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. A time series of catch (1950-2017 or 1979-2017) and that of standardized CPUE (longline 'joint') were used for the analysis. Convergence and reasonable results were obtained for the scenarios which assumed 1%/yr increase of catchability, and was regarded as reference case. 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 10% higher than current level. The results for the scenarios without increase of catchability were more optimistic.

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), 2014 (IOTC, 2014; Matsumoto et al., 2014) and 2016 (IOTC, 2016; Matsumoto, 2016). 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.

At the last (2016) Indian Ocean albacore stock assessment, the results of stock assessment models including ASPIC were unreasonably optimistic except for SS3. This may be because joint longline CPUE (Japanese, Korean and Taiwanese longline) used for stock assessment didn't fully incorporate albacore targeting, and so

was unrealistic.

At this year's IOTC WPTmT meeting (albacore data preparatory meeting, January 2019), joint longline CPUE (Japanese, Korean and Taiwanese longline) was created by removing catch and effort data by Japanese longline in the southeast area after 2005 due to apparent change in fishing strategy and resultant sharp increase in albacore CPUE (IOTC 2019). This means that joint CPUE has improved from the previous stock assessment.

This year's IOTC WPTmT meeting (albacore data preparatory meeting) decided to use several stock assessment models including ASPIC with several specifications for this year's albacore stock assessment. ASPIC is very simple model and can't incorporate historical change in size selectivity, but this can be used for comparison of the results with other assessment 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 2019 in the 2019 IOTC WPTmT web page (https://www.iotc.org/WPTmTa/07/Data/03-NC). Fig. 1 shows the trend of catch by fishery. 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).

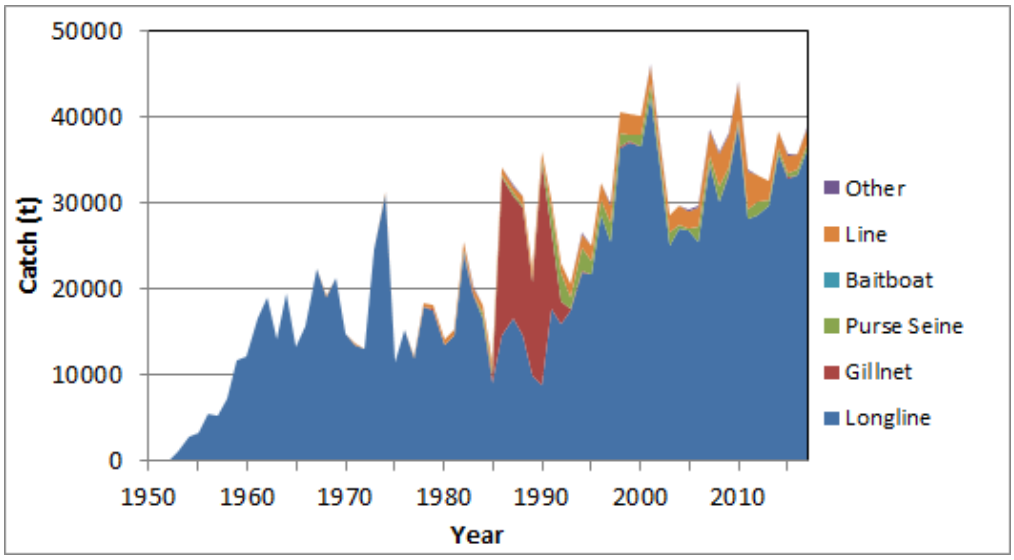

Fig. 1 Trend of albacore tuna catch in the Indian Ocean by gear type.

2.2 CPUE

Standardized 'joint CPUE' by Japanese, Korean and Taiwanese longline fishery combined (1959-2017) are available. Joint CPUE for area "A4" (**Fig. 2**), for which the indices for all the subareas (subarea 1-4) or south (main fishing) areas (subarea 3-4) averaged with weighing, was used. CPUE during early period shows steep decline. This is probably because of target shift from albacore to other species. Therefore, CPUE in this period was considered not appropriate, and was not used for analyses. CPUE from 1979 was used because vessel ID used for CPUE standardization is available from 1979, and so was considered to have consistency. According to the decision at this year's IOTC WPTmT meeting (albacore data preparatory meeting), joint CPUE with 1 % catchability increase per year was also used as for sensitivity case. **Fig. 3** shows trend of the indices used for the analyses.

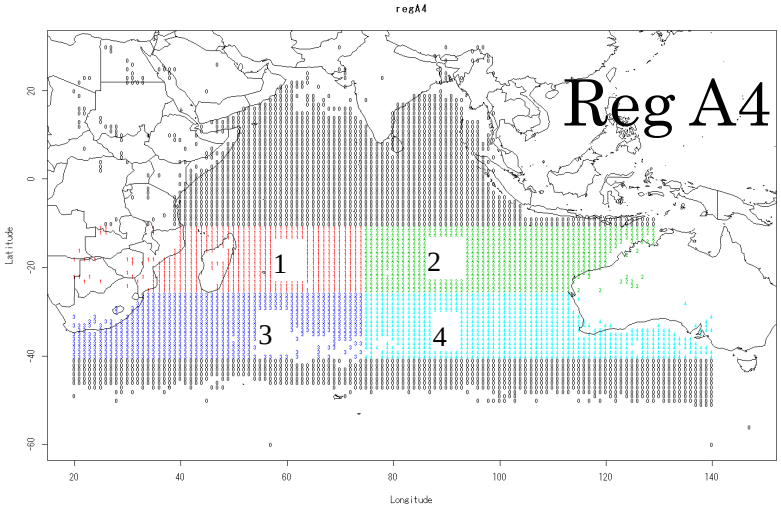

Fig. 2 Area definition for joint CPUE by Japanese, Korean and Taiwanese longline fishery combined used in this study.

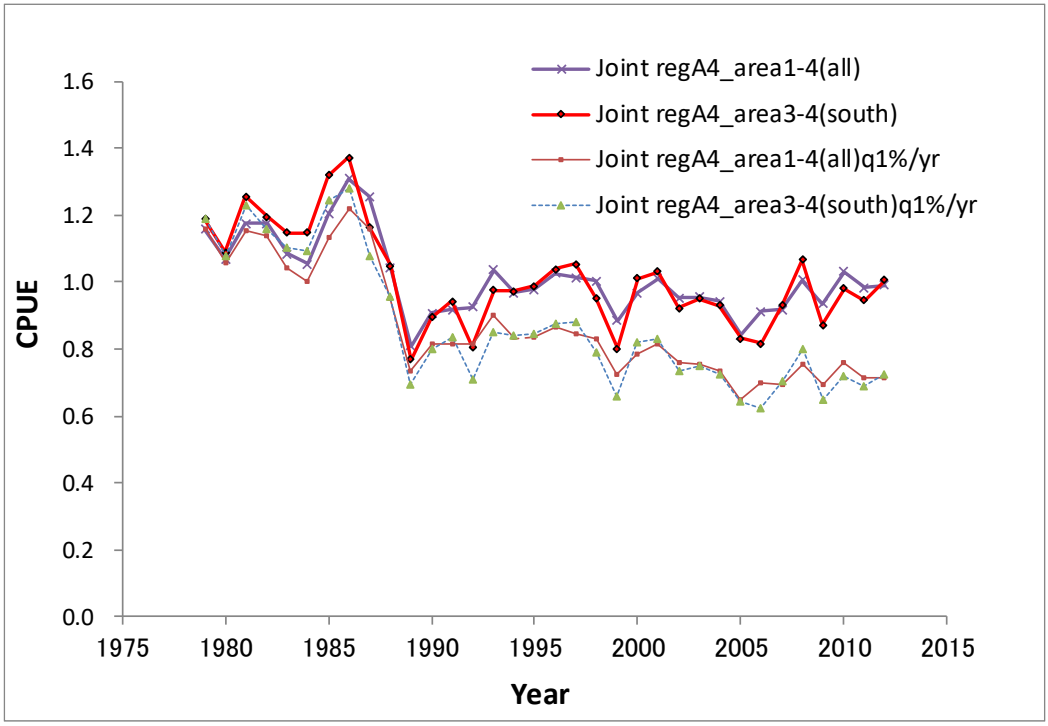

Fig. 3 CPUE used for ASPIC analysis.

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 (period for assessment), according to decision at this year's IOTC WPTmT meeting (albacore data preparatory meeting), both entire period (1950-2017) and the period in which CPUE was used (1979-2017) were examined. As for the fleet in the model, catch for all the fisheries was combined (i.e. 1 fleet) according to the decision at the data preparatory meeting. This may be appropriate because CPUE for the fisheries other than longline are not available and the majority of the catch is by longline fishery except for a part of period. B_1/K (ratio of initial biomass to carrying capacity) was fixed at 0.9 as with previous analyses for the scenarios which start in 1950, considering that stock status in 1950 is close to virgin biomass. B_1/K for the scenarios which start in 1979 was calculated by using the following equation.

$$B_1/K=0.9*B_{1979}/B_{1950}$$

Where B_{1950} and B_{1979} are biomass in year 1950 and 1979, respectively, estimated from a scenario which starts in 1950 and which used the same CPUE.

Therefore, a total of 8 scenarios (combination of 2 areas for CPUE, with or without catchability increase and

2 start year) were examined. Table 1 shows summary of specifications and results of ASPIC runs. The results of the scenarios with the CPUE in the all area were a bit more optimistic than those with the CPUE in the south area. The results of the scenarios with assessment period (catch and CPUE data) 1979-2017 were similar to those with assessment period 1950-2017. The scenarios with no increase of catchability seemed to be a bit too optimistic (e.g. B/B_{MSY} was close to 2.0 and F/F_{MSY} was around 0.4 or lower). On the other hand, the scenarios with 1%/yr increase of catchability seemed to be more realistic. Therefore, in this document the scenarios with 1%/yr increase of catchability, with CPUE in the all area and with assessment period 1950-2017 (Run 3) is regarded as base model.

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 all the scenarios. Regarding the base model ("Joint regA4_area1-4(all)_q1%yr"), B-ratio and F-ratio show almost consistent decreasing and increasing trend, respectively, with fluctuation. F ratio exceeded 0.8 when catch level was high in 2001 and 2010. The scenarios without increase of catchability show very slight decrease of B-ratio and slight increase of F-ratio. Fig. 5 shows CPUE fit for all the runs. Fit to CPUE looks well. Fig. 6 shows Kobe 1 plot based on the results of Run 3. Currently and historically the stock was in the green zone at point estimate, and most (96%) of 95% confidence region in the current year (2017) is also in the green zone.

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

Scenario No	Model	Catch	CPUE	Statistical weight	B1/K	MSY 1000t tons	TB current million tons	TB msy million tons	TB ratio	F current	F msy	F ratio	Comments
2011 final	Fox	1980-2010	TWN 1980-2010	Equal	Fix(0.9)	29.9	0.13	0.14	0.89	0.34	0.21	1.61	Base case for 2011 assessment
2012 final	Fox	1950-2010	1980-2010, weighted AVE by catch	Equal	Fix(0.9)	35.9	0.11	0.09	1.16	0.38	0.38	1.00	Base case for 2012 assessment
2014 run3	Fox	1950-2012	TWN 1980-2012 South2a	Equal	Fix(0.9)	34.7	0.07	0.07	1.05	0.47	0.50	0.94	Base case for 2014 assessment
2014 run3'	Fox	1950-2013	TWN 1980-2012 South2a	Equal	Fix(0.9)	35.7	0.07	0.07	1.06	0.57	0.53	1.09	
2016 run3	Fox	1950-2014	TWN 1980-2014 Core	Equal	Fix(0.9)	43.8	0.17	0.11	1.65	0.23	0.42	0.55	Base case for 2016 document
2016 SS3 base			Joint area specific (south, 1979-2014)			38.8	0.03	0.03	1.80			0.85	SB level instead of total biomass (TB)
1	Fox	1950-2017	Joint A4 all area 1979-2017	Equal	Fix(0.9)	58.2	0.36	0.18	1.99	0.11	0.32	0.33	Too optimistic
2	Fox	1950-2017	Joint A4 south area 1979-2017	Equal	Fix(0.9)	52.3	0.26	0.14	1.88	0.15	0.38	0.39	Too optimistic
3	Fox	1950-2017	Joint A4 all area 1979-2017 q 1%/yr	Equal	Fix(0.9)	36.5	0.19	0.14	1.32	0.20	0.25	0.80	Base model in this document
4	Fox	1950-2017	Joint A4 south area 1979-2017 q 1%/yr	Equal	Fix(0.9)	36.5	0.15	0.12	1.28	0.26	0.32	0.82	
5	Fox	1979-2017	Joint A4 all area 1979-2017	Equal	Fix(0.8858)	57.3	0.36	0.18	1.97	0.11	0.31	0.34	Too optimistic
6	Fox	1979-2017	Joint A4 south area 1979-2017	Equal	Fix(0.8728)	51.5	0.26	0.14	1.86	0.15	0.37	0.40	Too optimistic
7	Fox	1979-2017	Joint A4 all area 1979-2017 q 1%/yr	Equal	Fix(0.8083)	36.1	0.20	0.15	1.30	0.19	0.24	0.82	
8	Fox	1979-2017	Joint A4 south area 1979-2017 q 1%/yr	Equal	Fix(0.8087)	36.3	0.15	0.12	1.27	0.25	0.30	0.83	

TB: total biomass, TB 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) (2017)	38,713
Mean catch over last 5 years (t) (2013-2017)	36,235
MSY (1000 t) (80%CI)	36.5 (34.7-38.7)
Current data period	1950-2017
F(Current)/F(MSY) (2017) (80% CI)	0.80 (0.70-0.89)
B(Current)/B(MSY) (2017) (80% CI)	1.32 (1.23-1.41)
SB(Current)/SB(MSY)	NA
B(Current)/B(0) (2017) (80% CI)	0.54 (NA)
SB(Current)/SB(0)	NA
SB(Current)/SB(Current, F=0)	NA

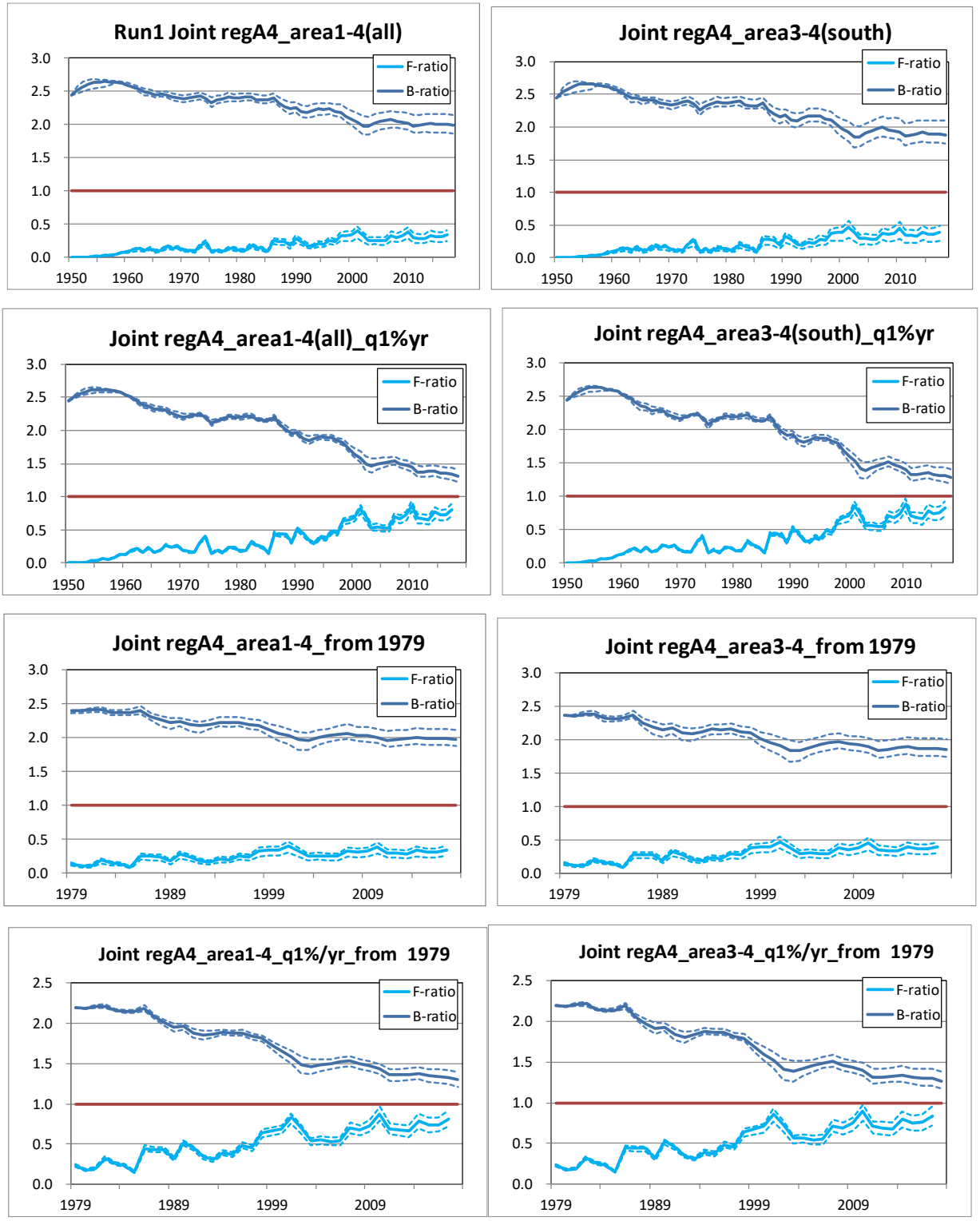

Fig. 4 Trajectories of B-ratio (B/BMSY) and F-ratio (F/FMSY) with 80% confidence limits (dashed lines) for ASPIC runs.

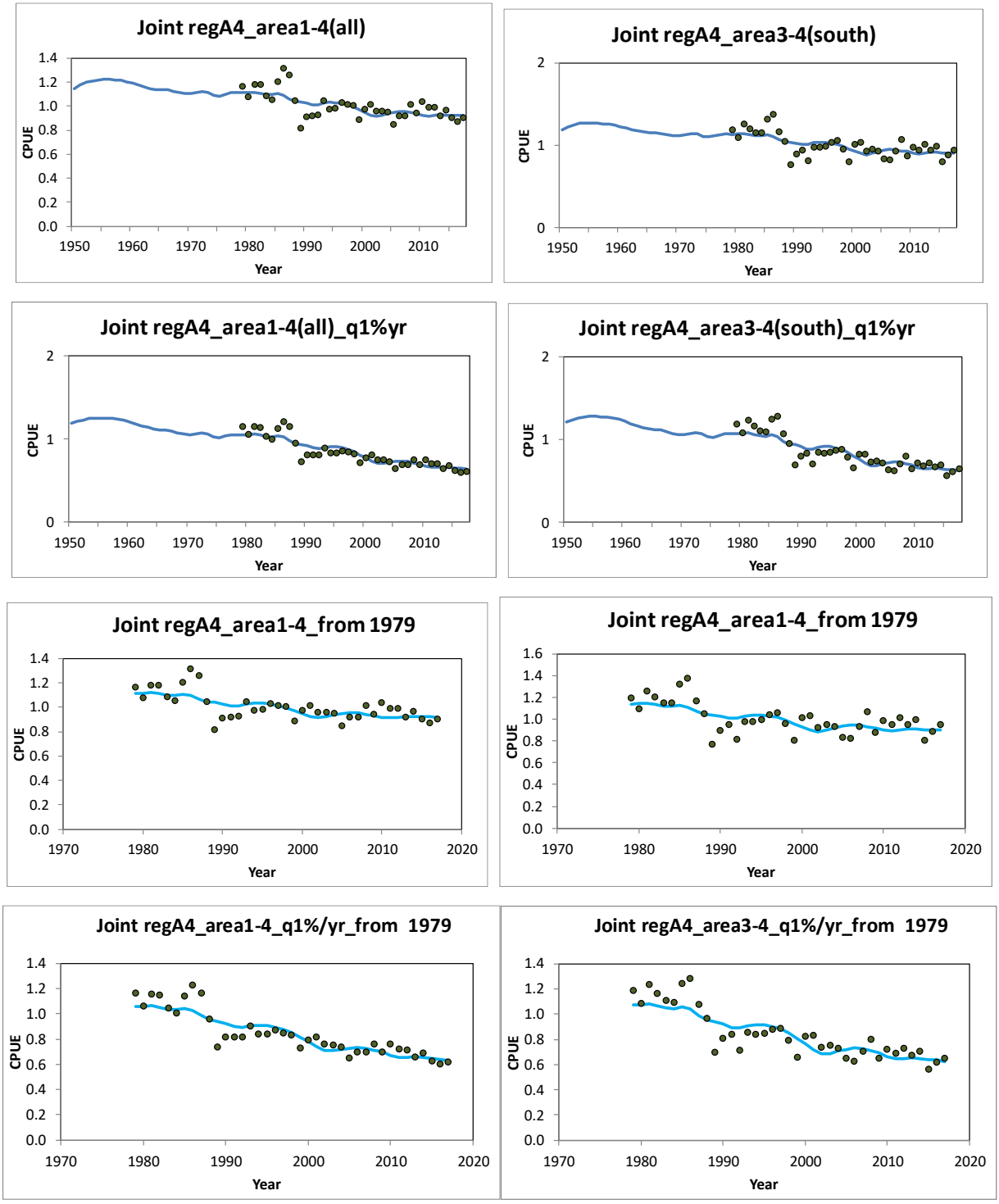

Fig. 5 CPUE fit for the four ASPIC runs. Line: estimated, circles: observed.

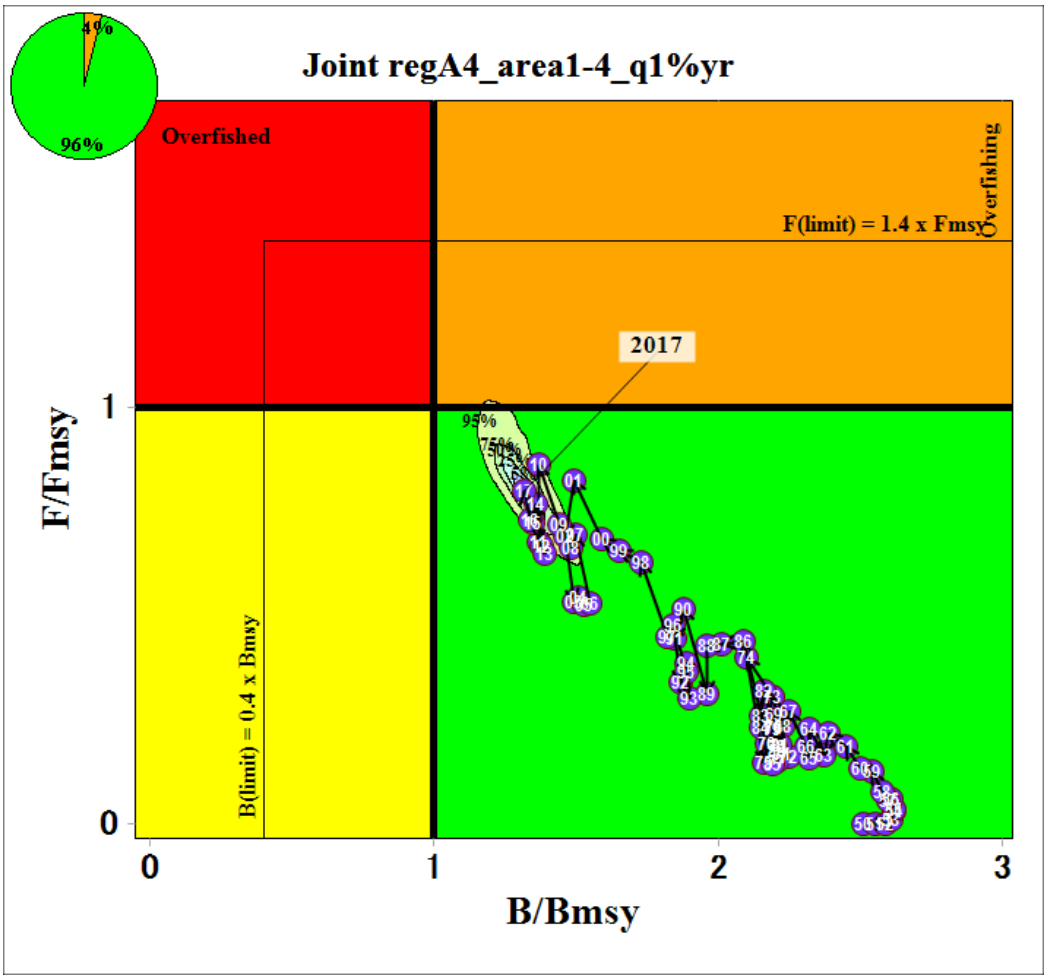

Fig. 6 Kobe plot with 95% confidence surface for Run 3.

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 2018 and 2019 was assumed to be the average of 2015-2017 catch (36,690t) because the catch in these years is not available 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 2018-2027 (2018-2028 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 10% higher than current level or lower.

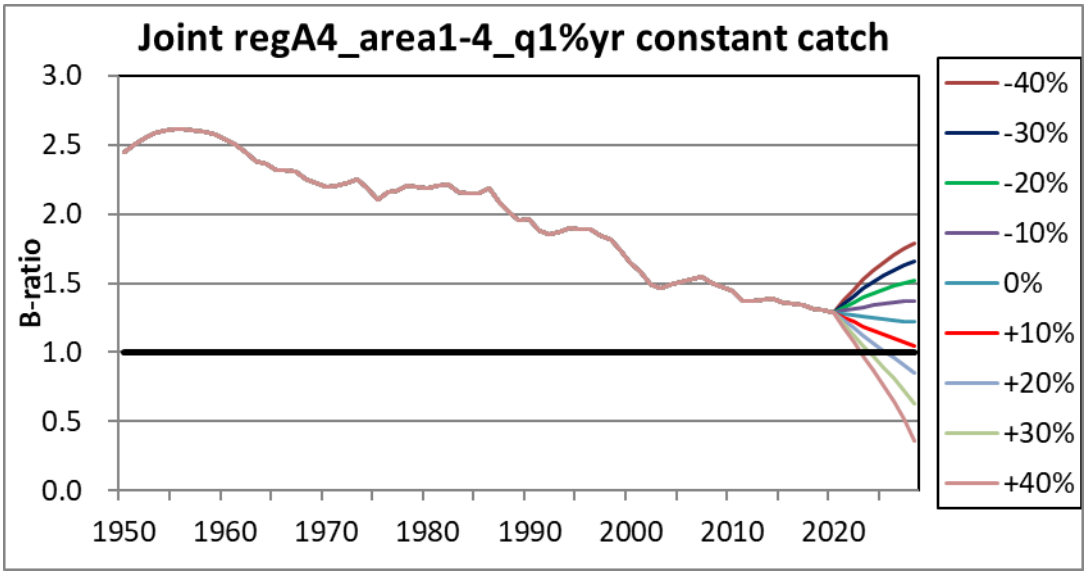

Fig. 7 Future projection of B ratio with constant catch for Run 3.

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)	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
-40%	22,014	18%	19%	19%	13%	7%	4%	2%	1%	1%	1%	1%
-30%	25,683	18%	19%	19%	15%	9%	6%	5%	4%	3%	2%	2%
-20%	29,352	18%	19%	19%	16%	14%	11%	8%	7%	6%	5%	5%
-10%	33,021	18%	19%	19%	18%	17%	16%	15%	14%	13%	13%	12%
0%	36,690	18%	19%	19%	19%	20%	21%	22%	23%	24%	24%	25%
10%	40,359	18%	19%	19%	23%	25%	28%	31%	33%	38%	41%	45%
20%	44,028	18%	19%	19%	25%	30%	36%	41%	48%	54%	59%	64%
30%	47,697	18%	19%	19%	27%	35%	45%	53%	60%	67%	72%	77%
40%	51,366	18%	19%	19%	30%	41%	53%	62%	71%	75%	81%	85%

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 10% higher than current level.

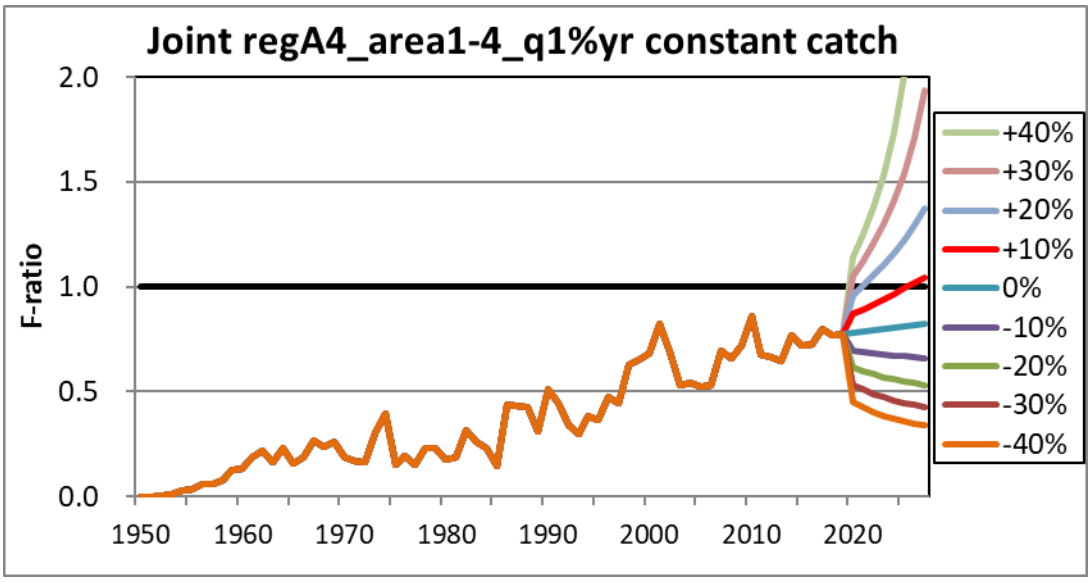

Fig. 8 Future projection of F ratio with constant catch for Run 3.

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)	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
-40%	22,014	19%	19%	0%	0%	0%	0%	0%	0%	0%	0%
-30%	25,683	19%	19%	1%	1%	0%	0%	0%	0%	0%	0%
-20%	29,352	19%	19%	5%	3%	1%	1%	1%	1%	1%	1%
-10%	33,021	19%	19%	12%	10%	9%	8%	7%	6%	6%	5%
0%	36,690	19%	19%	20%	20%	22%	23%	23%	24%	25%	25%
10%	40,359	19%	19%	31%	35%	38%	41%	46%	49%	53%	56%
20%	44,028	19%	19%	45%	51%	55%	60%	66%	69%	73%	76%
30%	47,697	19%	19%	55%	63%	68%	74%	77%	80%	83%	87%
40%	51,366	19%	19%	65%	72%	77%	81%	84%	89%	91%	93%

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