gillnets effectively closed this gillnet fishery.

Catches of albacore were relatively stable until the mid-1980s, except for high catches recorded in 1973 and 1974 (Fig. 2). The catches increased markedly during the mid-1980's due to the use of drifting gillnets by Taiwan,China, with total catches in excess of 30,000 t. Following the removal of the drifting gillnet fleet, catches dropped to less than 20,000 t by 1993. However, catches more than doubled over the period from 1993 (less than 20,000 t) to 2001 (44,000 t). Record catches of albacore were reported in 2007, at around 45,000 t, and again in 2008, at 48,000 t. Catches for 2009 are estimated to be approximately 40,000 t, while preliminary catches for 2010 amount to 43,711 t (Table 3).

TABLE 2. Biology of Indian Ocean albacore (*Thunnus alalunga*)

Parameter	Description
Range and stock structure	A temperate tuna living mainly in the mid oceanic gyres of the Pacific, Indian and Atlantic oceans. In the Pacific and Atlantic oceans there is a clear separation of southern and northern stocks associated with the oceanic gyres that are typical of these areas. In the Indian Ocean, there is probably only one southern stock, distributed from 5°N to 40°S, because there is no northern gyre. Albacore is a highly migratory species and individuals swim large distances during their lifetime. It can do this because it is capable of thermoregulation, has a high metabolic rate, and advanced cardiovascular and blood/gas exchange systems. Pre-adults (2-5 year old albacore) appear to be more migratory than adults. In the Pacific Ocean, the migration, distribution availability, and vulnerability of albacore are strongly influenced by oceanographic conditions, especially oceanic fronts. It has been observed on all albacore stocks that juveniles concentrate in cold temperate areas (for instance in a range of sea-surface temperatures between 15 and 18°C), and this has been confirmed in the Indian Ocean where albacore tuna are more abundant north of the subtropical convergence (an area where these juvenile were heavily fished by driftnet fisheries during the late 1980's). It appears that juvenile albacore show a continuous geographical distribution in the Atlantic and Indian oceans in the north edge of the subtropical convergence. Albacore may move across the jurisdictional boundary between ICCAT and IOTC. It is likely that the adult Indian Ocean albacore tunas do yearly circular counter-clockwise migrations following the surface currents of the south tropical gyre between their tropical spawning and southern feeding zones. In the Atlantic Ocean, large numbers of juvenile albacore are caught by the South African pole-and-line fishery (catching about 10,000 t yearly) and it has been hypothesized that these juveniles may be taken from a mixture of fish born in the Atlantic (north east of Brazil) and from the Indian Ocean. For the purposes of stock assessments, one pan-ocean stock has been assumed.
Longevity	8 years (reported to 10 years in the Pacific)
Maturity (50%)	Age: females 5–6 years; males n.a. Size: females n.a.; males n.a.
Spawning season	Little is known about the reproductive biology of albacore in the Indian Ocean but it appears, based on biological studies and on fishery data, that the main spawning grounds are located east of Madagascar between 15° and 25°S during the 4th and 1st quarters of each year. Like other tunas, adult albacore spawn in warm waters (SST>25°C).
Size (length and weight)	n.a.

n.a. = not available. SOURCES: Froese & Pauly (2009) ; Xu & Tian (2011)

Catches of albacore in recent years have come almost exclusively from vessels flagged in Indonesia and Taiwan,China, although the catches of albacore reported for the fresh tuna longline fishery of Indonesia have increased considerably since 2003 to around 17,000 t (Fig. 3), which represents approximately 40% of the total catches of albacore in the Indian Ocean.

Longliners from Japan and Taiwan,China have been operating in the Indian Ocean since the early 1950s (Fig. 3). While the Japanese albacore catch ranged from 8,000 t to 18,000 t in the period 1959 to 1969, in 1972 catches rapidly decreased to around 1,000 t, due to a change in the target species, mainly to southern bluefin tuna and bigeye tuna. Albacore became a bycatch species for the Japanese fleet with catches between 200 t and 2,500 t. In recent years the Japanese albacore catch has been around 2,000 to 6,000 t.

In contrast to the Japanese longliners, catches by Taiwan,China longliners increased steadily from the 1950's to average around 10,000 t by the mid-1970s. Between 1998 and 2002 catches ranged between 21,500 t to 26,900 t, equating to just over 60% of the total Indian Ocean albacore catch. Between 2003 and 2010 the albacore catches by Taiwan,China longliners have been between 10,000 and 18,000 t, with catches appearing to be on the increase in recent years. There has been a shift in the proportion of catches of albacore by deep-freezing and fresh-tuna longliners in recent years, with increasing catches of fresh-tuna (68% of the total catches for 2008–2010) as opposed to deep-freezing longliners (Fig. 2; Table 3).

While most of the catches of albacore have traditionally come from the western Indian Ocean, in recent years a larger proportion of the catch has come from the southern and eastern Indian Ocean (Fig. 4; Table 4). The relative increase in catches in the eastern Indian Ocean since the early 2000's is mostly due to increased activity of fresh-tuna longliners from Taiwan,China and Indonesia (Indonesia not represented in Fig. 4 as spatial catch-and-effort data is not available or highly uncertain for these fleets). In the western Indian Ocean, the catches of albacore mostly result from the activities of deep-freezing longliners and purse seiners.

Fleets of oceanic gillnet vessels from Iran and Pakistan and gillnet and longline vessels from Sri Lanka have extended their area of operation in recent years, to operate on the high seas closer to the equator. The lack of catch-and-effort data from these fleets makes it impossible to assess whether they are operating in areas where catches of juvenile albacore are likely to occur.

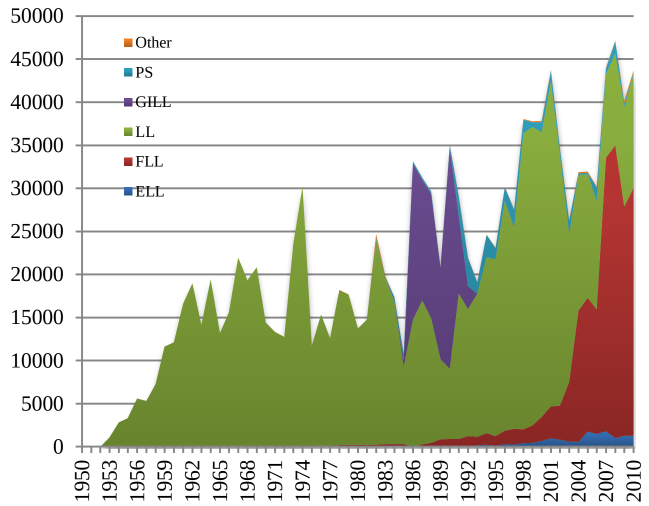

Fig. 2. Annual catches of albacore by gear recorded in the IOTC Database (1961–2010) (Data as of August 2011). Other gears nei (Other); Purse seine (PS); Freezing-longline (LL); Fresh-tuna longline (FLL); Swordfish-longline (ELL)

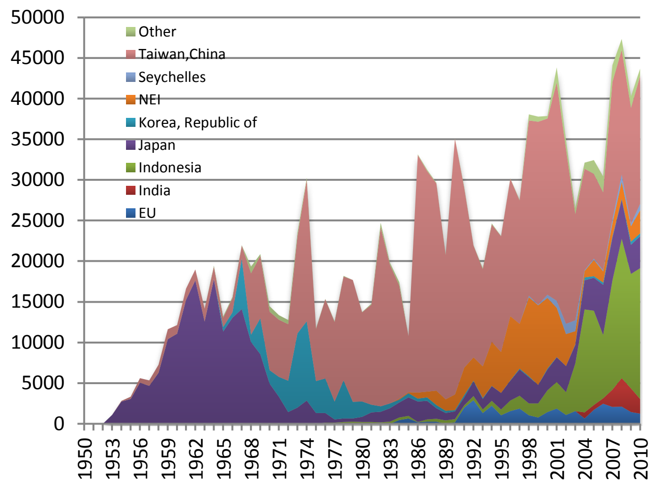

Fig. 3. Annual catches of albacore by fleet recorded in the IOTC Database (1961–2010) (Data as of August 2011).

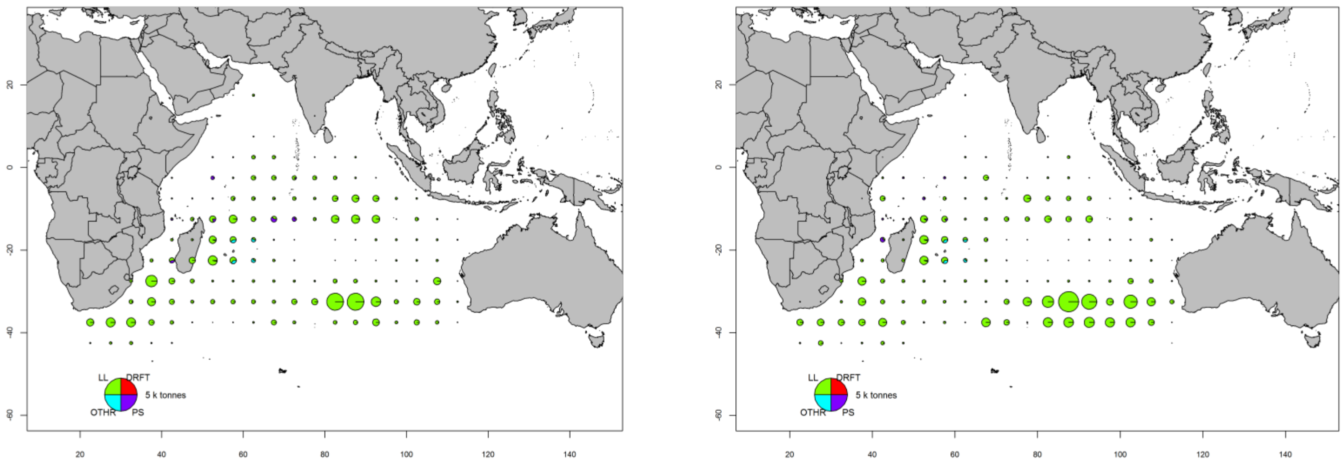

Fig. 4a–b. Time-area catches (total combined in tonnes) of albacore estimated for 2009 (left) and 2010 (right) by type of gear: Longline (LL, green), Driftnet (DFRT, red), Purse seine (PS, purple), Other fleets (OTHER, blue). Time-area catches are not available for all fleets; catches for those were assigned by 5x5 square and month using information from other fleets. Catches of fresh-tuna longliners are not represented (Data as of August 2011).

TABLE 3. Best scientific estimates of the catches of albacore (*Thunnus alalunga*) by gear and main fleets [or type of fishery] by decade (1950–2000) and year (2001–2010), in tonnes. Data as of October 2011. Catches by decade represent the average annual catch, noting that some gears were not used for all years (refer to Fig. 2).

	By decade (average)						By year (last ten years)									
Fishery	**1950s**	**1960s**	**1970s**	**1980s**	**1990s**	**2000s**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
DN				5,823	3,735											
LL	3,715	17,231	16,900	15,212	21,876	20,283	38,664	29,998	17,818	16,283	16,149	14,123	11,468	11,704	12,874	14,498
FLL			80	314	1,329	15,493	3,728	3,920	6,910	15,242	15,524	14,455	31,759	33,969	26,619	28,752
FS				195	1,578	855	1,030	755	1,493	230	149	1,388	705	1,391	366	166
LS				8	105	65	251	17	3	2	15	160	21	33	26	42
OT	5	9	24	67	61	148	172	139	131	150	143	108	107	91	293	254
Total	**3,721**	**17,240**	**17,005**	**21,620**	**28,684**	**36,844**	**43,845**	**34,829**	**26,355**	**31,906**	**31,979**	**30,234**	**44,059**	**47,189**	**40,178**	**43,711**

Fisheries: Driftnet (**DN**; Taiwan,China); Freezing-longline (**LL**); Fresh-tuna longline (**FLL**); Purse seine free-school (**FS**); Purse seine associated school (**LS**); Other gears nei (**OT**). Note: LL includes the ELL catches shown in Fig. 2.

TABLE 4. Best scientific estimates of the catches of albacore (*Thunnus alalunga*) by fishing area for the period 1950–2009 (in metric tons). Data as of October 2011.

Area	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
N	3,369	8,275	7,659	5,486	8,525	21,597	20,526	13,867	14,049	19,538	19,809	18,625	34,248	30,189	29,827	23,257
S	351	8,965	9,346	16,134	20,158	15,247	23,319	20,962	12,306	12,368	12,170	11,609	9,811	17,000	10,351	20,454
Total	**3,721**	**17,240**	**17,005**	**21,620**	**28,684**	**36,844**	**43,845**	**34,829**	**26,355**	**31,906**	**31,979**	**30,234**	**44,059**	**47,189**	**40,178**	**43,711**

Areas: North of 10ºS (**N**); South of 10ºS (**S**)

Uncertainty of catches

Retained catches are fairly well known (Fig. 5); however catches are uncertain for:

- Longliners of Indonesia, India and Malaysia operating in Southern waters: To date, Indonesian, Indian and Malaysian longline vessels operating in Southern waters have not reported catches of albacore, noting that the Secretariat has estimated these catches at around 3000 t annually.
- Fleets using gillnets on the high seas, in particular Iran, Pakistan and Sri Lanka: Catches are likely to be less than 1000 t.
- Non-reporting industrial longliners (NEI): Refers to catches from longliners operating under flags of non-reporting countries. Historically high catches, however thought to be between 1000 and 2000 t in recent years.

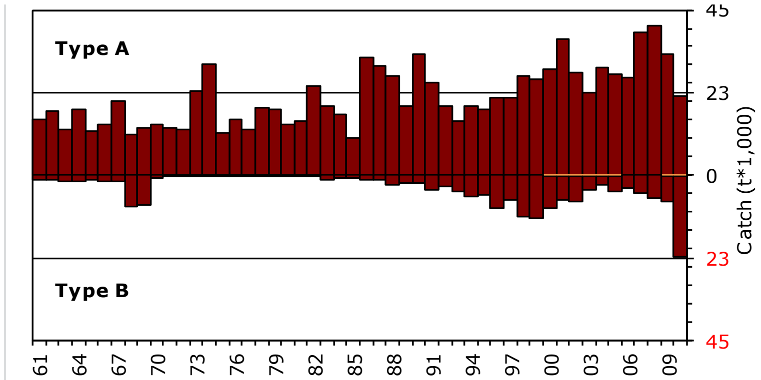

Fig. 5. Uncertainty of annual catch estimates for albacore (1950–2010) (Data as of August 2011).

*Catches below the zero-line (**Type B**) refer to fleets that do not report catch data to the IOTC (estimated by the IOTC Secretariat), do not report catch data by gear and/or species (broken by gear and species by the IOTC Secretariat) or any of the other reasons provided in the document. Catches over the zero-line (**Type A**) refer to fleets for which no major inconsistencies have been found to exist. Light bars represent data for artisanal fleets and dark bars represent data for industrial fleets.*

- The catch series for albacore in recent years has changed substantially, especially since 2003. This change was due to a review of the data series for Indonesian longliners (Fig. 6).
- Levels of discards are believed to be low although they are unknown for industrial fisheries other than European (EU) purse seiners.
- Catch-and-effort series are available from various industrial fisheries. Nevertheless, catch-and-effort are not available from some fisheries or they are considered to be of poor quality, especially during the last decade, for the following reasons:
    - uncertain data from significant fleets of longliners, including India, Indonesia and Philippines.
    - non-reporting by industrial purse seiners and longliners (NEI).

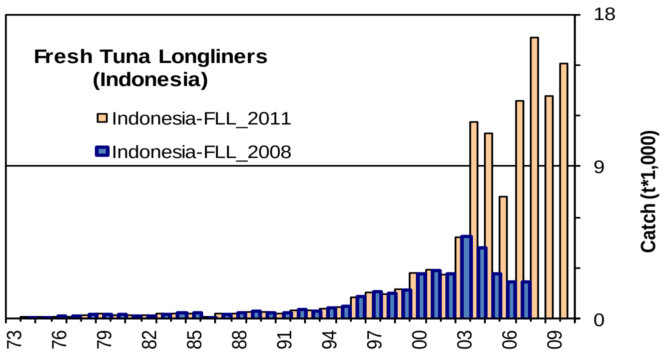

Fig. 6. Catches of fresh-tuna longline vessels based in Indonesia (domestic and foreign) estimated in 2011 (1973–2010) versus catches estimated in 2008 (1973–2006). The revised Indonesian nominal catch series data was estimated by the IOTC Secretariat.

Effort trends

Total effort from longline vessels flagged to Japan, Taiwan,China and EU,Spain by five degree square grid from 2007 to 2010 are provided in Fig. 7, and total effort from purse seine vessles flagged to the EU and Seychelles (operating under flags of EU countries, Seychelles and other flags), and others, by five degree square grid and main fleets, for the years 2007 to 2010 are provided in Fig. 8.

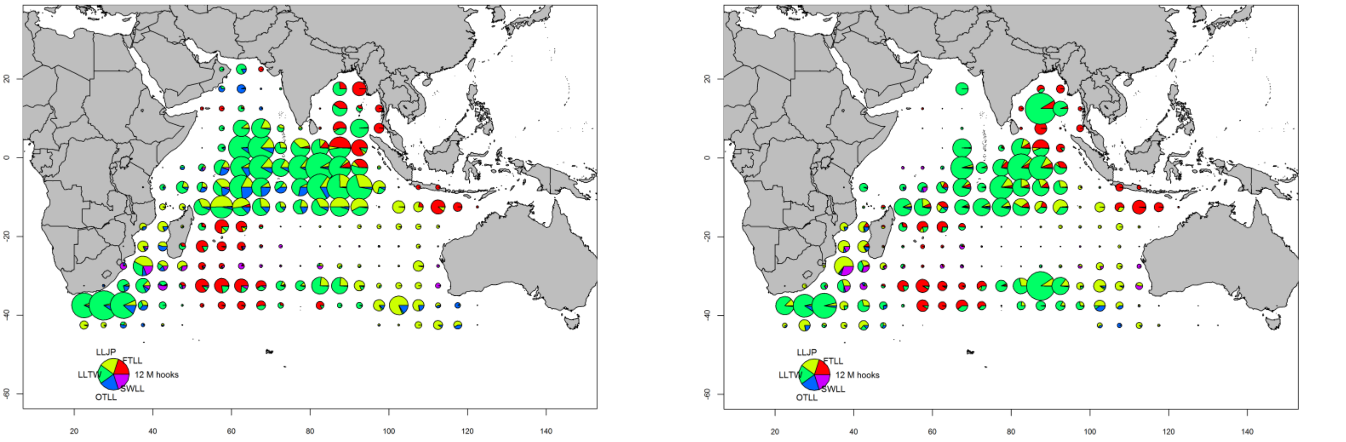

Fig. 7. Number of hooks set (millions) from longline vessels by five degree square grid and main fleets, for the years 2009 (left) and 2010 (right) (Data as of August 2011).
LLJP (light green): deep-freezing longliners from Japan
LLTW (dark green): deep-freezing longliners from Taiwan,China
SWLL (turquoise): swordfish longliners (Australia, EU, Mauritius, Seychelles and other fleets)
FTLL (red) : fresh-tuna longliners (China, Taiwan,China and other fleets)
OTLL (blue): Longliners from other fleets (includes Belize, China, Philippines, Seychelles, South Africa, Rep. of Korea and various other fleets)

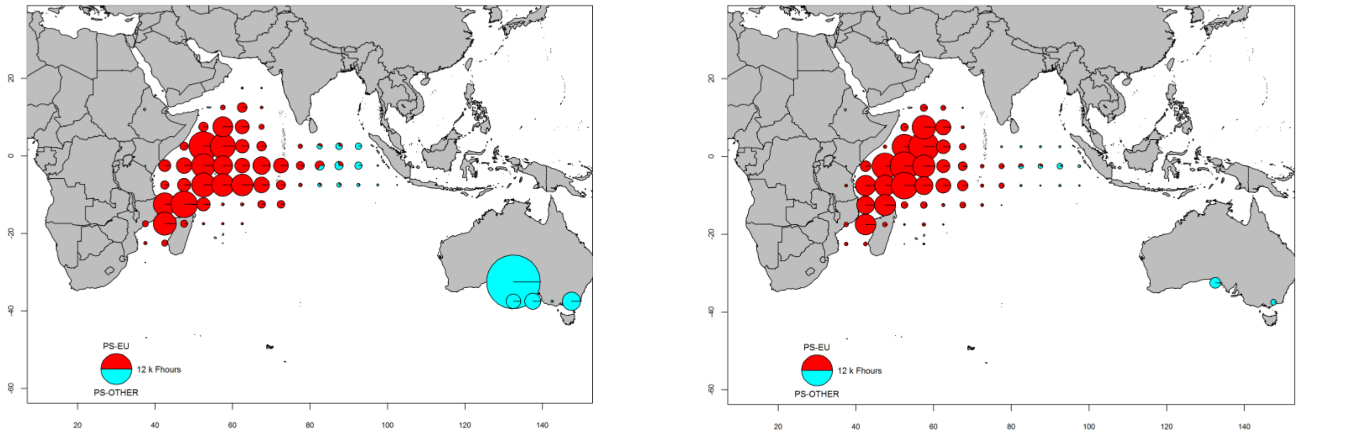

Fig. 8. Number of hours of fishing(Fhours) from purse seine vessels by 5 degree square grid and main fleets, for the years 2009 (left) and 2010 (right) (Data as of August 2011).
PS-EU (red): Industrial purse seiners monitored by the EU and Seychelles (operating under flags of EU countries, Seychelles and other flags)
PS-OTHER (green): Industrial purse seiners from other fleets (includes Japan, Mauritius and purse seiners of Soviet origin) (excludes effort data for purse seiners of Iran and Thailand)

Standardised catch–per–unit–effort (CPUE) trends

The CPUE series available for assessment purposes are shown in Fig. 9, although only the Taiwan,China series was used in the stock assessment model for 2011 for the reasons discussed in IOTC–2011–WPTmT03–R.

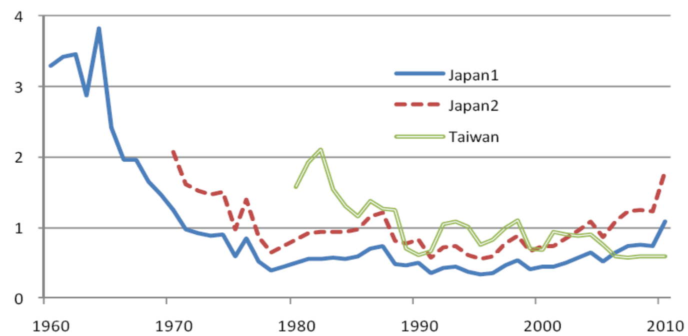

Fig. 9. Comparison of the three CPUE series for Indian Ocean albacore. Series have been rescaled relative to their respective means from 1960–2010.

Fish size or age trends (e.g. by length, weight, sex and/or maturity)

The size frequency data for the Taiwanese deep-freezing longline fishery for the period 1980–2009 is available. In general, the amount of catch for which size data for the species are available before 1980 is still very low. The data for the Japanese longline fleets is available; however, the number of specimens measured per stratum has been decreasing in recent years. Few data are available for the other fleets.

- Trends in average weight can be assessed for several industrial fisheries although they are incomplete or of poor quality for most fisheries before 1980, between 1986 and 1991, and in recent years, for the fleets referred to above (Fig. 10).
- Catch-at-Size(Age) tables are available but the estimates are highly uncertain for some periods and fisheries including:
  - all industrial longline fleets before the mid-60s, from the early-1970s up to the early-1980s and most fleets in recent years, in particular fresh-tuna longliners.
  - the paucity of catch by area data available for some industrial fleets (Taiwan,China, NEI, India and Indonesia).

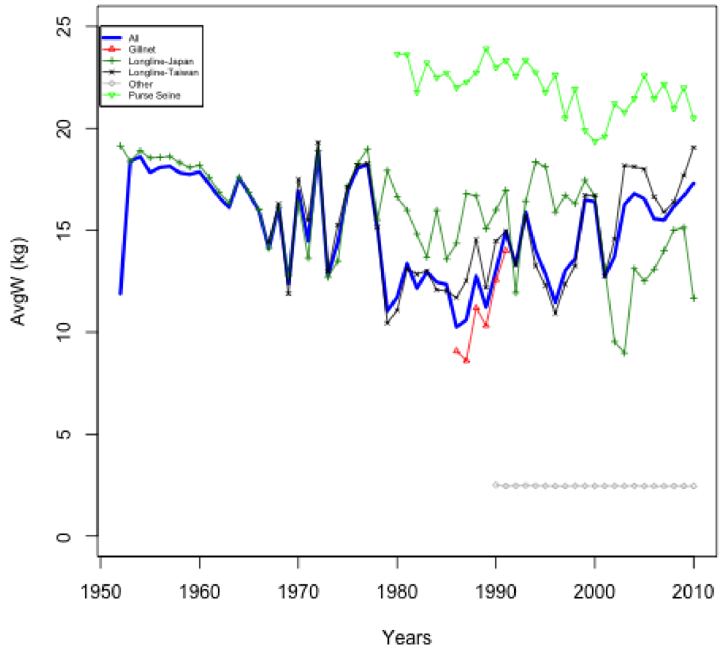

Fig. 10. Average weight in kg of the catches of all fleets (blue), gillnet (red), LL-JPN (dark green), LL-TWN (black), Purseine (green) and other gears (grey) from 1950 to 2010.

STOCK ASSESSMENT

A single quantitative modelling method, a highly aggregated "A Stock Production Model Including Covariate" (ASPIC) surplus production model, was applied to the albacore assessment in 2011.

The following is worth noting with respect to the modelling approach used:

- The Taiwan,China CPUE standardisation should be used over the Japanese CPUE series because the Japanese CPUE demonstrates strong targeting shifts away from albacore (1960s) and toward albacore in recent years (as a consequence of piracy in the western Indian Ocean), that was not accounted for in the standardization analysis.

- The Fox model had problems converging to a sensible solution when catch data prior to 1980 were included, when the Japanese CPUE were given substantial weight, and/or when the initial biomass was constrained to be less than or equal to the carrying capacity. The Working paper IOTC–2011–WPTmT03–19: *A note on the ASPIC Fox model and Indian Ocean albacore assessment*, examined this issue and found that the long catch time series tends to result in MSY estimates that approach 0. This causes a numerical failure. However, it appears that a range of MSY values may be reasonably consistent with the data.

The Fox model should be given a realistic biological constraint of B(1980) < carrying capacity (B(1980)/K=0.9), otherwise the model estimates B(1980) >> K. There was some incompatibility among the CPUE series, catch data and the Fox model. The structural rigidity of the Fox model limits the number of ways in which the error processes can be examined, and it was felt that this limited the scope of the analysis. Attempts to resolve the limitations are encouraged, as is the use of alternative models.

The general population trends and MSY parameters estimated by the Fox model appeared to be plausibly consistent with the general perception of the fishery and the data. However, these results are considered to be highly uncertain because of i) uncertainty in the catch rate standardization, ii) uncertainty in recent catches, and iii) limited ability to explore alternative interpretations of the data due to software constraints. The WPTmT had limited confidence in the assessment results.

TABLE 5. Albacore (*Thunnus alalunga*) stock status summary.

Management Quantity	**Aggregate Indian Ocean**
2010 catch estimate (1000 t)	43.7
Mean catch from 2006–2010 (1000 t)	41.1
MSY (1000 t) (80% CI)	29.9 (21.5–33.1)
Data period used in assessment	1980–2010
F_{2010}/F_{MSY} (80% CI)	1.61 (1.19–2.22)
B_{2010}/B_{MSY} (80% CI)	0.89 (0.65–1.12)
SB_{2010}/SB_{MSY}	–
B_{2010}/B_{1980} (80% CI)	0.39 (n.a.)
SB_{2010}/SB_{1980}	–
$B_{2010}/B_{1980,\ F=0}$	–
$SB_{2010}/SB_{1980,\ F=0}$	–

LITERATURE CITED

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Xu L & Tian SQ 2011. A study of fisheries biology for albacore based on Chinese observer data, IOTC–2011–WPTmT03–11.