

Stock and risk assessments of albacore in the Indian Ocean based on ASPIC

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Summary

An assessment for the Indian Ocean stock of albacore was conducted based on ASPIC with latest data. A time series of catch (Japanese and Taiwanese longline including similar longline fisheries, and other fisheries, 1950-2012) and that of standardized CPUE (Japanese and/or Taiwanese longline) were used for the analysis. Convergence and reasonable results were obtained for the scenarios with only Taiwanese CPUE or both Taiwanese and Japanese CPUE. The scenario with both Taiwanese and Japanese CPUE in main fishing area was selected as a reference case in this paper. The estimate of MSY in the reference case was 35,600 tons, and TB (total biomass) ratio and F ratio in 2013 and F ratio in 2012 was 1.19 and 0.80, respectively. The recent catch level is around 33,900 tons, which is about 2,000 tons lower than the MSY level. Hence the albacore stock is considered to be neither overfishing nor overfished. The Kobe plot 1 shows a large confidence surface (region), which implies that ASPIC analyses potentially possess large estimation uncertainties. According to KOBE II (risk assessments), if current catch level will be maintained in next 10 years, TB will exceed MSY level in 2023 with 48% of probability and F will be greater than F_{MSY} in 2022 with 43% probability. Therefore, according to the reference case analysis, the current level of catch may contribute to keeping the stock status around the MSY level. On the whole, the results in the present study were a bit more optimistic than those for the last assessment.

1. Introduction

Assessment of albacore stock in the Indian Ocean based on ASPIC (A Stock-Production Model Incorporating Covariates, Prager, 2004) was conducted at IOTC WPTmP meeting in 2011 (IOTC, 2011; Nishida and Matsumoto, 2011) and 2012 (IOTC, 2012; Matsumoto et al., 2012). In 2011, catch and CPUE data for 1980-2010 with only Taiwanese longline CPUE was used. At that time problem were raised that catch data only for short period was used and only Taiwanese CPUE was used. It was because no other models converged. In 2012, catch data for 1950-2010 (entire time series) with Japanese and Taiwanese longline combined CPUE (weighted average by amount of catch) was used. However, there was still concern that Japanese and Taiwanese CPUE couldn't be separately used. It was because large conflict of the trend for both CPUE was observed, and as a result the models didn't converge. As for the results of 2012 analysis, current F was almost MSY

level and current biomass was larger than MSY level, which were a bit more optimistic than the results for 2011 analysis. However, re-estimation of albacore catch was conducted in 2013 and it was found that albacore catch in recent years was mostly overestimated (maximum approximately 7,000 t) (Anonymous, 2013). It may affect the results of stock assessment. It is also necessary to compare the results with those for other assessment models, such as age structure and/or integrated models. Under these situations, we again conducted stock assessment for Indian Ocean albacore based on ASPIC.

2. Data

Two major input data to ASPIC are catch in weight by fleet and standardized CPUE by fleet. Following is explanation of this information.

2.1 Catch

We used the nominal catch data by gear (fleet) from the IOTC database (as of June, 2014). There are 5 gear types, i.e., (a) tuna longline (LL) fisheries (Japan type including Korea and others), (b) tuna longline fisheries (Taiwan type including Indonesian and others), (c) purse seine (PS) (d) Gill-net (GILL), (e) others including pole and line or bait boat (BB). Japan and Taiwan type LL were defined by the IOTC Secretariat. Fig. 1 shows the trends of catch by fleet type. In recent years, catch for Taiwan type longline accounts for most part of the entire catch. Entire catch peaked in 2001 (46,000t), and got second peak in 2010 (44,000t).

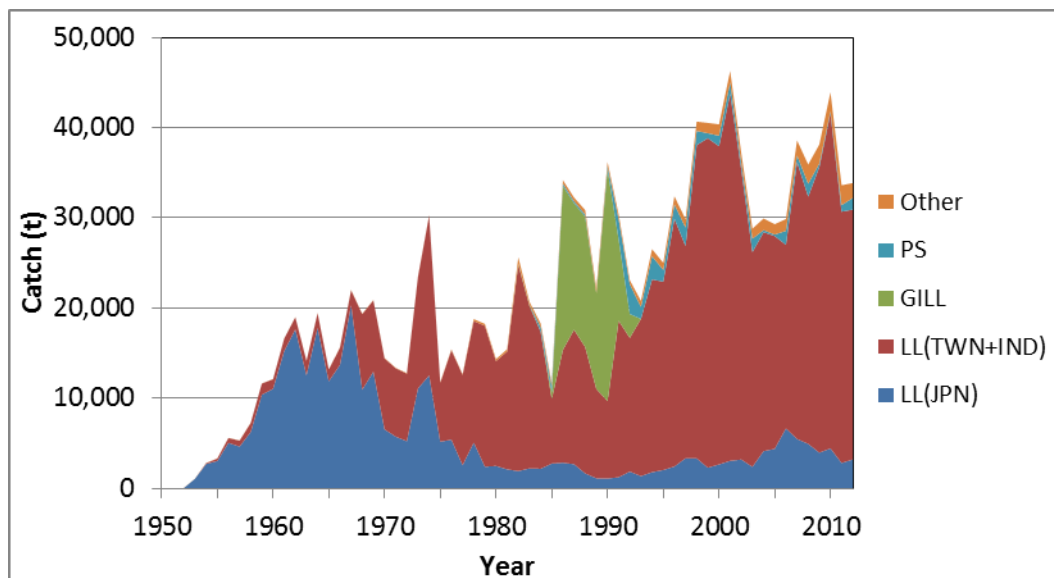


Fig. 1 Trend of albacore tuna catch in the Indian Ocean by gear (Fleet) type

(Source: IOTC database as of June, 2014).

2.2 CPUE

Standardized (STD) CPUE for Japanese tuna LL (1975-2012) (Matsumoto et al., 2014) and Taiwanese tuna LL (1980-2013) (Lee et al., 2014) are available. As for Japanese LL, CPUE for both south (25-40S, 20-50°E) and north (0-20°S, 20-120°E) areas are available, but south area was considered to be 'core area' (main fishing area) for albacore and so priority was given. As for Taiwanese LL, CPUE for all area, north area (0-20°S, 20-120°E) and south areas (South 1: 15-45°S, 60-90°E, South 2a: 15-45°S, 55-100°E, South 2b: 20-40°S, 20-70°E, South 3: 25-40°S, 20-50°E) are available. Central south area (South 1 or South 2a) was regarded as 'core area' because it seems to be main fishing ground for albacore by Taiwanese longline. Fig 2 shows comparison of these indices along with the trend for catch amount.

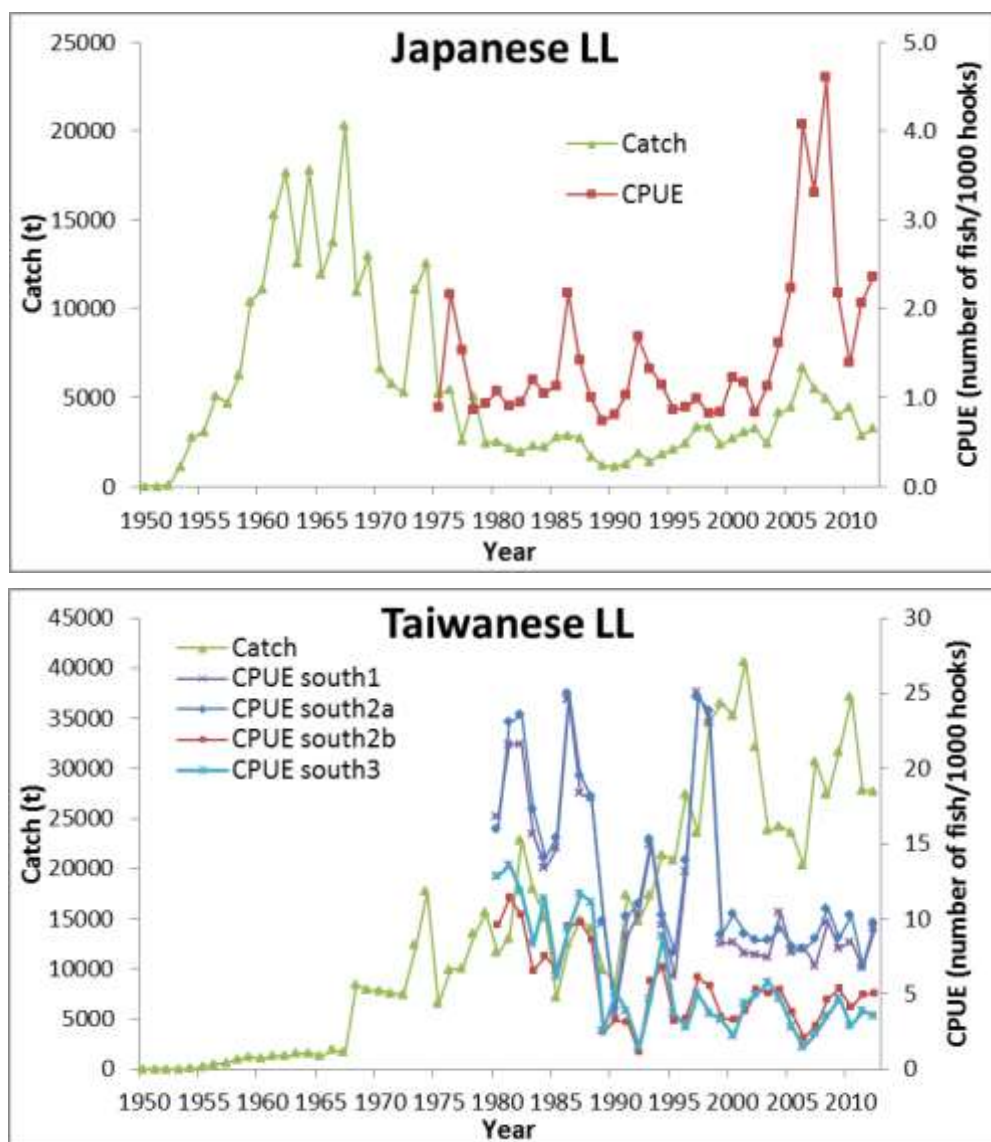


Fig. 2 Comparison of catch and STD CPUE for each fishery.

3. ASPIC analyses

3.1 Initial ASPIC runs

We used the FOX production model option available in the ASPIC software (ver. 5.34) developed by Prager (2004).

As for catch data, we thought that it is better to use the period as long as possible. Catch for IOTC database are available from 1950, so data for 1950-2012 were examined. Catch for fisheries other than longline was combined because CPUE for those fisheries are not available. As for CPUE, both Japanese and Taiwanese longline indices were used separately. B1/K (ratio of initial biomass to carrying capacity) was fixed to be 0.9 as with previous analyses, considering that stock status in 1950 is close to virgin biomass.

As for statistical weights for data series, in addition to equal weight, weighting by amount of catch (total catch during 1950-2012) was examined. Regarding CPUE for Japanese longline, the number of vessels operating in the south Indian Ocean increased around 2006, and they targeted tuna species other than southern bluefin tuna. Therefore, it seems that catchability of albacore changed in this period, and so in several scenarios CPUE for this period was truncated.

As a result, we were able to obtain convergence and reasonable results from the scenarios in which Japanese and Taiwanese CPUE were incorporated separately, or only Taiwanese CPUE was incorporated. In the previous assessment, the scenario with combined Japanese and Taiwanese CPUE was adopted. However, it may be better to use separate CPUE rather than combined CPUE. Therefore, this time combined CPUE was not used.

Total catch used to exceed current MSY level around 2000 and 2010, but it was slightly below MSY level in 2012. Fig. 4 shows Kobe 1 plot based on the results of Run 2. Currently the stock is in the green zone at point estimate, but a part of 95% confidence surface is in the yellow or red zone, which implies that ASPIC analyses include large uncertainties.

Table 1 shows summary results of ASPIC runs, which got reasonable results. The six scenarios got comparatively similar results, in which all the estimated parameters are reasonable and realistic. MSY was 34,700-39,800 tons, TB (Total biomass in the beginning of 2013) was 60,000-150,000 tons, TB (MSY) was 60,000-100,000 tons, TB ratio (in 2013) was 1.02-1.50, F (2012) was 0.22-0.53, F (MSY) was 0.39-0.55 and F ratio (in 2012) was 0.57-0.96. These are close to or a bit more optimistic compared with the assessment in 2012 (IOTC, 2012). Probably it is partly because the catch in the last two years (2011-2012) decreased from that during 2007-2010. Revision of catch estimate and resultant decrease in recent catch also may have affected the results.

Table 2 is summary of the ASPIC analysis for Run 2, whose results are almost in the median, and seems to be more reasonable because both Japanese and Taiwanese CPUEs were incorporated, and also Taiwanese CPUE for main fishing area was used. This scenario is regarded as base (reference) case in this document. Fig. 3 shows historical trend for total biomass, TB ratio, F ratio and catch with MSY level based on the results of Run 2. TB and TB ratio show decreasing trend, but they were comparatively constant in recent years, and were still above MSY level. F ratio shows increasing trend, and fluctuated between around 0.6 and 1.0 in recent years. Total catch used to exceed current MSY level around 2000 and 2010, but it was slightly below MSY level in 2012. Fig. 4 shows Kobe 1 plot based on the results of Run 2. Currently the stock is in the green zone at point estimate, but a part of 95% confidence surface is in the yellow or red zone, which implies that ASPIC analyses include large uncertainties.

Table 1 Summary and results of ASPIC runs, which got reasonable results.

Run No.	years	Model	Fleets			CPUE		Statistical weight	B1/K
			LL JP	LL TW	OT	JPN	TWN		
2011 base*	1980-2010	Fox	on		on		1980-2010	Equal	Fix(0.9)
2012 base**	1950-2010	Fox	on		on	1980-2010, weighted average by catch		Equal	Fix(0.9)
1	1950-2012	Fox	on	on	on		1980-2012 South1	Equal	Fix(0.9)
2	1950-2012	Fox	on	on	on	1975-2005 South	1980-2012 South1	Catch	Fix(0.9)
3	1950-2012	Fox	on	on	on		1980-2012 South2a	Equal	Fix(0.9)
4	1950-2012	Fox	on	on	on	1975-2005 South	1980-2012 South2a	Catch	Fix(0.9)
5	1950-2012	Fox	on	on	on		1980-2012 South2b	Equal	Fix(0.9)
6	1950-2012	Fox	on	on	on	1975-2005 South	1980-2012 South2b	Catch	Fix(0.9)

Run No.	MSY 1000 tons	TB current million tons	TB msy million tons	TB ratio	F current	F msy	F ratio
2011 base*	29.9	0.13	0.14	0.89	0.34	0.21	1.61
2012 base**	35.9	0.11	0.09	1.16	0.38	0.38	1.00
1	34.7	0.06	0.06	1.02	0.53	0.55	0.96
2	35.6	0.10	0.08	1.19	0.35	0.43	0.80
3	34.7	0.07	0.07	1.05	0.47	0.50	0.94
4	35.7	0.11	0.09	1.23	0.31	0.41	0.78
5	37.2	0.12	0.09	1.34	0.28	0.41	0.69

6	39.8	0.15	0.10	1.50	0.22	0.39	0.57
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* Final model for 2011 assessment, ** Final model for 2012 assessment, TB: total biomass, TB ratio: $TB_{\text{current}}/TB_{\text{MSY}}$, F ratio: $F_{\text{current}}/F_{\text{MSY}}$. Current year is 2013 and 2012 for TB and F, respectively.

Table 2 Indian Ocean albacore stock status summary based on the ASPIC analyses (Run 2).

Management Quantity	Indian Ocean
Most recent catch estimate (t) (2012)	33,864
Mean catch over last 5 years (t) (2008-2012)	37,090
MSY (1000 t) (80%CI)	35.6 (30.6-39.7)
Current data period	1950-2012
F(Current)/F(MSY) (2012) (80% CI)	0.80 (0.53-1.10)
B(Current)/B(MSY) (2013) (80% CI)	1.19 (0.92-1.51)
SB(Current)/SB(MSY)	NA
B(Current)/B(0) (2013) (80% CI)	0.49 (NA)
SB(Current)/SB(0)	NA
SB(Current)/SB(Current, F=0)	NA

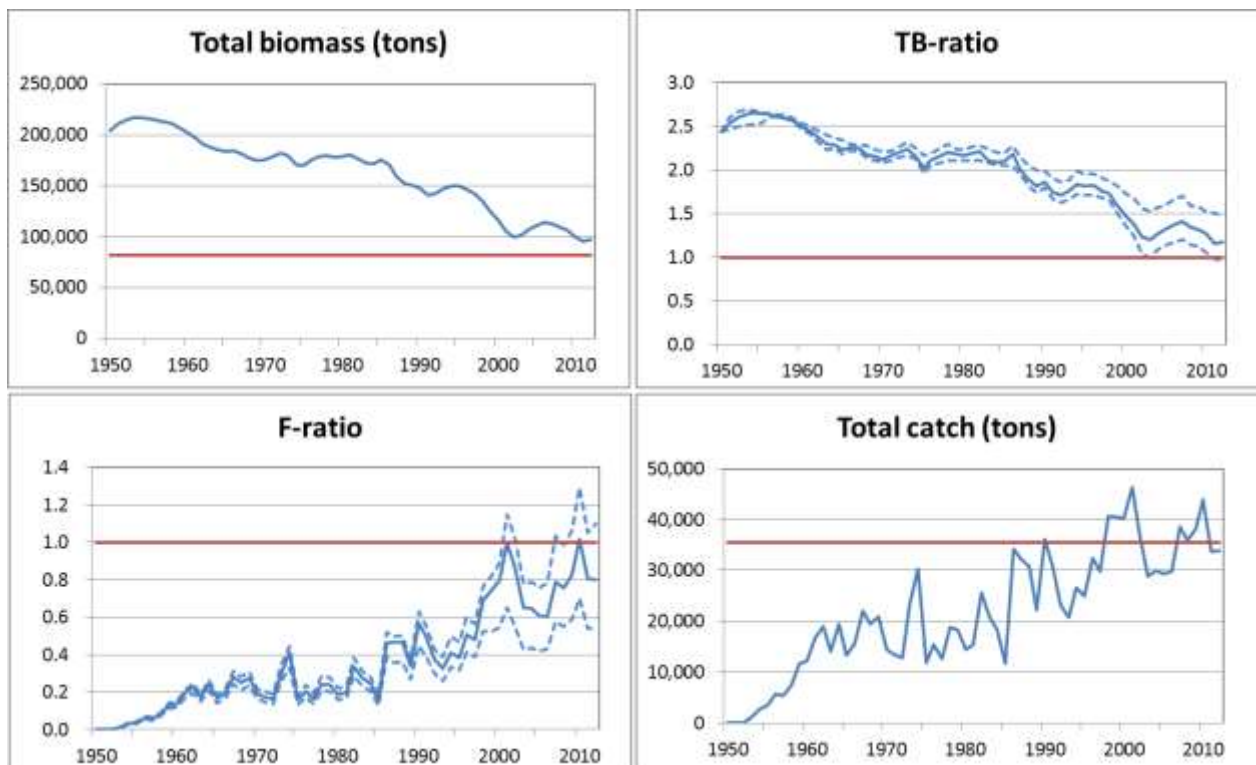


Fig. 3 Results of the run2. Horizontal lines indicate MSY level, and dashed lines indicate 80% confidence limits.

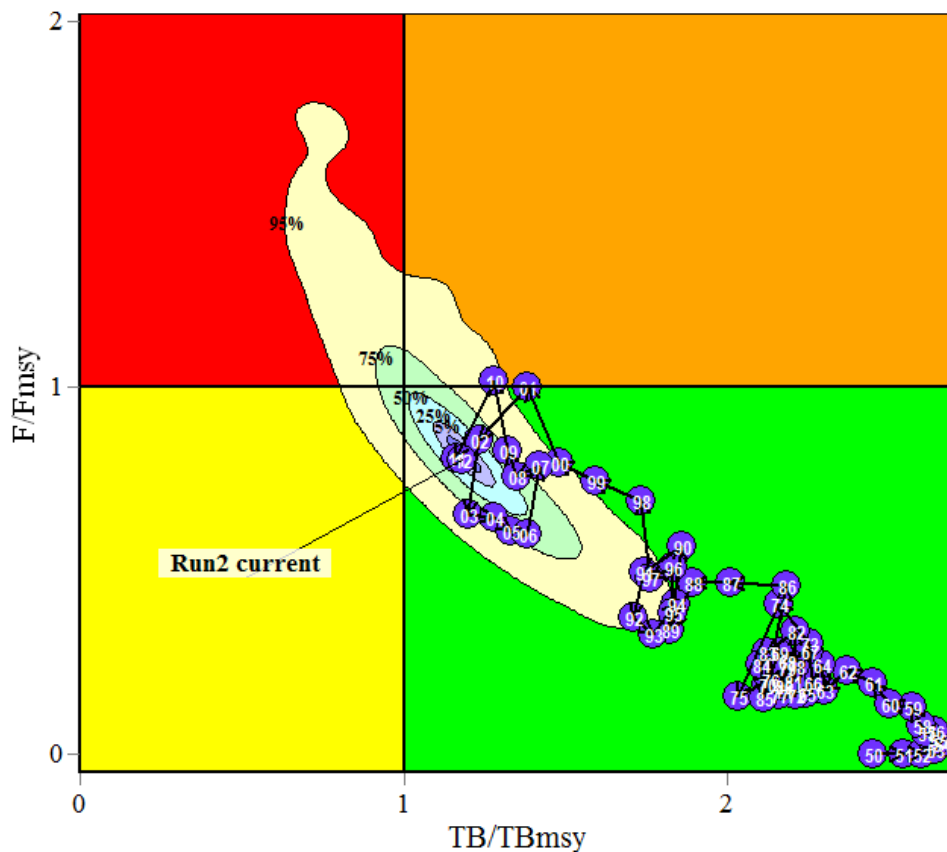


Fig. 4 Kobe plot with 95% confidence surface for Run 2.

4. Risk assessments

Five tuna RFMOs meetings in Kobe in 2007 recommended to produce Kobe plot (stock trajectory) and also in Barcelona in 2010 they recommended to conduct the risk analyses for SSB (spawning stock biomass) or TB (total biomass) ratio (our case). Degrees of risks are represented by probabilities to exceed TB ratio=1 (at MSY level) and F ratio =1 (at MSY level). Risks will be evaluated by 5 scenarios, i.e., in case catch level of the current year was continued and in case $\pm 10\%$, -15% , $\pm 20\%$ and $\pm 40\%$ of current catch were continued (constant catch). The scenarios with variant future F (-40% to 40% of current F) were also examined. Catch in 2013 and 2014 was fixed at 2012 catch (33,864t) for both constant catch and constant F scenario because the catch in these years completely or almost can't be controlled. Using these scenarios they suggested evaluating risk probabilities within 10 years. To conduct the risk assessments, we generated 500 bootstraps to obtain possible values of TB ratios and F ratios by utilizing ASPIC-P ver. 5.34 (projection module available in ASPIC).

4.1 Risk assessments on TB ratio

Using results of the ASPIC analysis for Run 2, 500 values of TB ratio and F ratio were generated by the bootstrap function available in the ASPIC-P for 2013-2022 (2013-2023 for biomass level). As a first step, we made future projections of TB ratios (Fig. 5). Then we made the Kobe 2 risk matrix (

Table 3). These results indicated the high risk of TB ratio exceeding TB (MSY) level in the future if future catch or F is higher than current level (or greater than the MSY level). TB will exceed MSY level by 48% of probability in 2023 with current level future catch. The probability of exceeding MSY level in 2023 becomes over 50% if future catch increases by 10% or more compared with current level.

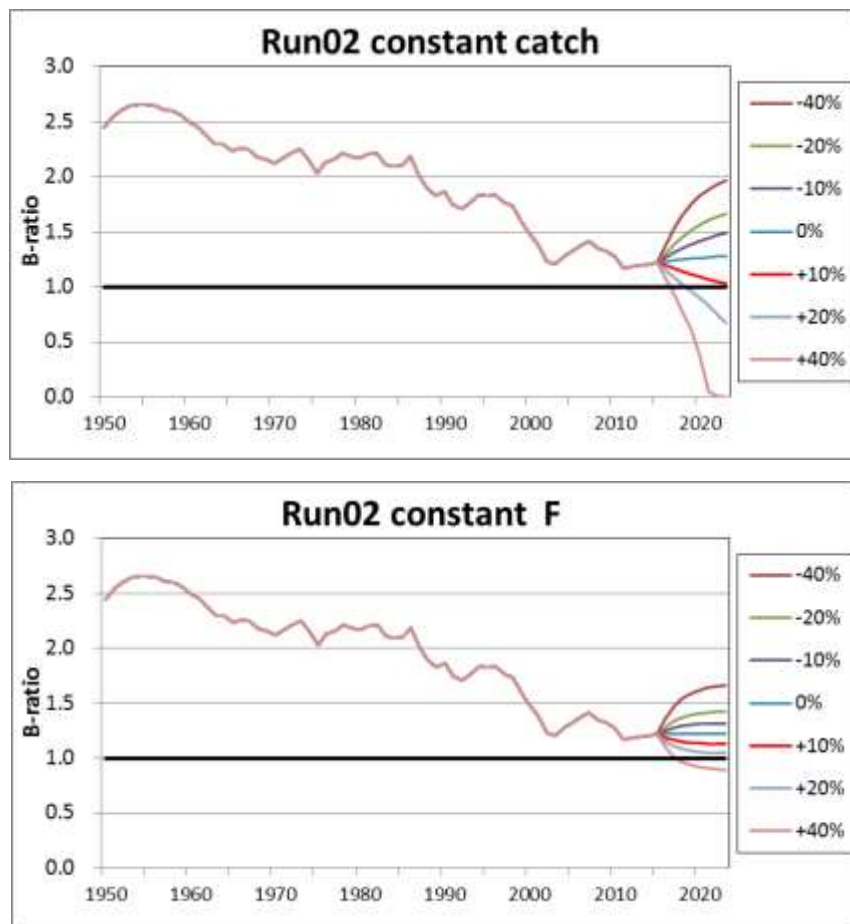


Fig. 5 Future projection of TB ratio with constant catch (top) and constant F (bottom) for Run 2.

Table 3 Kobe II risk matrix for TB ratio (probability of exceeding MSY level) under constant catch (top) and constant F (bottom) for Run 2.

TB	Catch (t)	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
-40%	20,318	51%	50%	50%	34%	23%	17%	15%	13%	13%	12%	12%
-30%	23,705	51%	50%	50%	38%	28%	22%	19%	17%	16%	15%	15%
-20%	27,091	51%	50%	50%	42%	35%	29%	26%	23%	22%	20%	19%
-10%	30,477	51%	50%	50%	45%	42%	38%	36%	33%	32%	31%	30%
0%	33,864	51%	50%	50%	49%	49%	49%	48%	48%	48%	48%	48%
10%	37,250	51%	50%	50%	53%	55%	57%	58%	59%	61%	63%	64%
20%	40,636	51%	50%	50%	55%	58%	62%	65%	68%	70%	72%	74%
30%	44,023	51%	50%	50%	57%	62%	68%	71%	73%	76%	80%	84%
40%	47,409	51%	50%	50%	59%	66%	70%	75%	79%	83%	87%	89%

F		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
-40%	0.21	51%	50%	50%	37%	28%	26%	25%	24%	23%	23%	23%
-30%	0.24	51%	50%	50%	40%	34%	32%	30%	29%	29%	29%	29%
-20%	0.28	51%	50%	50%	44%	40%	38%	36%	36%	35%	35%	35%
-10%	0.31	51%	50%	50%	47%	45%	44%	43%	43%	42%	42%	42%
0%	0.35	51%	50%	50%	50%	50%	50%	50%	50%	51%	51%	51%
10%	0.38	51%	50%	50%	53%	54%	55%	55%	55%	55%	55%	56%
20%	0.42	51%	50%	50%	55%	57%	57%	58%	59%	60%	60%	60%
30%	0.45	51%	50%	50%	56%	59%	61%	62%	63%	63%	63%	64%
40%	0.49	51%	50%	50%	57%	61%	63%	65%	66%	67%	68%	68%

4.2 Risk assessments on F ratio

In the same way as for TB ratio, the future projection (Fig. 6) and Kobe 2 matrix (Table 4) were made. These results also indicated high risk of F ratio exceeding F (MSY) level in the future if future catch or F is higher than current level (or greater than the MSY level). F will exceed FMSY by 43% of probability in 2022 with current level future catch. The probability of exceeding MSY level in 2022 becomes over 50% if future catch increases by 10% or more compared with current level.

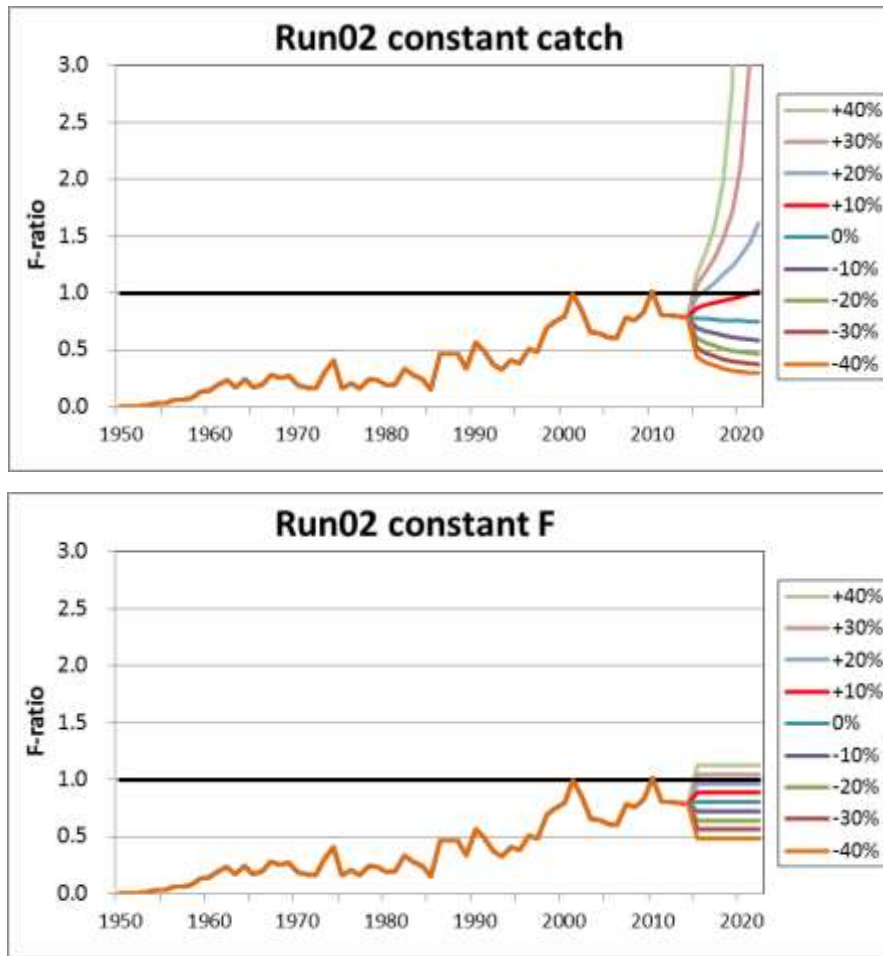


Fig. 6 Future projection of F ratio with constant catch (top) and constant F (bottom) for Run 2.

Table 4 Kobe II risk matrix for F ratio (probability of exceeding MSY level) under constant catch (top) and constant F (bottom) for Run 2.

F											
	Catch (t)	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
-40%	20,318	46%	45%	6%	2%	1%	1%	1%	1%	1%	1%
-30%	23,705	46%	45%	11%	8%	6%	5%	4%	4%	4%	4%
-20%	27,091	46%	45%	23%	16%	12%	11%	10%	9%	9%	9%
-10%	30,477	46%	45%	33%	28%	26%	24%	22%	21%	20%	19%
0%	33,864	46%	45%	45%	45%	45%	45%	45%	44%	44%	43%
10%	37,250	46%	45%	55%	56%	58%	59%	61%	63%	65%	67%
20%	40,636	46%	45%	61%	64%	67%	69%	71%	73%	75%	77%
30%	44,023	46%	45%	66%	69%	73%	76%	78%	82%	85%	87%
40%	47,409	46%	45%	69%	74%	78%	81%	85%	88%	90%	91%

F											
	F	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
-40%	0.21	46%	45%	12%	12%	12%	12%	12%	12%	12%	12%
-30%	0.24	46%	45%	21%	21%	21%	21%	21%	21%	21%	21%
-20%	0.28	46%	45%	29%	29%	29%	29%	29%	29%	29%	29%
-10%	0.31	46%	45%	38%	38%	38%	38%	38%	38%	38%	38%
0%	0.35	46%	45%	47%	47%	47%	47%	47%	47%	47%	47%
10%	0.38	46%	45%	54%	54%	54%	54%	54%	54%	54%	54%
20%	0.42	46%	45%	58%	58%	58%	58%	58%	58%	58%	58%
30%	0.45	46%	45%	63%	63%	63%	63%	63%	63%	63%	63%
40%	0.49	46%	45%	67%	67%	67%	67%	67%	67%	67%	67%

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Appendix

In response to the request at IOTC WPTmT05, additional ASPIC analysis was conducted using catch (tentative) and CPUE data up to 2013. It is because tentative 2013 catch was approximately 22% higher than the 2012 catch level. The assumptions are the same as those for Run03 (final base case) in Table 1, in which only Taiwanese CPUE (central south area, South2a) was used.

Table 5 shows summary results of additional run (Run 03') as well as final base case scenario. The results were similar to those for base case scenario (Run 03) and biomass in 2013 was still lower than MSY level, although F-ratio (1.09) was higher and exceeded MSY level.

Table 5 Summary and results of ASPIC additional run (Run 03') with those for base case (Run 03).

Scenario (run)	Years	CPUE		Statistical weight	B1/K	MSE	MSY 1000 tons	TB Current million tons	TB msy million tons	TB ratio	F Current	F msy	F ratio
		JPN	TWN										
3 (base)	1950- 2012	-	1980- 2012 South2a	Equal	Fix (0.9)	0.135	34.7	0.07	0.07	1.05	0.47	0.50	0.94
3'	1950- 2013	-	1980- 2013 South2a	Equal	Fix (0.9)	0.138	35.7	0.07	0.07	1.06	0.57	0.53	1.09

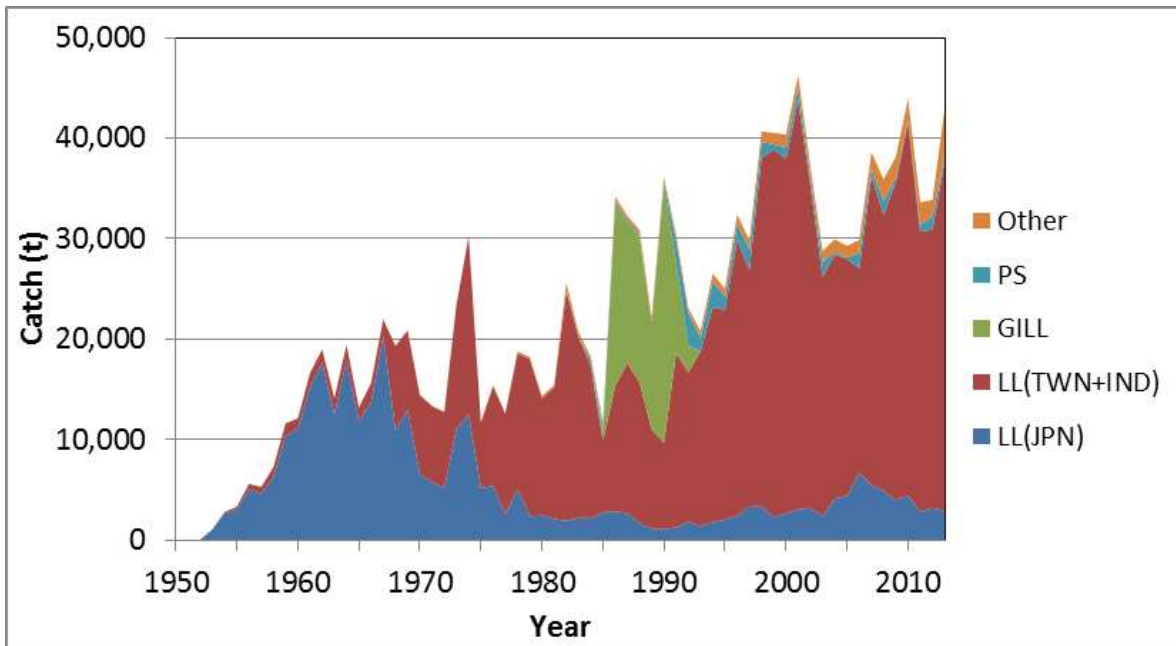


Fig. 7 Trend of albacore tuna catch in the Indian Ocean by gear (Fleet) type, which includes tentative catch amount for 2013.

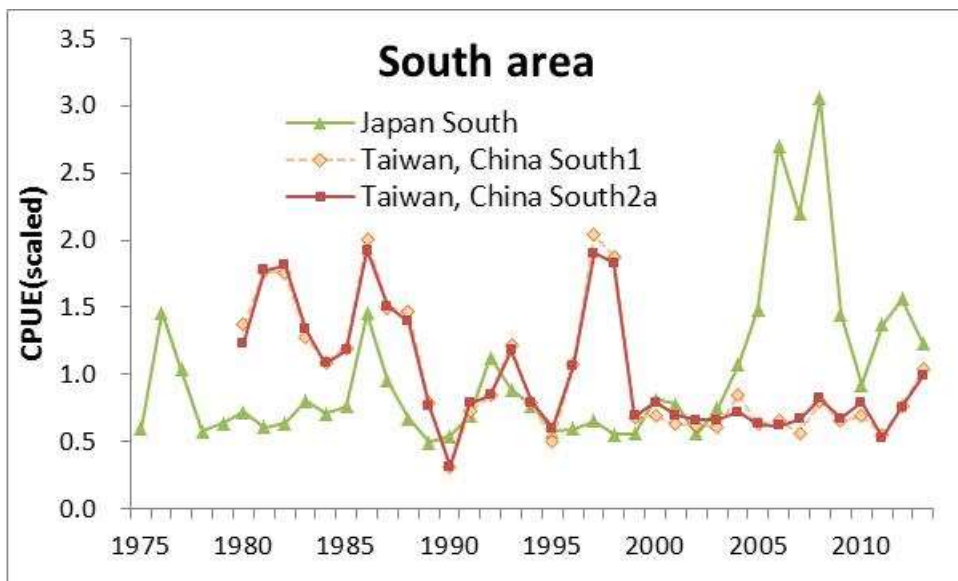


Fig. 8 Albacore CPUE by Taiwanese and Japanese longline fishery in the south area up to 2013.

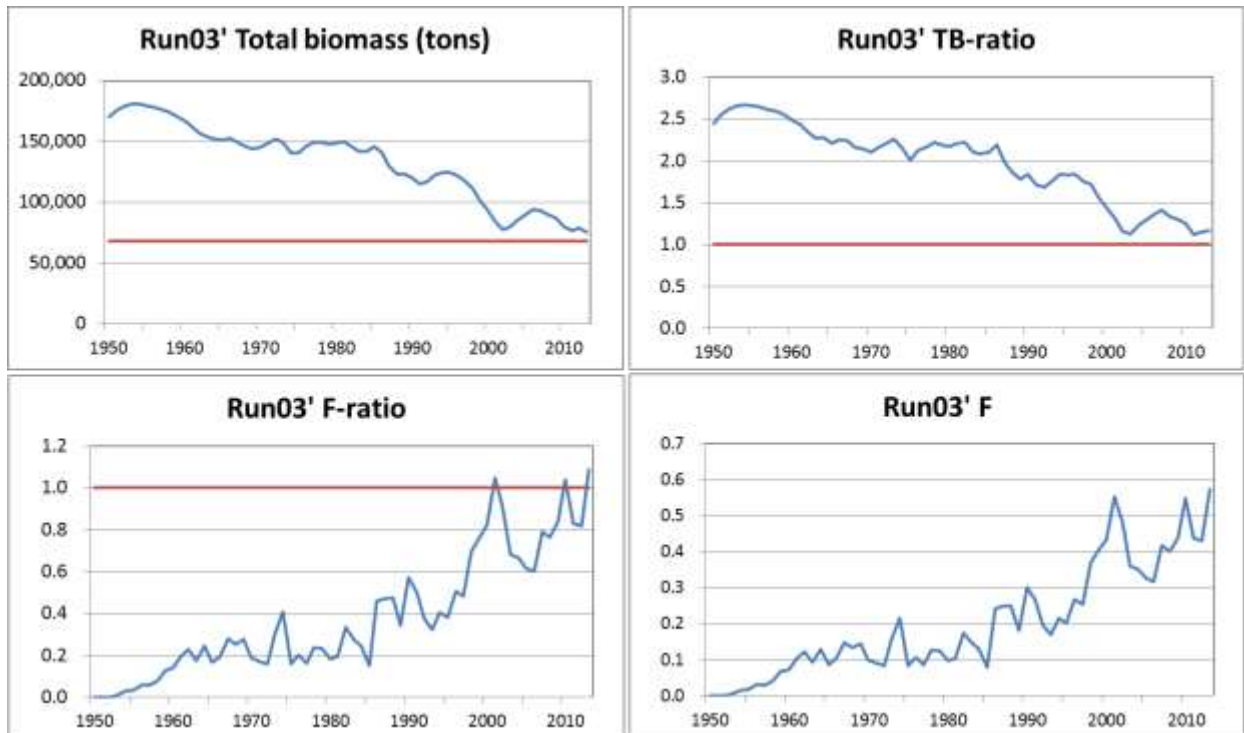


Fig. 9 Results of additional ASPIC run (Run3'). Horizontal lines indicate MSY level.

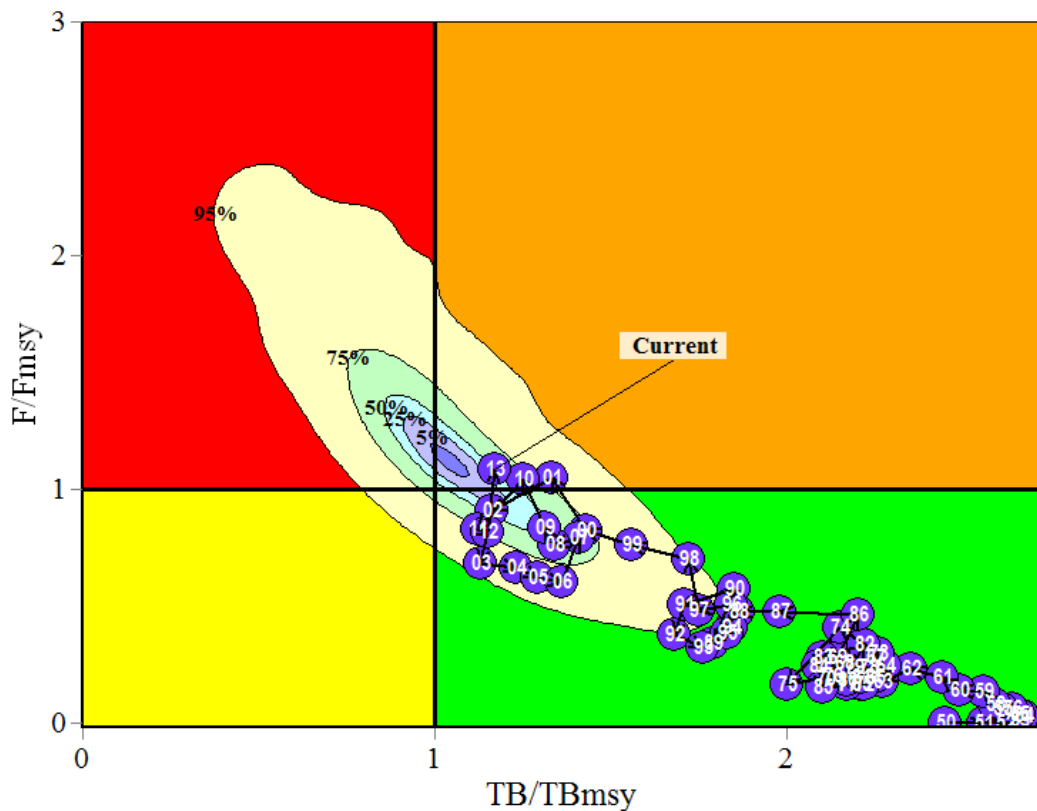


Fig. 10 Kobe plot with 95% confidence surface for Run 3'.