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

Takayuki Matsumoto[1]

[1]*National Research Institute of Far Seas Fisheries (NRIFSF), Fisheries Research Agency (FRA), 5-7-1, Orido, Shimizu, Shizuoka, 424-8633, Japan*

Summary

An assessment for the Indian Ocean stock of albacore was conducted based on ASPIC. A time series of catch (1950-2014) and that of standardized CPUE (Taiwanese longline or longline 'joint') were used for the analysis. Convergence and reasonable results were obtained for the scenarios which incorporated Taiwanese CPUE and/or joint longline CPUE. The scenario with only Taiwanese CPUE in main fishing area was selected as a reference case in this paper. According to the reference case, the stock status was estimated to be in the green zone of Kobe plot. Kobe II (risk assessments) indicated that the risk of B and F exceeding MSY level is lower than 50% if future catch is up to 40% and 30% higher than current level, respectively. On the whole, the results in the present study were 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), 2012 (IOTC, 2012; Matsumoto et al., 2012) and 2014 (IOTC, 2014; Matsumoto et al., 2014). In 2011, catch and CPUE data for 1980-2010 with only Taiwanese longline CPUE was used. At that time a problem was raised that catch data only for short period was used and only Taiwanese CPUE was used. It was because no other scenarios 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 per year) (Anonymous, 2013). In 2014, catch data for 1950-2012 (entire time series) with Japanese and Taiwanese longline CPUE separately or only Taiwanese CPUE were used, and the scenario with only Taiwanese CPUE was selected for base case. At that time, as for continuity analysis, base case scenario with catch and CPUE up to 2013 was also examined, and the results were similar to those for the base case.

In April 2016, IOTC 1st joint CPUE analysis was conducted and standardized CPUEs for albacore were created using operational level data for Japanese, Korean and Taiwanese longline fishery combined ('joint

CPUE'). It is a good opportunity to examine stock assessment using joint CPUE. It is also necessary to compare the results with those for other assessment models, such as age structured 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, 2016). Fig. 1 shows the trends of catch by fleet type. Most of the catch is by longline fishery, but a certain proportion of catch was made by gillnet fishery between mid-1980s and early 1990s. 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).

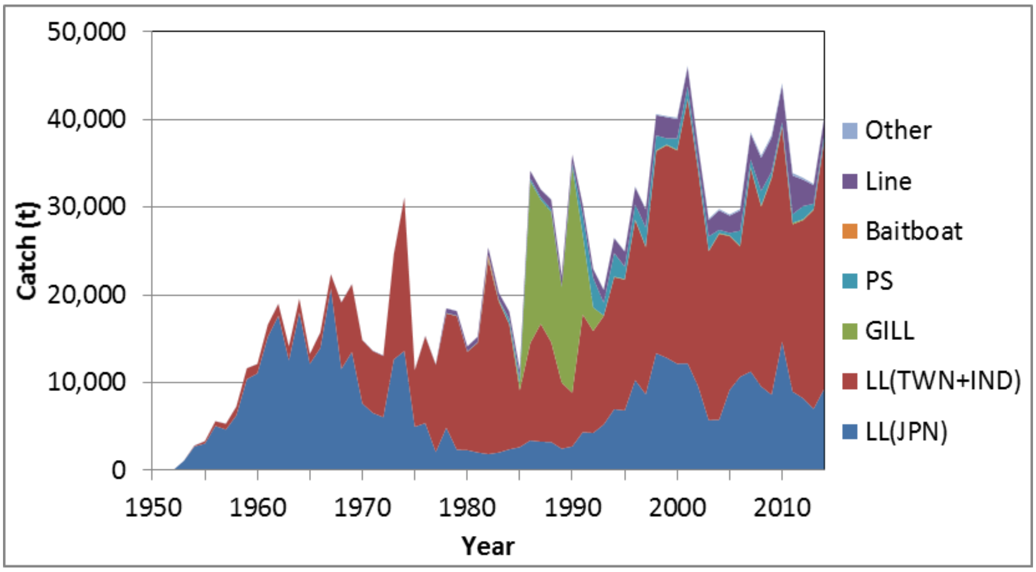

Fig. 1 Trend of albacore tuna catch in the Indian Ocean by gear (Fleet) type.

(Source: IOTC database as of June, 2016).

2.2 CPUE

Standardized (STD) CPUE for Japanese tuna LL (1954-2014) (Matsumoto and Kitakado, 2016), Taiwanese tuna LL (1980-2013: Lee et al., 2014 and 1980-2014: Chang and Yeh, 2016) and joint CPUE by Japanese, Korean and Taiwanese longline fishery combined (1958-2014) (Hoyle et al., 2016) are available. Japanese LL CPUE was not used because there is a concern for target shift and so was not used for ASPIC base case scenario in the past assessments. As for Taiwanese LL, index for central south area (15-45°S, 55-100°E or 15-45°S, 60-90°E), which corresponds to 'core area' was used. As for joint LL CPUE, index for area "A5" (15-45°S, 55-100°E, **Fig. 2**) was used. Index for joint CPUE in area A5 is available for 1958-2014, but the index in the recent years (2008-2014) was truncated due to sharp target shift by Japanese longline fishery. **Fig. 3** shows trend of these indices.

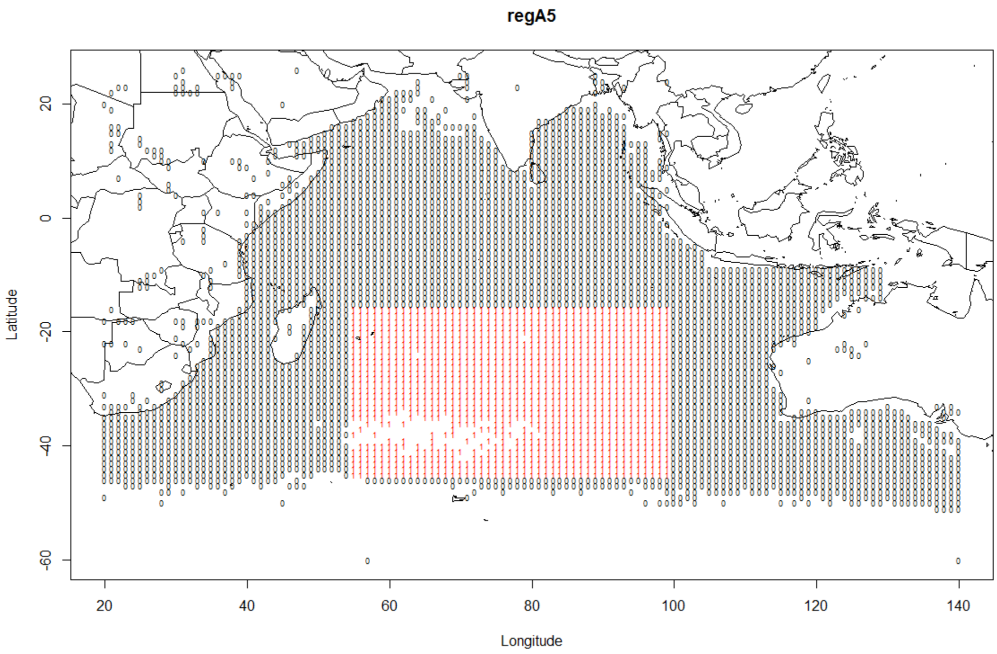

Fig. 2 Area definition for joint CPUE by Japanese, Korean and Taiwanese longline fishery combined used in this study.

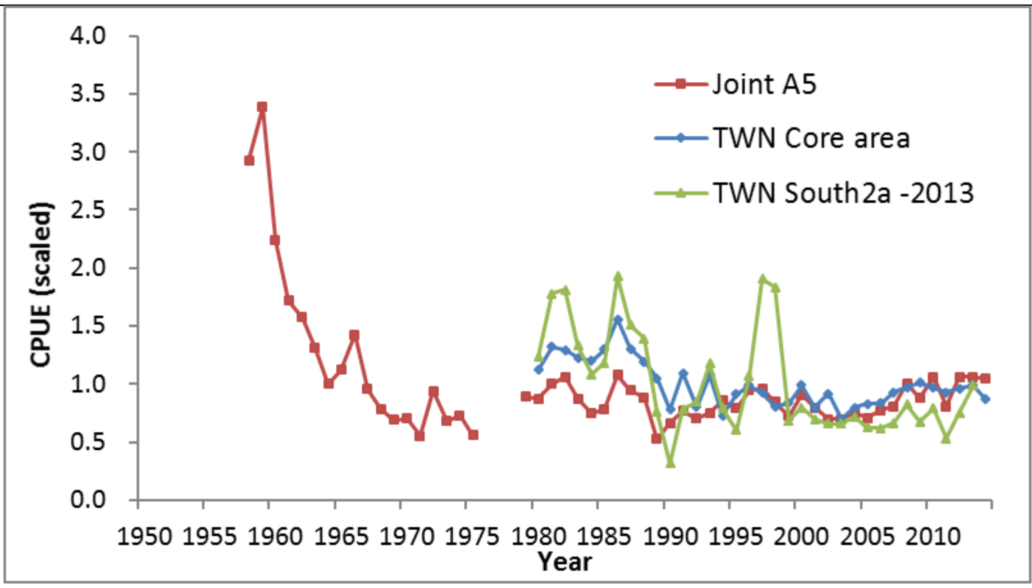

Fig. 3 CPUE used for ASPIC analysis.

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 with past assessments.

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 1950-2014 were examined. Catch for fisheries other than longline was combined because CPUE for those fisheries are not available. As for CPUE, Taiwanese longline (Lee et al., 2014 or Chang and Yeh, 2016) or joint CPUE (Korean and Taiwanese longline fishery combined, Hoyle et al., 2016) were used. B1/K (ratio of initial biomass to carrying capacity) was fixed at 0.9 as with previous analyses, considering that stock status in 1950 is close to virgin biomass.

As a result, we were able to obtain convergence and reasonable results from the scenarios in which joint and Taiwanese CPUE were incorporated separately, or only one of them was incorporated. In the 2012 assessment, the scenario with combined Japanese and Taiwanese CPUE (average of both CPUE) was adopted. However, it may be better to use separate or single CPUE rather than combined CPUE. Therefore, this time combined CPUE was not used.

Table 1 shows summary results of ASPIC runs, which got reasonable results. There are some differences of the results among scenarios. Run 3 (only with new Taiwanese LL CPUE) got most optimistic results. Run 1 (only with old Taiwanese LL CPUE) got least optimistic results, but current stock status was still not overfishing nor overfished. MSY was 35,500-43,800 tons, B (biomass in the beginning of 2015) was 70,000-

180,000 tons, B (MSY) was 60,000-140,000 tons, B ratio (in 2015) was 1.10-1.65, F (MSY) was 0.24-0.56 and F ratio (in 2014) was 0.55-0.99. These are close to or more optimistic compared with the assessment in 2014 (IOTC, 2014).

Runs 2 and 4 incorporates joint CPUE in the early period (before 1980). Sharp decrease in this CPUE is observed before 1970 (**Fig. 3**). Most of the catch and effort data available in this period is for Japanese LL (Hoyle et al., 2016). During this period, target shift occurred from albacore to other species for Japanese LL. Therefore, albacore CPUE in this period by Japanese LL seems to be not representative of abundance of the stock. Method for standardization of Taiwanese LL CPUE in this year (Chang and Yeh, 2016) may have improved compared with that for the last assessment (Lee et al., 2014). Therefore, Run3, which incorporated new Taiwanese LL CPUE, was selected as tentative base case in this document.

Table 2 is summary of the ASPIC analysis for Run 3. Fig. 4 shows historical trend for B ratio and F ratio based on the results of four scenarios. B ratio shows 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 0.5 and 1.0 (differs depending on scenarios) in recent years. Total catch used to exceed current MSY level at least when catch level peaked in 2001 (46,000t), and in 2014 catch exceeded MSY level except for one scenario (Run2). Fig. 5 shows CPUE fit for the four ASPIC runs. Fit for Taiwanese longline CPUE looks comparatively well especially for new index (Run3). However, joint index in the early period (prior to 1970) does not fit at all. Fig. 6 shows Kobe 1 plot based on the results of Run 3. Currently the stock is in the green zone at point estimate, and 95% confidence region is also in the green zone.

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	Joint		
2011 base[*1]	1980-2010	Fox	on		on		1980-2010		Equal	Fix(0.9)
2012 base[*2]	1950-2010	Fox	on		on	1980-2010, weighted average by catch			Equal	Fix(0.9)
2014 base[*3]	1950-2012	Fox	on	on	on		1980-2012 South2a		Equal	Fix(0.9)
2014 continuity[*4]	1950-2013	Fox	on	on	on		1980-2013 South2a		Equal	Fix(0.9)
1	1950-2014	Fox	on		on		1980-2013 South2a		Equal	Fix(0.9)
2	1950-2014	Fox	on		on			1958-2007 A5	Equal	Fix(0.9)
3	1950-2014	Fox	on		on		1980-2014 Core		Equal	Fix(0.9)
4	1950-2014	Fox	on		on		1980-2014 Core	1958-1975 A5_boat	Equal	Fix(0.9)

Run No.	MSY 1000 tons	B current million tons	B msy million tons	B ratio	F current	F msy	F ratio	K 1000 tons	r
2011 base*1	29.9	0.13	0.14	0.89	0.34	0.21	1.61	388	0.21
2012 base*2	35.9	0.11	0.09	1.16	0.38	0.38	1.00	257	0.38
2014 base*3	34.7	0.07	0.07	1.05	0.47	0.50	0.94	187	0.50
2014 continuity*4	35.7	0.07	0.07	1.06	0.57	0.53	1.09	187	0.52
1	35.5	0.07	0.06	1.10	0.55	0.56	0.99	173	0.56
2	34.9	0.18	0.14	1.24	0.22	0.24	0.92	388	0.24
3	43.8	0.17	0.11	1.65	0.23	0.42	0.55	287	0.42
4	39.0	0.15	0.11	1.45	0.26	0.36	0.70	291	0.36

*1 Final model for 2011 assessment, *2 final model for 2012 assessment, *3 final model for 2014 assessment, *4 continuity run (catch and CPUE up to 2013 using 2014 base case scenario) for 2014 assessment, B: total biomass, B ratio: $B_{current}/B_{MSY}$, F ratio: $F_{current}/F_{MSY}$.

Table 2 Indian Ocean albacore stock status summary based on the ASPIC analysis (Run3).

Management Quantity	**Indian Ocean**
Most recent catch estimate (t) (2014)	40,233
Mean catch over last 5 years (t) (2010-2014)	36,855
MSY (1000 t) (80%CI)	43.8 (37.5-50.6)
Current data period	1950-2014
F(Current)/F(MSY) (2014) (80% CI)	0.55 (0.38-0.67)
B(Current)/B(MSY) (2014) (80% CI)	1.65 (1.50-1.92)
SB(Current)/SB(MSY)	NA
B(Current)/B(0) (2014) (80% CI)	0.68 (NA)
SB(Current)/SB(0)	NA
SB(Current)/SB(Current, F=0)	NA

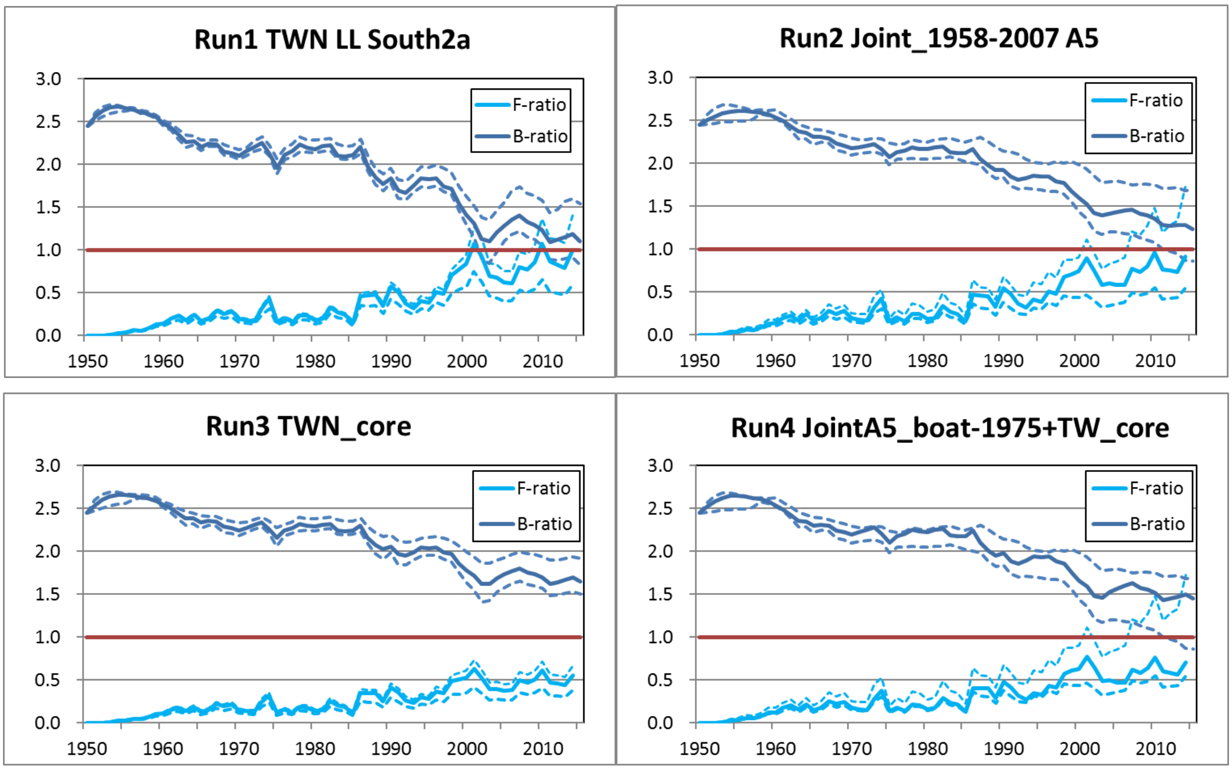

Fig. 4 Trajectories of B-ratio (B/BMSY) and F-ratio (F/FMSY) with 80% confidence limits (dashed lines) for ASPIC runs.

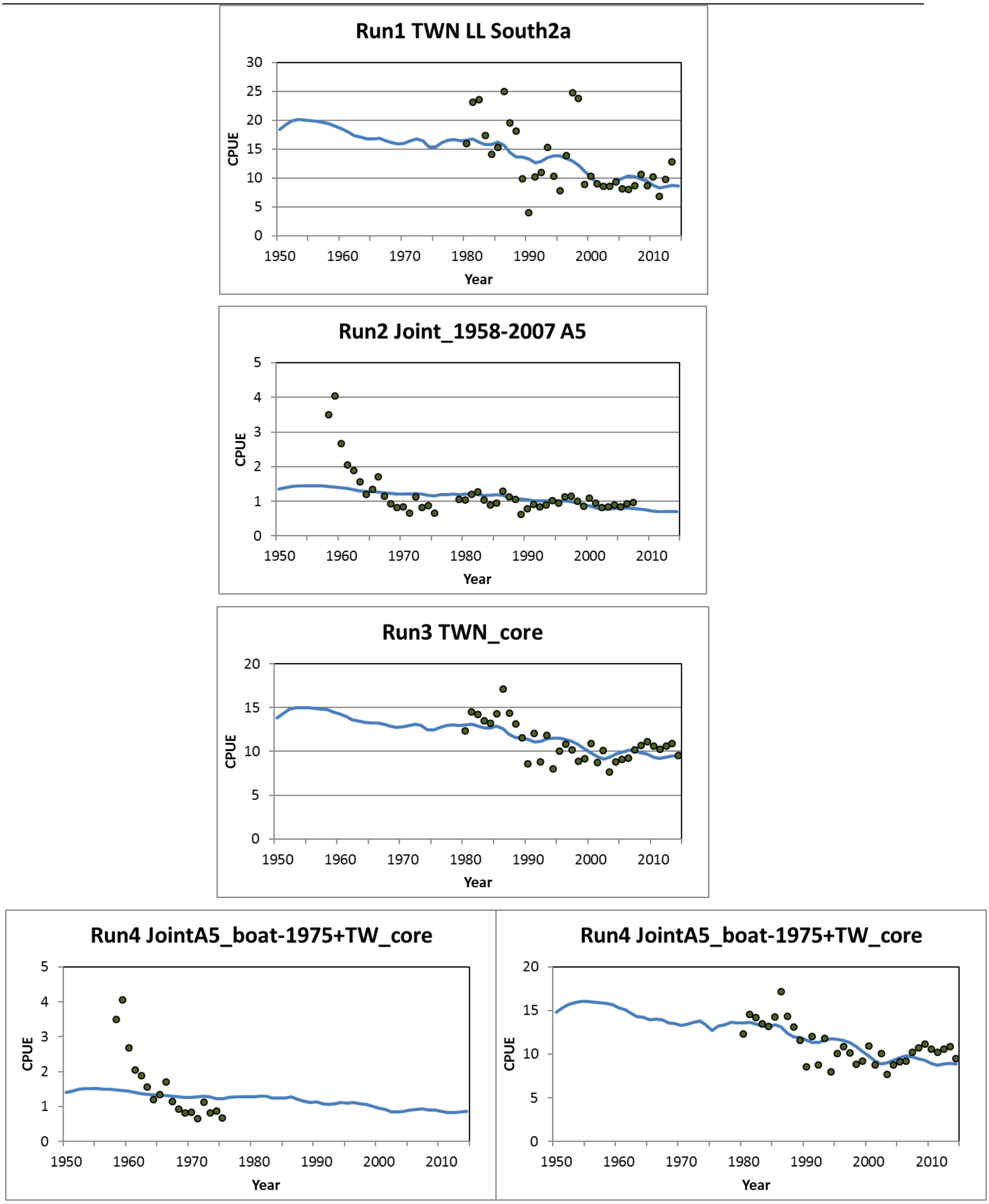

Fig. 5 CPUE fit for the four ASPIC runs. Line: estimated, circles: observed.

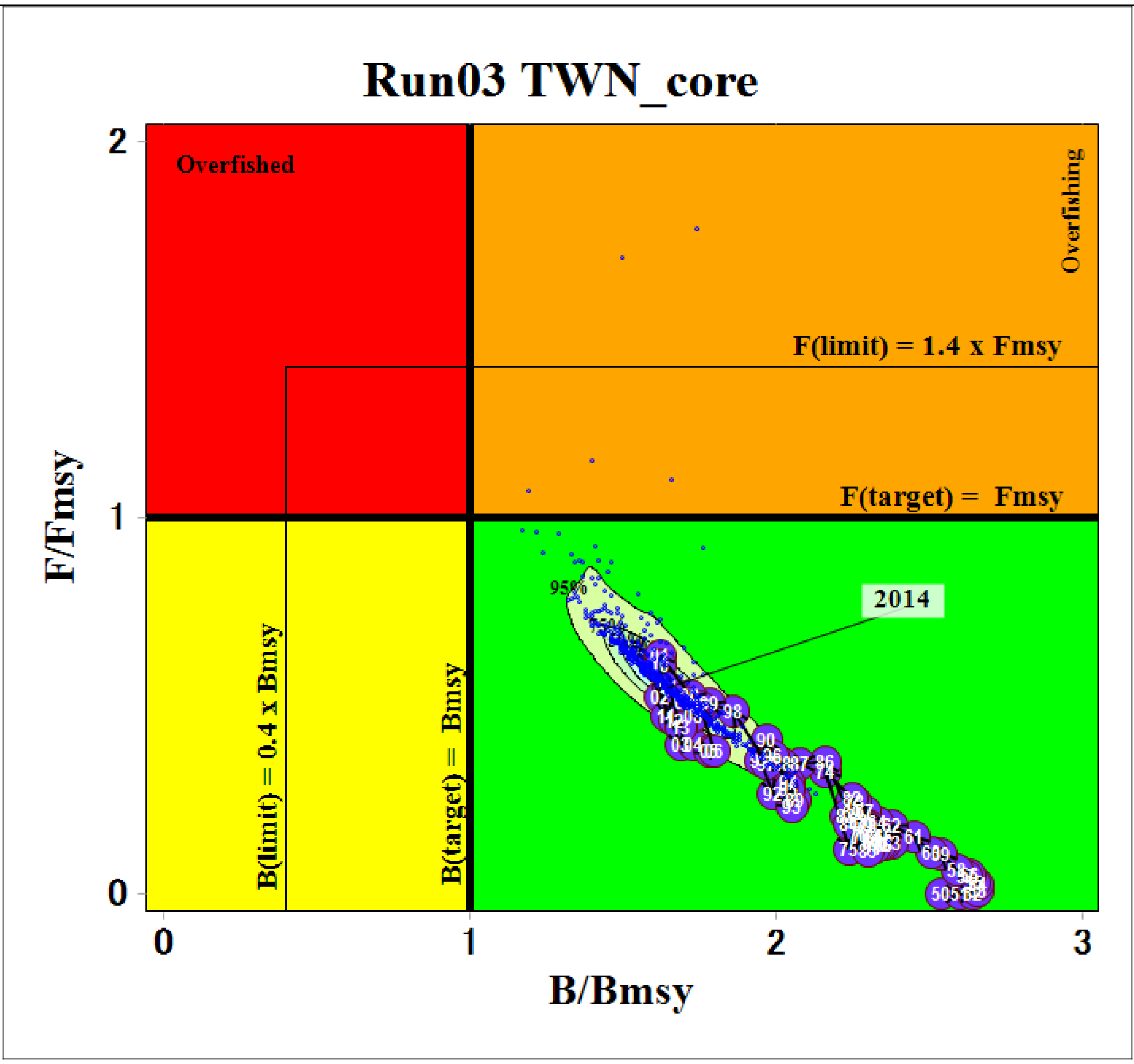

Fig. 6 Kobe plot with 95% confidence surface for Run 3.

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 B (total biomass) ratio (our case). Degrees of risks are represented by probabilities to exceed B 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 ±10%, ±20% and ±40% of current catch were continued (constant catch). Catch in 2015 and 2016 was assumed to be the average of 2012-2014 catch (35,413t) 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 B ratios and F ratios by utilizing ASPIC-P ver. 3.16 (projection module available in ASPIC).

4.1 Risk assessments on B ratio

Using results of the ASPIC analysis for Run 3, 500 values of B ratio and F ratio were generated by the boot-strap function available in the ASPIC-P for 2015-2024 (2015-2025 for biomass level). As a first step, we made future projections of B ratios (Fig. 7). Then we made the Kobe 2 risk matrix (Table 3). These results indicated low (<50%) risk of B ratio not exceeding B (MSY) level in the future if future catch is even 40% higher than current level.

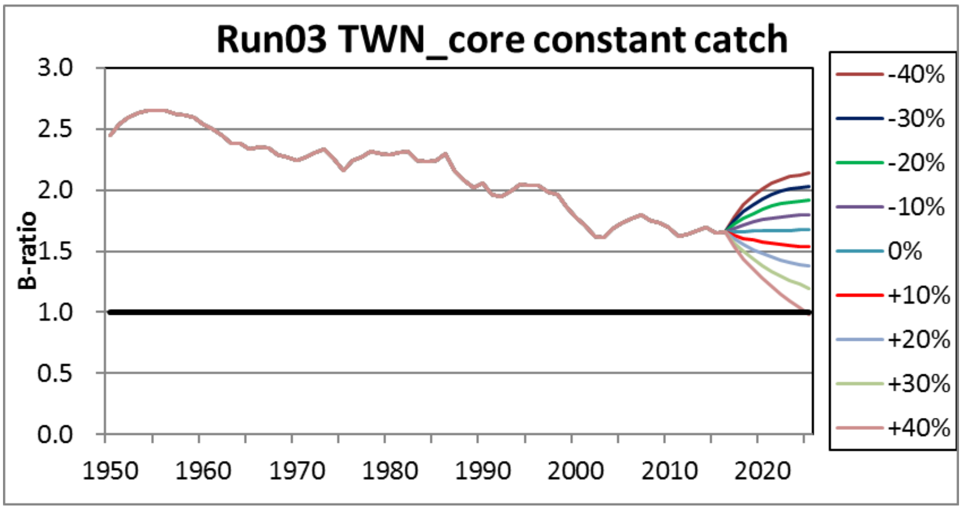

Fig. 7 Future projection of B ratio with constant catch for Run 3.

Table 3 Kobe II risk matrix for B ratio (probability of not exceeding MSY level) under constant catch for Run 3. “Catch level” means increase or decrease from current level.

Catch level	Catch (t)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
-40%	21,248	22%	22%	22%	14%	11%	8%	7%	6%	6%	6%	6%
-30%	24,789	22%	22%	22%	16%	12%	11%	10%	10%	9%	9%	9%
-20%	28,330	22%	22%	22%	19%	15%	14%	12%	12%	12%	12%	12%
-10%	31,872	22%	22%	22%	20%	19%	18%	17%	17%	16%	16%	16%
0%	35,413	22%	22%	22%	22%	22%	21%	21%	21%	21%	21%	21%
10%	38,954	22%	22%	22%	23%	23%	24%	24%	25%	25%	26%	26%
20%	42,496	22%	22%	22%	24%	26%	28%	29%	30%	31%	32%	33%
30%	46,037	22%	22%	22%	25%	29%	30%	33%	35%	37%	38%	40%
40%	49,578	22%	22%	22%	27%	30%	34%	37%	40%	43%	47%	48%

4.2 Risk assessments on F ratio

In the same way as for B ratio, the future projection (Fig. 8) and Kobe 2 matrix (Table 4) were made. These results indicated high risk of F ratio exceeding F (MSY) level in the future if future catch is 40% higher than current level.

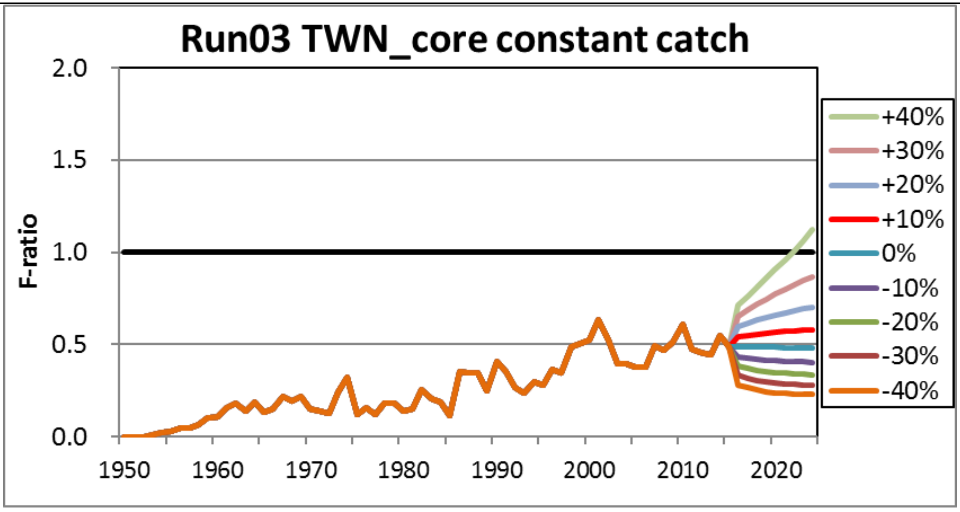

Fig. 8 Future projection of F ratio with constant catch for Run 3.

Table 4 Kobe II risk matrix for F ratio (probability of exceeding MSY level) under constant catch for Run 3. "Catch level" means increase or decrease from current level.

Catch level	Catch (t)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
-40%	21,248	10%	9%	0%	0%	0%	0%	0%	0%	0%	0%
-30%	24,789	10%	9%	0%	0%	0%	0%	0%	0%	0%	0%
-20%	28,330	10%	9%	1%	0%	0%	0%	0%	0%	0%	0%
-10%	31,872	10%	9%	5%	4%	3%	3%	3%	3%	3%	3%
0%	35,413	10%	9%	9%	9%	9%	9%	9%	9%	9%	9%
10%	38,954	10%	9%	15%	18%	18%	19%	19%	20%	20%	21%
20%	42,496	10%	9%	22%	23%	25%	27%	28%	29%	30%	31%
30%	46,037	10%	9%	27%	30%	31%	34%	36%	38%	40%	41%
40%	49,578	10%	9%	30%	35%	38%	42%	45%	49%	51%	54%

References

Anonymous (2013) Report and documentation of the Indian Ocean Tuna Fisheries of Indonesia Albacore Catch Estimation Workshop: Review of Issues and Considerations Bogor, 21 June 2013 Jakarta, 24-25 June 2013. IOTC-2013-WPDCS09-INF01. 32pp.

Chang, Y. and Yeh, S.Y. (2016) CPUE of Taiwanese Albacore Long Line Fishery in Indian Ocean which confirmed by observer data. IOTC–2016–WPTmT06–17. 26pp.

Hoyle, S. D., Chang, Y., Satoh, K., Matsumoto, T., Kim, D. N. and Lee, S. I. (2016) Collaborative study of albacore tuna CPUE from multiple Indian Ocean longline fleets. IOTC–2016–WPTmT06–19.

IOTC (2011) Report of the Third Session of the IOTC Working Party on Temperate Tunas, Busan, Republic of Korea, 20–22 September 2011. 34pp.

IOTC (2012) Report of the Fourth Session of the IOTC Working Party on Temperate Tunas, Shanghai, China, 20–22 August 2012. 43pp.

IOTC (2014) Report of the Fifth Session of the IOTC Working Party on Temperate Tunas, Busan, Rep. of Korea, 28–31 July 2014. 53pp.

Lee, L. K., Hsu, C. C. and Chang, F.C. (2014) Albacore (*Thunnus alalunga*) CPUE trend from Indian Core Albacore Areas based on Taiwanese longline catch and effort statistics dating from 1980 to 2013. IOTC-2014-WPTmT05-19.

Matsumoto, T., Nishida, T. and, Kitakado T. (2012) Stock and risk assessments of albacore in the Indian Ocean based on ASPIC. IOTC–2012–WPTmT04–20_Rev2. 12pp.

Matsumoto, T. and Kitakado, T. (2016) Standardization of albacore CPUE by Japanese longline fishery in the Indian Ocean. IOTC–2016–WPTmT06–15. 12pp.

Matsumoto, T., Nishida, T. and, Kitakado T. (2014) Stock and risk assessments of albacore in the Indian Ocean based on ASPIC. IOTC–2014–WPTmT05–22_Rev1. 14pp.

Nishida, T. and Matsumoto, T. (2011) Stock and risk assessments of albacore tuna (*Thunnus alalunga*) in the Indian Ocean by A Stock-Production Model Incorporating Covariates (ASPIC). IOTC-2011-WPTmT03-17. 15pp.

Prager, M. (2004) User’s Manual for ASPIC: A Stock-Production Model Incorporating Covariates (ver. 5) and auxiliary programs, Population Dynamics Team, Center for Coastal Fisheries and Habitat Research, National Oceanic and Atmospheric Administration, 101 Pivers Island Road, Beaufort, North Carolina 28516 USA: National Marine Fisheries Service Beaufort Laboratory Document BL-2004-01