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STOCK ASSESSMENT FOR ATLANTIC YELLOWFIN TUNA USING A NON-EQUILIBRIUM PRODUCTION MODEL

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SUMMARY

A Stock-Production Model Incorporating Covariates (ASPIC), a non-equilibrium surplus-production model, was attempted for the stock assessment for the Atlantic Ocean yellowfin tuna, using the software package ASPIC ver. 5.34. The model configuration and fleet categorization are mainly based on the decision at and after this year's data preparatory meeting. Several models indicated reasonable results. Those models predicted that at some stage in the recent past, yellowfin stock had been overfishing and had been overfished. In these cases, the fishing pressure appears to have eased in recent years, with a subsequent recovery in biomass. Based on the results of future projection, stock status in the near future will be in green zone with high probability (>60%) for future catch up to 120,000-140,000 t. Some of the sensitivity and retrospective analyses indicated non reasonable results.

RÉSUMÉ

Un modèle de production du stock incorporant des covariances (ASPIC), un modèle de production excédentaire en conditions de non-équilibre, a été tenté pour l'évaluation du stock d'albacore de l'océan Atlantique, en utilisant le logiciel ASPIC version 5.34. La configuration du modèle et la catégorisation des flottilles reposent essentiellement sur la décision prise pendant et après la réunion de préparation des données de cette année. Plusieurs modèles ont indiqué des résultats raisonnables. Ces modèles ont prédit qu'à un moment donné dans le passé récent, le stock d'albacore avait fait l'objet de surpêche et avait été surexploité. Dans ces cas, la pression de la pêche semble s'être atténuée au cours de ces dernières années, la biomasse s'étant rétablie par la suite. Sur la base des résultats de projections futures, l'état du stock sera dans un proche avenir dans la zone verte avec une forte probabilité (>60%) de prises futures se situant entre 120.000 et 140.000. Certaines analyses de sensibilité et rétrospectives ont indiqué des résultats non raisonnables.

RESUMEN

Se probó un modelo de producción de stock que incorporaba covariables (ASPIC), un modelo de producción excedente en condición de no equilibrio, para la evaluación del stock de rabil del océano Atlántico, utilizando el paquete de software ASPIC versión 5.34. La configuración del modelo y la categorización de la flota se basan principalmente en la decisión tomada en la reunión de preparación de datos de este año y después. Varios modelos produjeron resultados razonables. Estos modelos predijeron que en alguna etapa del pasado reciente, el stock de rabil había sido objeto de sobrepesca y había estado sobrepescado. En estos casos, la presión pesquera parece haberse atenuado en años recientes, con la consiguiente recuperación de la biomasa. Basándose en los resultados de las proyecciones futuras, el estado del stock en el futuro cercano estará en la zona verde con una elevada probabilidad (>60%) para capturas futuras de hasta 120.000-140.000 t. Algunos de los análisis retrospectivos y de sensibilidad produjeron resultados no razonables.

KEYWORDS

Stock assessment, mathematical model, yield predictions, yellowfin tuna, catch/effort

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Introduction

At 2011 ICCAT yellowfin tuna stock assessment meeting, stock assessment was held based on a Stock-Production Model Incorporating Covariates (ASPIC) and VPA 2-box models. At that time the results for both models, which were comparatively similar, were adopted for management advice. At 2016 ICCAT yellowfin tuna data preparatory meeting, it was decided that ASPIC will again be used for one of the stock assessment models for yellowfin tuna assessment in 2016 (ICCAT, 2016). Some of CPUE indices have been revised after the data preparatory meeting, and decision has been made which CPUE will be used.

This paper provides preliminary stock assessment results based ASPIC model version 5.34 (Prager, 1992) applied to the Atlantic yellowfin tuna stock.

1. Model description and data input

1.1. Data and structural assumptions of the model

The model was fit to six or seven time series of catch (1950-2014) and four or five time series of CPUE (1965-2014) data. Fleet description (**Table 1**) is based on the agreement by the ICCAT yellowfin tuna working group members. The combination of CPUEs is based on their trend; one cluster ("Cluster 1") of indices (Japanese LL, Ven LL, US LL, Chinese Taipei 1970-1992) shows an initial early decline, and then generally varies without trend. The second cluster (URU LL, BRZ LL, Chinese Taipei 1993-2014) shows an increase in CPUE in the mid-90s and then a subsequent decline. These are different from base model specifications at 2011 assessment, in which one fleet with one combined CPUE was used. As for continuity analysis, the model with one fleet and combined CPUE was examined. Combined CPUE was created using CPUE indices shown in Table 2 with weighted average by the number of 5x5 latitude and longitude counts summed by quarter within year (count of cell number with positive catch of YFT). In addition, the models with one fleet and only Japanese or US longline CPUE were also examined.

Table 3 and **Figure 1** show catch by fleet and **Table 4** and **Figure 2** show CPUE indices used for the models.

Both logistic (Schaefer) and Fox shape were used to fit the data. B_1/K was fixed to 0.9. Weighting of the fleet was either equal weight or weighted by average catch amount. The list of the scenarios is shown in **Table 5**.

1.2. Future projection

Software package ASPICP ver 3.16 was used for future projections. Based on bootstrapping (500 times) of above scenarios, future projections were conducted. Projection period is 15 years (2015-2029). Constant future catch with 70,000 t to 150,000 t (at 10,000 t interval) or constant future F with $0.75*F_{2014}/F_{MSY}$ to $1.00*F_{2014}/F_{MSY}$ (at $0.05*F_{2014}/F_{MSY}$ interval) was assumed. Catch for 2015 and 2016 was tentatively assumed to be the same as 2014 level.

1.3. Sensitivity analysis

Several sensitivity and retrospective analyses were conducted for one scenario (Cluster 1, logistic model) of ASPIC model (**Table 6**). In the scenario with start year 1970, B_1/K was set at 0.84 which was calculated from K and biomass in 1970 estimated in the base model. Sensitivity analyses include scenarios with different B_1/K and scenarios which exclude one or more CPUE.

2. Result and discussion

Table 7 shows summary results of ASPIC runs. No reasonable results were obtained for Cluster 2, and so its results were not referred hereafter. As for Cluster 1, estimation of MSY ranged 126 to 133 thousand tons, which was much higher than 2014 catch (97 thousand tons). B-ratio (B_{2015}/B_{MSY}) was close to or over 1.0, and F-ratio (F_{2014}/F_{MSY}) was lower than 1.0. Estimation of r (intrinsic growth rate) differed depending on scenarios. Results of the scenarios with catch weighting were more optimistic than those with equal weighting, and Fox model more optimistic than those with logistic model. The results for "Cluster 1_sens" were more optimistic than those for Cluster 1. Results for "continuity runs" (with combined CPUE) indicated very pessimistic results compared with those for Cluster 1.

Model fits to the indices of abundance are similar among scenarios, and **Figure 3** shows an example (1_Logi_eq). CPUE fit was comparatively good except for a part of period. **Figure 4** shows trends of B-ratio (B/B_{MSY}) and F-ratio (F/F_{MSY}) for each scenario, and

Figure 5 shows Kobe I plot for scenarios of Cluster 1, which indicate reasonable result. It appears that the stock had been overfishing and overfished during the last 10-20 years, but is recovering in recent years and the stock is currently in a green or yellow zone.

Figure 6 shows the trends of F-ratio and B-ratio, respectively, for the future projection for the four scenarios of Cluster 1. It was estimated that F exceeds and biomass drops under MSY level within 15 years if future catch is over 130,000 t for logistic model equal weight and Fox model equal weight, and more optimistic for logistic and Fox model equal weight.

Table 8 shows Kobe II matrixes (risk assessment) based on future projections for the four scenarios of Cluster 1. If future catch is 120,000 t to 140,000 t (differs depending on scenarios), the probability of being in the green zone of the Kobe plot becomes >60% within 15 years.

It seems that, in recent years, due to lower catch level (**Figure 1**), Atlantic yellowfin stock is recovering, and will continue to recover if current catch level is continued.

Figure 7 shows the results of sensitivity analyses for the scenario Cluster 1 logistic model equal weight. Changes in B_1/K caused very large difference for B_1/K 0.8, but little effect for 1.0. No reasonable results were obtained if Taiwanese or Venezuela longline CPUE was excluded, or if only Japanese and Taiwanese longline CPUE were used. The model with start year 1970 also didn't get reasonable results.

Figure 8 shows the results of retrospective analyses for the four scenarios of Cluster 1. No reasonable result was obtained and the model didn't converge for the scenario which excluded one year as for logistic model equal weight and Fox model equal weight, respectively. Comparatively large difference (up to more or less 50%) was observed near the terminal years for logistic model equal weight. As for the rest, the results were close to that for the base model. Based on these results, logistic model with equal weight (and possibly Fox model equal weight as well) seems to be less appropriate for the base case.

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Table 1. Fleet descriptions and CPUE used in the ASPIC models in this study.

Fleet	Chinese Taipei LL	US LL	Venezuela LL	Japan LL	Uruguay LL	Brazil LL	Other LL*	Surface
Cluster1	1970-1992	1987-2014	1991-2014	1976-2014			Catch only	Catch only
Cluster2	1970-1992, 1993-2014				1982-1991, 1992-2010	1978-2012	Catch only	Catch only
CLUSTER_1_Sens	1970-1992	1987-2014	1991-2014	1965-2014			Catch only	Catch only

* Aggregation of longline fishery for which CPUE is not used in the cluster.

Table 2. List of CPUE indices used for creating combined CPUE.

	abbreviation	Fleet	source
1	JPLL	Japan longline	JAP_CPUEN (column F)
2	BRLL	Brazil longline	BRA_LL (column K)
3	TLLE	Chinese Taipei longline	TAI_M1_CPUEN (column D)
4	TLLL		TAI_M4_CPUEN (column D)
5	GOLL	Gulf of Mexico longline	SCRS/2016/041 (Table 15) Stand. CPUE
6	ATLL	U.S. longline (Atl. only)	SCRS/2016/041 (Table 13) Stand. CPUE
7	ULLE	Uruguay longline	URU_LL_CPUEW (column F)
8	ULLL		URU_LL_CPUEW (column M)
9	VELL	Venezuela longline	VEN_LL_N (column H)
10	BRBB	Brazil baitboat	RelictIndices (column AS)
11	EDBB	EU Dakar baitboat	RelictIndices (column AG)
12	CIBB	Canarias Islands baitboat	RelictIndices (column AQ)
13	USRR	U.S. rod and reel recreational	RelictIndices (column F)
14	EPS3	EU purse seine 3%	ASPIC_combined_indexes_base_case2.xlsx worksheet (indexes base) (columns N)
15	EPS1	EU_PS_1%	ASPIC_combined_indexes_base_case2.xlsx worksheet (indexes base) (column O)
16	EPSF	ES_FAD_PS	ASPIC_combined_indexes_base_case2.xlsx worksheet (indexes base) (column P)
17	EPS7	EU purse seine 7%	ASPIC_combined_indexes_base_case2.xlsx worksheet (indexes base) (columns Q)
18	VEPS	Venezuela purse seine	RelictIndices (column AR)

Table 3. Catches (t) of yellowfin tuna for each fleet listed in Table 1

	Chinese Taipei LL	US LL	Venezuela LL	Japan LL	Brazil LL	Uruguay LL	Other LL (Cluster 1)	Other LL (Cluster 2)	Other LL (Cluster 1_Sens)	Surface
1950	0	0	0	0	0	0	0	0	0	1,200
1951	0	0	0	0	0	0	0	0	0	1,358
1952	0	0	0	0	0	0	0	0	0	2,787
1953	0	0	0	0	0	0	0	0	0	3,600
1954	0	0	0	0	0	0	0	0	0	3,407
1955	0	0	0	0	0	0	0	0	0	4,300
1956	0	0	0	612	0	0	0	612	0	5,985
1957	0	0	688	13,198	0	0	0	13,886	0	9,812
1958	0	0	1,050	27,159	1,740	0	1,740	28,209	1,740	10,632
1959	0	111	1,780	44,071	5,920	0	5,920	45,962	5,920	5,887
1960	0	0	1,597	50,822	4,700	0	4,702	52,421	4,702	11,372
1961	0	0	1,728	42,609	4,400	0	4,425	44,362	4,425	10,041
1962	278	17	3,001	41,973	1,400	0	1,423	45,014	1,423	10,831
1963	399	8	2,781	37,717	2,400	0	4,249	42,355	4,249	19,444
1964	396	0	1,787	35,106	1,624	0	3,038	38,307	3,038	28,601
1965	183	0	1,657	36,918	696	0	2,085	39,964	2,085	26,878
1966	1,243	0	1,978	22,354	464	0	2,341	26,209	2,341	30,820
1967	3,023	0	1,637	12,824	812	0	6,939	20,588	6,939	35,802
1968	8,884	0	1,661	13,913	812	0	7,771	22,533	7,771	52,094
1969	12,202	0	2,268	9,966	464	0	10,043	21,813	10,043	60,092
1970	7,990	0	1,748	6,809	812	0	14,447	22,192	14,447	43,461
1971	4,938	0	2,149	10,629	347	0	13,518	25,949	13,518	43,231
1972	5,317	0	2,398	6,497	233	0	16,508	25,170	16,508	63,908
1973	3,000	0	1,921	3,803	153	0	24,422	29,993	24,422	61,987
1974	2,630	0	1,210	3,475	232	0	24,967	29,420	24,967	74,859
1975	2,669	0	563	4,192	260	0	22,235	26,730	22,235	95,137
1976	1,962	0	626	3,366	681	0	18,871	22,182	18,871	100,136
1977	372	0	827	1,467	928	0	22,903	24,269	22,903	105,444
1978	384	0	1,306	1,923	795	0	17,249	19,683	17,249	113,182
1979	1,038	0	1,000	1,986	1,076	0	12,030	13,940	12,030	111,463
1980	687	52	1,000	2,839	521	0	14,681	18,051	14,681	111,484
1981	867	45	1,000	4,145	1,159	67	13,252	17,216	13,252	136,829
1982	610	65	484	6,062	935	214	13,161	18,623	13,161	144,861
1983	539	165	1,248	2,069	887	357	10,354	12,592	10,354	151,236
1984	646	593	1,667	3,967	484	368	11,189	16,564	11,189	95,996
1985	926	738	1,626	5,308	515	354	11,677	18,480	11,677	136,342
1986	1,410	3,975	910	3,405	1,057	270	15,227	22,190	15,227	121,681
1987	902	4,888	646	3,365	653	109	11,147	19,284	11,147	124,403
1988	1,848	8,644	731	5,982	898	177	11,080	25,362	11,080	107,952
1989	858	6,247	497	6,970	1,126	64	10,467	22,991	10,467	137,353
1990	7,465	4,474	258	5,919	661	18	11,100	21,072	11,100	164,388
1991	4,172	4,141	338	4,718	582	62	9,813	18,366	9,813	144,340
1992	4,528	5,337	459	3,715	1,248	74	9,815	18,004	9,815	139,916
1993	4,196	3,886	707	3,096	1,514	20	8,777	14,932	8,777	142,785
1994	6,660	3,246	850	4,783	1,084	59	10,888	18,625	10,888	147,317
1995	4,698	3,645	687	5,227	1,312	53	10,652	18,845	10,652	129,679
1996	6,653	3,320	383	5,250	734	171	10,512	18,560	10,512	123,039
1997	4,466	3,773	381	3,539	849	53	9,878	16,670	9,878	115,337
1998	5,328	2,449	560	5,173	1,014	88	12,032	19,112	12,032	118,954
1999	4,411	3,541	504	3,405	2,930	45	15,193	19,668	15,193	109,271
2000	5,661	2,901	421	4,061	2,754	45	14,085	18,669	14,085	105,025
2001	4,805	2,200	451	2,691	4,883	90	12,295	12,664	12,295	131,013
2002	4,659	2,573	266	2,105	3,321	91	8,185	9,717	8,185	116,637
2003	6,486	2,164	323	2,754	1,940	95	7,623	10,829	7,623	103,100
2004	5,824	2,492	558	6,260	1,968	204	12,421	19,560	12,421	91,889
2005	3,596	1,746	833	4,247	4,695	644	11,349	12,836	11,349	79,980
2006	1,260	2,010	593	4,643	1,329	218	12,983	18,681	12,983	83,171
2007	1,947	2,395	613	9,037	1,552	35	13,009	23,466	13,009	68,962
2008	1,122	1,394	712	6,252	1,744	66	12,279	18,826	12,279	84,957
2009	1,391	1,686	898	4,994	1,039	76	11,208	17,671	11,208	93,259
2010	824	1,218	1,249	4,580	1,145	122	10,719	16,499	10,719	90,192
2011	1,768	1,462	1,090	4,454	1,794	24	8,513	13,701	8,513	85,351
2012	1,071	2,270	736	4,661	1,815	6	9,337	15,184	9,337	86,436
2013	1,260	1,544	738	4,577	1,584	0	9,851	15,126	9,851	79,299
2014	1,047	1,456	790	3,828	703	0	6,569	11,940	6,569	83,342

Table 4. Standardized CPUE series for yellowfin tuna included in the ASPIC models.

Year	CH_TAI_LLN_1_70_92	US_LL_W	VEN_LL_N	Japan_W_76_14	URU_W_1	URU_W_2	BR_LL_N	Japan_N_65_14	Combined
1965								1.991	2.050
1966								1.597	1.644
1967								3.280	3.377
1968								2.655	2.734
1969								2.265	2.080
1970	2.031							1.530	1.786
1971	1.261							1.437	1.431
1972	1.242							1.211	1.340
1973	1.297							1.037	1.272
1974	0.769							1.565	1.237
1975	0.775							0.843	0.963
1976	0.972			1.691				1.141	1.166
1977	0.797			1.002				0.604	0.897
1978	0.806			1.712			1.1	1.048	1.008
1979	0.873			1.696			1.4	1.379	1.166
1980	0.908			1.712			0.69	0.888	0.907
1981	0.796			1.771			1.04	0.871	0.931
1982	0.794			1.453	2.44		0.64	0.786	0.833
1983	0.742			1.477	0.68		0.54	0.881	0.858
1984	0.769			2.039	0.41		0.52	1.150	0.906
1985	0.680			0.950	0.81		0.5	0.584	0.762
1986	0.944			1.632	1.28		0.94	1.148	1.112
1987	0.932	1.741		1.483	0.66		1.83	1.123	1.076
1988	0.831	1.768		1.316	1.47		1.05	1.031	0.993
1989	0.739	1.683		1.047	0.49		0.95	0.783	0.903
1990	0.922	1.399		1.655	0.21		2.68	1.481	1.259
1991	1.405	1.129	1.044	1.229	1.56		0.67	1.026	1.030
1992	1.208	1.330	0.913	1.120		1.76	0.71	0.890	0.893
1993		0.820	0.711	0.578		0.32	2.25	0.480	0.819
1994		0.753	0.743	0.810		2.00	1.1	0.708	0.991
1995		1.073	0.686	0.582		1.29	0.84	0.479	0.898
1996		0.923	0.985	0.609		2.11	2.07	0.475	0.836
1997		0.893	0.725	0.478		1.35	1.5	0.416	0.659
1998		0.617	0.830	0.512		1.81	0.85	0.478	0.631
1999		0.920	0.987	0.628		1.09	1.29	0.588	0.722
2000		0.896	1.050	0.587		1.27	1.18	0.592	0.645
2001		0.878	0.897	0.476		0.94	0.73	0.534	0.490
2002		0.713	0.954	0.433		0.42	0.48	0.488	0.550
2003		0.582	0.622	0.612		0.61	0.660	0.575	0.744
2004		1.135	0.870	0.727		0.54	0.740	0.722	0.731
2005		1.001	1.573	0.575		1.16	0.540	0.576	0.624
2006		1.075	1.187	0.712		0.93	0.610	0.639	0.654
2007		1.289	1.894	0.673		0.52	0.710	0.646	0.607
2008		0.679	1.286	0.583		0.28	0.840	0.577	0.489
2009		0.581	1.055	0.547		0.03	0.690	0.511	0.490
2010		0.807	1.001	0.451		0.56	0.650	0.483	0.461
2011		0.741	0.895	0.676			0.650	0.809	0.543
2012		0.975	0.967	0.785			1.360	0.921	0.643
2013		0.970	0.992	1.128				1.212	0.619
2014		0.814	1.133	0.857				0.869	0.546

Table 5. Specification of model runs presented in this paper.

Model run	Cluster	B1/K	Production function	Weighting of fleets	Comment
1_Fox_eq	1	0.9	Fox	Equal	
1_Fox_cw	1	0.9	Fox	Catch	
1_Logi_eq	1	0.9	Logistic	Equal	
1_Logi_cw	1	0.9	Logistic	Catch	
2_Fox_eq	2	0.9	Fox	Equal	
2_Fox_cw	2	0.9	Fox	Catch	
2_Logi_eq	2	0.9	Logistic	Equal	
2_Logi_cw	2	0.9	Logistic	Catch	
1_sens_Fox_eq	1_sens	0.9	Fox	Equal	
1_sens_Fox_cw	1_sens	0.9	Fox	Catch	
1_sens_Logi_eq	1_sens	0.9	Logistic	Equal	
1_sens_Logi_cw	1_sens	0.9	Logistic	Catch	
JPN_7614_Logi	None	0.9	Logistic	None	1 fleet, only Japan LL CPUE (1976-2014)
JPN_7614_FOX	None	0.9	Fox	None	1 fleet, only Japan LL CPUE (1976-2014)
US_LL_logi	None	0.9	Logistic	None	1 fleet, only US LL CPUE
US_LL_FOX	None	0.9	Fox	None	1 fleet, only US LL CPUE
Comb_CPUE_Logi	None	0.9	Logistic	None	1 fleet, combined CPUE
Comb_CPUE_Fox	None	0.9	Fox	None	1 fleet, combined CPUE

Table 6. Scenarios of sensitivity analyses for the ASPIC model runs for yellowfin tuna.

Scenario	Abbreviation in the graph
B1/K fix at 0.8	B1/K 0.8
B1/K fix at 1.0	B1/K 1.0
Drop index of Japan LL	no JPLL
Drop index of Taiwanese LL	no TWLL
Only with Taiwanese LL and JPN LL indices	only TWLL&JPLL
Drop index of US LL	no USLL
Drop index of Venezuela LL	no VenLL
Start year 1970	Start 1970

Table 7. Results of the ASPIC model runs.

Model run	MSY (t)	FMSY	BMSY	B2015/ BMSY	F2014/ FMSY	K	r
1_Fox_eq	126,000	0.170	739,800	1.019	0.770	2,011,000	0.17
1_Fox_cw	131,500	0.181	727,100	1.296	0.578	1,977,000	0.18
1_Logi_eq	132,400	0.168	787,100	0.908	0.827	1,574,000	0.34
1_Logi_cw	132,600	0.148	898,500	1.137	0.654	1,797,000	0.30
2_Fox_eq	No convergence						
2_Fox_cw	No convergence						
2_Logi_eq	9,651,000	1.868	5,167,000	1.995	0.005	10,330,000	3.74
2_Logi_cw	769,300	1.426	539,600	1.935	0.065	1,079,000	2.85
1_sens_Fox_eq	129,700	0.173	749,000	1.236	0.615	2,036,000	0.17
1_sens_Fox_cw	137,400	0.206	666,700	1.483	0.483	1,812,000	0.21
1_sens_Logi_eq	132,800	0.162	818,300	1.055	0.706	1,637,000	0.32
1_sens_Logi_cw	136,500	0.166	821,600	1.271	0.567	1,643,000	0.33
JPN_7614_Logi	145,000	0.338	429,500	0.978	0.723	859,100	0.68
JPN_7614_FOX	133,800	0.261	512,200	0.984	0.764	1,392,000	0.26
US_LL_Logi	126,400	0.131	965,500	0.770	1.012	1,931,000	0.26
US_LL_FOX	119,100	0.135	882,300	0.885	0.933	2,398,000	0.14
Comb_CPUE_Logi	114,500	0.086	1,329,000	0.654	1.298	2,658,000	0.17
Comb_CPUE_Fox	101,500	0.073	1,394,000	0.852	1.123	3,789,000	0.07

Table 8. Kobe II risk matrix (probability of not exceeding MSY level) based on ASPIC results for yellowfin tuna.

1_Logi_eq Probability B>BMSY

Catch (t)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
70,000	31%	38%	46%	64%	84%	95%	98%	99%	100%	100%	100%	100%	100%	100%	100%
80,000	31%	38%	46%	62%	79%	91%	96%	98%	99%	99%	99%	99%	99%	99%	100%
90,000	31%	38%	46%	59%	73%	84%	92%	96%	98%	98%	98%	99%	99%	99%	99%
100,000	31%	38%	46%	56%	66%	76%	85%	91%	94%	96%	97%	97%	98%	98%	98%
110,000	31%	38%	46%	52%	60%	67%	73%	79%	85%	90%	91%	93%	94%	95%	95%
120,000	31%	38%	46%	50%	54%	57%	61%	65%	70%	72%	76%	79%	82%	85%	87%
130,000	31%	38%	46%	46%	46%	48%	48%	48%	49%	49%	49%	49%	49%	50%	51%
140,000	31%	38%	46%	43%	39%	38%	36%	33%	30%	28%	26%	22%	20%	17%	15%
150,000	31%	38%	46%	39%	37%	32%	26%	23%	18%	14%	11%	8%	6%	4%	3%
F	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
0.75*FMSY	31%	38%	46%	55%	63%	71%	75%	78%	81%	83%	84%	86%	87%	88%	88%
0.80*FMSY	31%	38%	46%	53%	60%	64%	69%	73%	75%	76%	78%	79%	79%	80%	80%
0.85*FMSY	31%	38%	46%	52%	56%	60%	63%	65%	68%	70%	71%	72%	73%	74%	74%
0.90*FMSY	31%	38%	46%	50%	52%	55%	57%	59%	60%	61%	62%	63%	64%	64%	64%
0.95*FMSY	31%	38%	46%	47%	49%	51%	52%	52%	53%	54%	54%	54%	55%	55%	55%
1.00*FMSY	31%	38%	46%	46%	46%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%

1_Logi_eq Probability F<FMSY

Catch (t)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
70,000	90%	96%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
80,000	90%	96%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
90,000	90%	96%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
100,000	90%	96%	98%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
110,000	90%	96%	89%	94%	96%	98%	99%	100%	100%	100%	100%	100%	100%	100%
120,000	90%	96%	73%	76%	80%	83%	87%	90%	93%	94%	95%	96%	96%	97%
130,000	90%	96%	51%	51%	51%	52%	54%	54%	54%	56%	57%	57%	57%	58%
140,000	90%	96%	34%	32%	29%	27%	24%	23%	20%	18%	16%	13%	11%	10%
150,000	90%	96%	21%	18%	15%	13%	10%	8%	6%	5%	3%	3%	2%	2%
F	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
0.75*FMSY	90%	96%	93%	93%	93%	93%	93%	93%	93%	93%	93%	93%	93%	93%
0.80*FMSY	90%	96%	86%	86%	86%	86%	86%	86%	86%	86%	86%	86%	86%	86%
0.85*FMSY	90%	96%	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%
0.90*FMSY	90%	96%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%
0.95*FMSY	90%	96%	57%	57%	57%	57%	57%	57%	57%	57%	57%	57%	57%	57%
1.00*FMSY	90%	96%	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%

1_Logi_eq Probability green zone of Kobe plot

Catch (t)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
70,000	31%	38%	46%	64%	84%	95%	98%	99%	100%	100%	100%	100%	100%	100%
80,000	31%	38%	46%	62%	79%	91%	96%	98%	99%	99%	99%	99%	99%	99%
90,000	31%	38%	46%	59%	73%	84%	92%	96%	98%	98%	98%	99%	99%	99%
100,000	31%	38%	46%	56%	66%	76%	85%	91%	94%	96%	97%	97%	98%	98%
110,000	31%	38%	46%	52%	60%	67%	73%	79%	85%	90%	91%	93%	94%	95%
120,000	31%	38%	46%	50%	54%	57%	61%	65%	70%	72%	76%	79%	82%	85%
130,000	31%	38%	46%	46%	46%	48%	48%	48%	49%	49%	49%	49%	49%	50%
140,000	31%	38%	34%	32%	29%	27%	24%	23%	20%	18%	16%	13%	11%	10%
150,000	31%	38%	21%	18%	15%	13%	10%	8%	6%	5%	3%	3%	2%	2%
F	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
0.75*FMSY	31%	38%	46%	55%	63%	71%	75%	78%	81%	83%	84%	86%	87%	88%
0.80*FMSY	31%	38%	46%	53%	60%	64%	69%	73%	75%	76%	78%	79%	79%	80%
0.85*FMSY	31%	38%	46%	52%	56%	60%	63%	65%	68%	70%	71%	72%	73%	74%
0.90*FMSY	31%	38%	46%	50%	52%	55%	57%	59%	60%	61%	62%	63%	64%	64%
0.95*FMSY	31%	38%	46%	47%	49%	51%	52%	52%	53%	54%	54%	54%	55%	55%
1.00*FMSY	31%	38%	45%	45%	45%	45%	45%	45%	45%	45%	44%	44%	44%	44%

Table 8. Kobe II risk matrix (probability of not exceeding MSY level) based on ASPIC results for yellowfin tuna. (continued)

1_Logi_cw   Probability B>BMSY

Catch (t)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
70,000	70%	76%	85%	94%	98%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%
80,000	70%	76%	85%	92%	97%	99%	99%	100%	100%	100%	100%	100%	100%	100%	100%
90,000	70%	76%	85%	91%	95%	98%	99%	99%	99%	99%	99%	100%	100%	100%	100%
100,000	70%	76%	85%	89%	92%	95%	98%	98%	98%	98%	99%	99%	99%	99%	99%
110,000	70%	76%	85%	88%	90%	92%	93%	95%	97%	97%	97%	97%	97%	98%	98%
120,000	70%	76%	85%	85%	87%	88%	89%	89%	90%	91%	92%	92%	93%	93%	94%
130,000	70%	76%	85%	84%	83%	83%	83%	83%	82%	82%	82%	81%	81%	81%	80%
140,000	70%	76%	85%	82%	79%	76%	74%	72%	70%	69%	66%	65%	64%	63%	60%
150,000	70%	76%	85%	79%	75%	70%	67%	64%	60%	58%	53%	49%	46%	42%	39%

F	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
0.75*FMSY	70%	76%	85%	85%	86%	87%	87%	87%	88%	88%	88%	88%	88%	89%	89%
0.80*FMSY	70%	76%	85%	84%	84%	83%	83%	83%	83%	83%	83%	83%	82%	82%	82%
0.85*FMSY	70%	76%	85%	82%	80%	78%	78%	76%	76%	76%	75%	75%	75%	74%	74%
0.90*FMSY	70%	76%	85%	80%	77%	75%	73%	71%	70%	70%	69%	68%	68%	68%	67%
0.95*FMSY	70%	76%	85%	78%	75%	71%	69%	68%	66%	65%	64%	63%	61%	61%	60%
1.00*FMSY	70%	76%	85%	77%	71%	68%	66%	64%	61%	59%	58%	58%	56%	55%	54%

1_Logi_ cw   Probability F<FMSY

Catch (t)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
70,000	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
80,000	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
90,000	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
100,000	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
110,000	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
120,000	100%	100%	97%	98%	98%	98%	99%	99%	99%	99%	99%	99%	99%	99%
130,000	100%	100%	88%	87%	86%	85%	85%	85%	85%	85%	84%	84%	84%	84%
140,000	100%	100%	71%	70%	67%	65%	64%	62%	60%	57%	57%	55%	53%	51%
150,000	100%	100%	59%	55%	50%	46%	43%	40%	36%	33%	31%	30%	27%	24%

F	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
0.75*FMSY	100%	100%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
0.80*FMSY	100%	100%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
0.85*FMSY	100%	100%	76%	76%	76%	76%	76%	76%	76%	76%	76%	76%	76%	76%
0.90*FMSY	100%	100%	67%	67%	67%	67%	67%	67%	67%	67%	67%	67%	67%	67%
0.95*FMSY	100%	100%	58%	58%	58%	58%	58%	58%	58%	58%	58%	58%	58%	58%
1.00*FMSY	100%	100%	48%	48%	48%	48%	48%	48%	48%	48%	48%	48%	48%	48%

1_Logi_ cw   Probability green zone of Kobe plot

Catch (t)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
70,000	70%	76%	85%	94%	98%	99%	100%	100%	100%	100%	100%	100%	100%	100%
80,000	70%	76%	85%	92%	97%	99%	99%	100%	100%	100%	100%	100%	100%	100%
90,000	70%	76%	85%	91%	95%	98%	99%	99%	99%	99%	99%	100%	100%	100%
100,000	70%	76%	85%	89%	92%	95%	98%	98%	98%	98%	99%	99%	99%	99%
110,000	70%	76%	85%	88%	90%	92%	93%	95%	97%	97%	97%	97%	97%	98%
120,000	70%	76%	85%	85%	87%	88%	89%	89%	90%	91%	92%	92%	93%	93%
130,000	70%	76%	85%	84%	83%	83%	83%	83%	82%	82%	82%	81%	81%	81%
140,000	70%	76%	71%	70%	67%	65%	64%	62%	60%	57%	57%	55%	53%	51%
150,000	70%	76%	59%	55%	50%	46%	43%	40%	36%	33%	31%	30%	27%	24%

F	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
0.75*FMSY	70%	76%	85%	85%	86%	87%	87%	87%	88%	88%	88%	88%	88%	89%
0.80*FMSY	70%	76%	85%	84%	84%	83%	83%	83%	83%	83%	83%	83%	82%	82%
0.85*FMSY	70%	76%	76%	76%	76%	76%	76%	75%	75%	75%	75%	75%	75%	74%
0.90*FMSY	70%	76%	67%	67%	67%	67%	67%	67%	67%	67%	67%	67%	67%	67%
0.95*FMSY	70%	76%	58%	58%	58%	58%	58%	58%	58%	58%	58%	58%	58%	58%
1.00*FMSY	70%	76%	48%	48%	48%	48%	48%	48%	48%	48%	48%	48%	48%	48%

Table 8. Kobe II risk matrix (probability of not exceeding MSY level) based on ASPIC results for yellowfin tuna. (continued)

1_Fox_eq Probability $B>B_{MSY}$

Catch (t)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
70,000	53%	65%	73%	89%	97%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
80,000	53%	65%	73%	87%	96%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%
90,000	53%	65%	73%	84%	92%	97%	99%	100%	100%	100%	100%	100%	100%	100%	100%
100,000	53%	65%	73%	82%	89%	94%	97%	99%	100%	100%	100%	100%	100%	100%	100%
110,000	53%	65%	73%	78%	84%	88%	91%	94%	97%	98%	99%	100%	100%	100%	100%
120,000	53%	65%	73%	75%	77%	79%	81%	83%	85%	87%	88%	90%	92%	92%	93%
130,000	53%	65%	73%	72%	71%	70%	69%	68%	66%	64%	63%	61%	59%	57%	56%
140,000	53%	65%	73%	69%	64%	60%	53%	47%	41%	36%	30%	27%	22%	18%	15%
150,000	53%	65%	73%	66%	57%	47%	39%	28%	22%	17%	13%	10%	7%	6%	5%

F	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
0.75*FMSY	53%	65%	73%	79%	84%	87%	90%	91%	93%	94%	94%	94%	94%	94%	95%
0.80*FMSY	53%	65%	73%	78%	80%	83%	85%	87%	88%	89%	89%	90%	90%	91%	91%
0.85*FMSY	53%	65%	73%	75%	77%	78%	79%	80%	81%	82%	82%	82%	83%	83%	83%
0.90*FMSY	53%	65%	73%	73%	73%	73%	73%	73%	73%	73%	73%	73%	73%	73%	73%
0.95*FMSY	53%	65%	73%	71%	71%	69%	69%	67%	66%	66%	65%	65%	64%	64%	64%
1.00*FMSY	53%	65%	73%	70%	67%	64%	62%	60%	57%	55%	54%	54%	52%	51%	51%

1_Fox_ eq Probability $F<F_{MSY}$

Catch (t)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
70,000	98%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
80,000	98%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
90,000	98%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
100,000	98%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
110,000	98%	99%	96%	98%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%
120,000	98%	99%	85%	87%	89%	90%	91%	93%	94%	95%	96%	97%	98%	98%
130,000	98%	99%	65%	64%	63%	61%	59%	57%	55%	53%	51%	48%	46%	44%
140,000	98%	99%	41%	37%	30%	26%	22%	19%	16%	14%	12%	10%	9%	7%
150,000	98%	99%	23%	17%	14%	11%	8%	7%	5%	5%	4%	2%	2%	1%

F	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
0.75*FMSY	98%	99%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%
0.80*FMSY	98%	99%	91%	91%	91%	91%	91%	91%	91%	91%	91%	91%	91%	91%
0.85*FMSY	98%	99%	83%	83%	83%	83%	83%	83%	83%	83%	83%	83%	83%	83%
0.90*FMSY	98%	99%	73%	73%	73%	73%	73%	73%	73%	73%	73%	73%	73%	73%
0.95*FMSY	98%	99%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%
1.00*FMSY	98%	99%	48%	48%	48%	48%	48%	48%	48%	48%	48%	48%	48%	48%

1_Fox_ eq Probability green zone of Kobe plot

Catch (t)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
70,000	53%	65%	73%	89%	97%	100%	100%	100%	100%	100%	100%	100%	100%	100%
80,000	53%	65%	73%	87%	96%	99%	100%	100%	100%	100%	100%	100%	100%	100%
90,000	53%	65%	73%	84%	92%	97%	99%	100%	100%	100%	100%	100%	100%	100%
100,000	53%	65%	73%	82%	89%	94%	97%	99%	100%	100%	100%	100%	100%	100%
110,000	53%	65%	73%	78%	84%	88%	91%	94%	97%	98%	99%	100%	100%	100%
120,000	53%	65%	73%	75%	77%	79%	81%	83%	85%	87%	88%	90%	92%	92%
130,000	53%	65%	65%	64%	63%	61%	59%	57%	55%	53%	51%	48%	46%	44%
140,000	53%	65%	41%	37%	30%	26%	22%	19%	16%	14%	12%	10%	9%	7%
150,000	53%	65%	23%	17%	14%	11%	8%	7%	5%	5%	4%	2%	2%	1%

F	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
0.75*FMSY	53%	65%	73%	79%	84%	87%	90%	91%	93%	94%	94%	94%	94%	94%
0.80*FMSY	53%	65%	73%	78%	80%	83%	85%	87%	88%	89%	89%	90%	90%	91%
0.85*FMSY	53%	65%	73%	75%	77%	78%	79%	80%	81%	82%	82%	82%	83%	83%
0.90*FMSY	53%	65%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
0.95*FMSY	53%	65%	63%	63%	63%	63%	63%	62%	62%	62%	62%	62%	61%	61%
1.00*FMSY	53%	65%	48%	48%	48%	48%	48%	48%	48%	48%	47%	47%	47%	47%

Table 8. Kobe II risk matrix (probability of not exceeding MSY level) based on ASPIC results for yellowfin tuna. (continued)

1_Fox_cw Probability B>B_{MSY}

Catch (t)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
70,000	96%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
80,000	96%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
90,000	96%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
100,000	96%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
110,000	96%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
120,000	96%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
130,000	96%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	99%	99%	99%	99%
140,000	96%	99%	100%	100%	99%	98%	97%	96%	95%	94%	93%	91%	87%	85%	82%
150,000	96%	99%	100%	99%	98%	96%	94%	91%	85%	80%	76%	68%	62%	56%	52%
F	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
0.75*FMSY	96%	99%	100%	100%	99%	99%	98%	98%	98%	97%	97%	97%	97%	97%	97%
0.80*FMSY	96%	99%	100%	99%	98%	97%	97%	96%	95%	95%	94%	94%	94%	93%	93%
0.85*FMSY	96%	99%	100%	99%	97%	96%	94%	93%	92%	91%	89%	87%	86%	86%	85%
0.90*FMSY	96%	99%	100%	98%	96%	94%	92%	88%	85%	83%	82%	80%	78%	77%	77%
0.95*FMSY	96%	99%	100%	98%	94%	92%	86%	82%	79%	76%	73%	71%	69%	67%	66%
1.00*FMSY	96%	99%	100%	97%	93%	87%	81%	77%	72%	67%	64%	61%	58%	56%	56%

1_Fox_ cw Probability F<F_{MSY}

Catch (t)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
70,000	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
80,000	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
90,000	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
100,000	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
110,000	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
120,000	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
130,000	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
140,000	100%	100%	97%	96%	94%	93%	91%	88%	85%	81%	80%	77%	74%	70%
150,000	100%	100%	90%	82%	78%	72%	65%	58%	52%	48%	45%	41%	35%	32%
F	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
0.75*FMSY	100%	100%	97%	97%	97%	97%	97%	97%	97%	97%	97%	97%	97%	97%
0.80*FMSY	100%	100%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%
0.85*FMSY	100%	100%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%
0.90*FMSY	100%	100%	73%	73%	73%	73%	73%	73%	73%	73%	73%	73%	73%	73%
0.95*FMSY	100%	100%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%
1.00*FMSY	100%	100%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%

1_Fox_ cw Probability green zone of Kobe plot

Catch (t)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
70,000	96%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
80,000	96%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
90,000	96%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
100,000	96%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
110,000	96%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
120,000	96%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
130,000	96%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	99%	99%	99%
140,000	96%	99%	97%	96%	94%	93%	91%	88%	85%	81%	80%	77%	74%	70%
150,000	96%	99%	90%	82%	78%	72%	65%	58%	52%	48%	45%	41%	35%	32%
F	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
0.75*FMSY	96%	99%	97%	97%	97%	97%	97%	97%	97%	97%	97%	97%	97%	97%
0.80*FMSY	96%	99%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	94%	93%
0.85*FMSY	96%	99%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%
0.90*FMSY	96%	99%	73%	73%	73%	73%	73%	73%	73%	73%	73%	73%	73%	73%
0.95*FMSY	96%	99%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%
1.00*FMSY	96%	99%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%

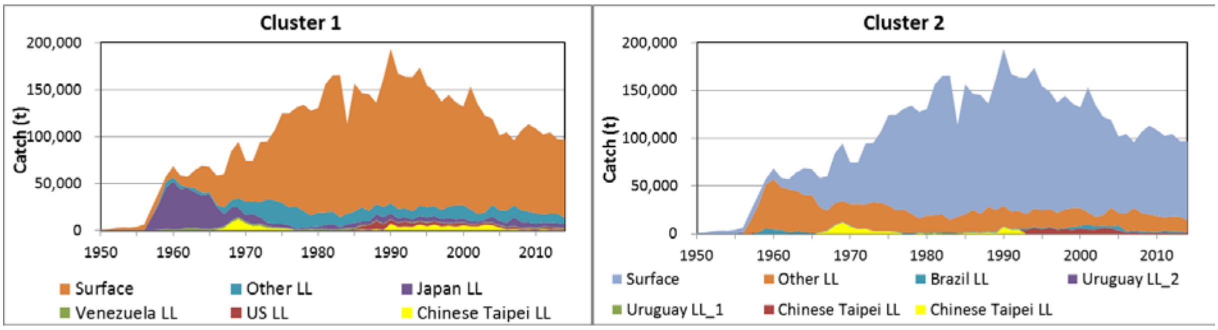

Figure 1. Annual trend of catch amount by fleet for ASPIC models for the Atlantic Ocean yellowfin tuna.

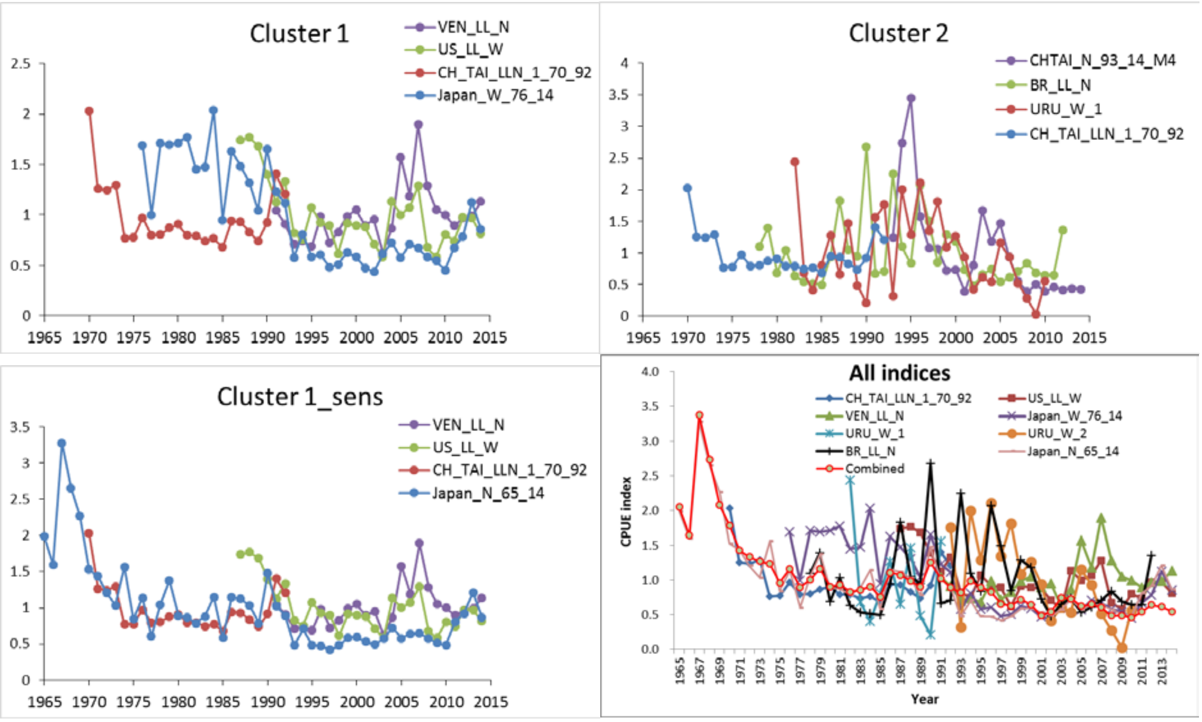

Figure 2. Annual trend of standardized CPUE included in the ASPIC models for the Atlantic Ocean yellowfin tuna.

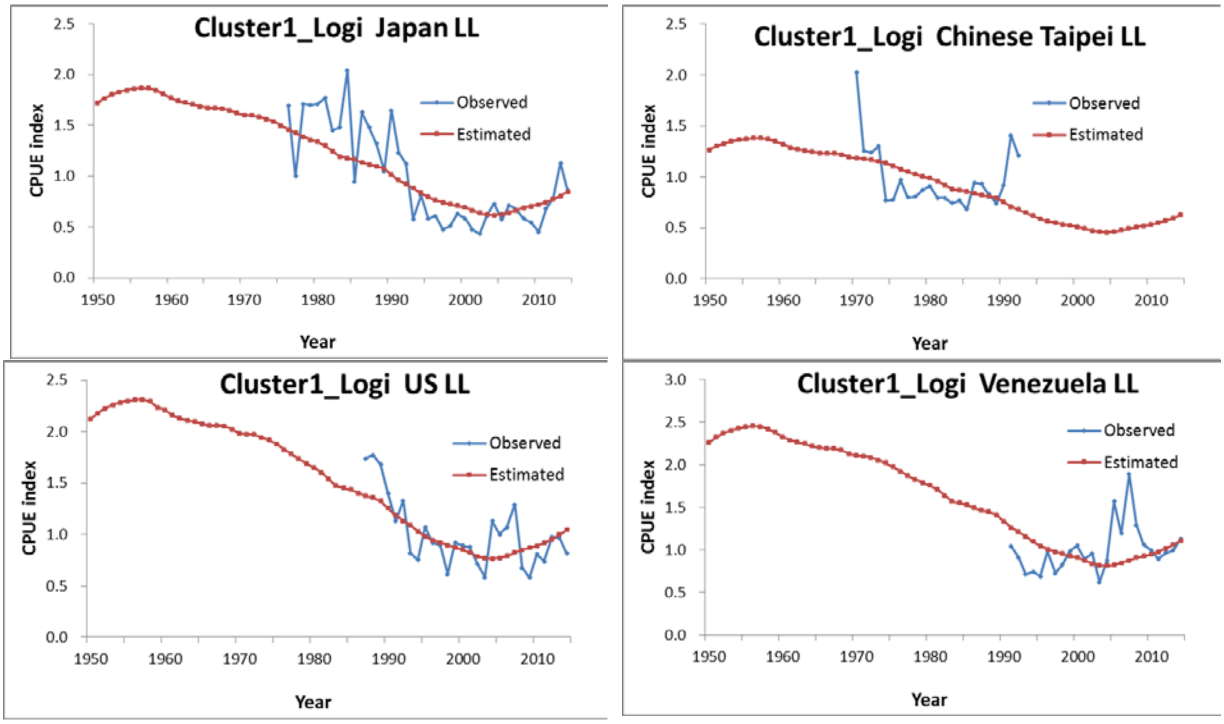

Figure 3. CPUE fit for ASPIC Cluster 1 equal weighted logistic model.

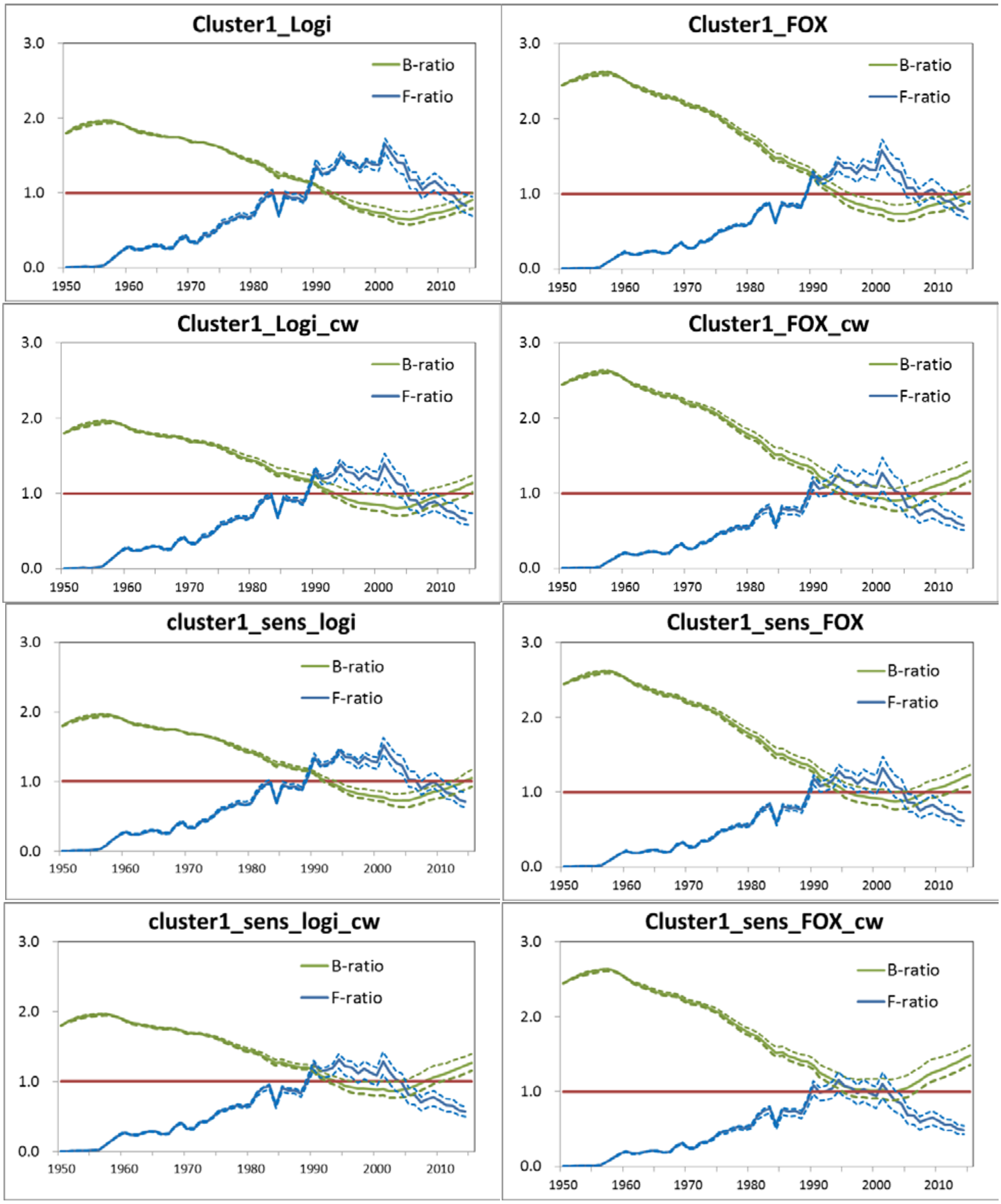

Figure 4. Trajectories of B-ratio (B/B_{MSY}) and F-ratio (F/F_{MSY}) with 80% confidence limits (dashed lines) for ASPIC runs.

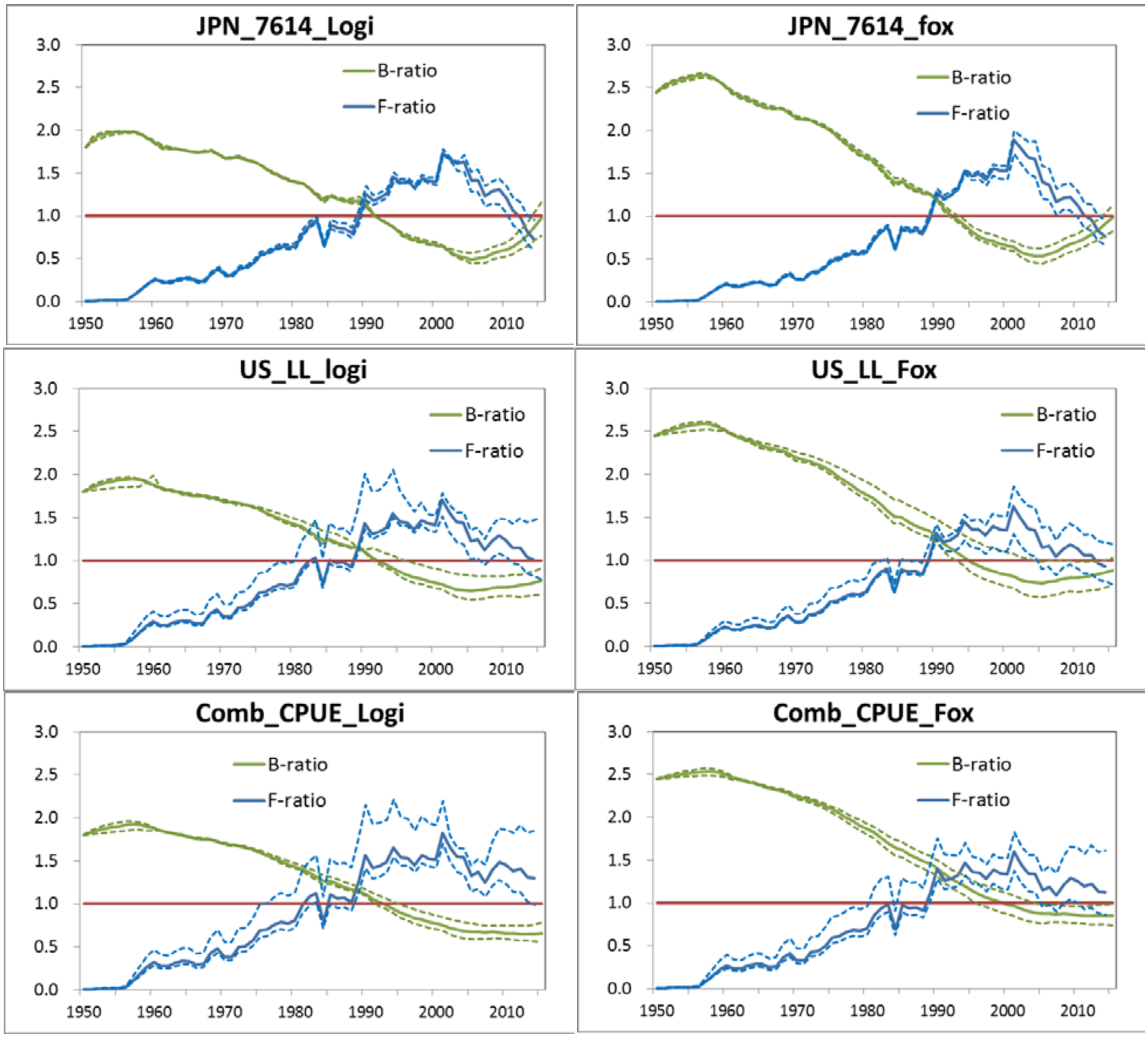

Figure 4. Trajectories of B-ratio (B/BMSY) and F-ratio (F/FMSY) with 80% confidence limits (dashed lines) for ASPIC runs. (continued)

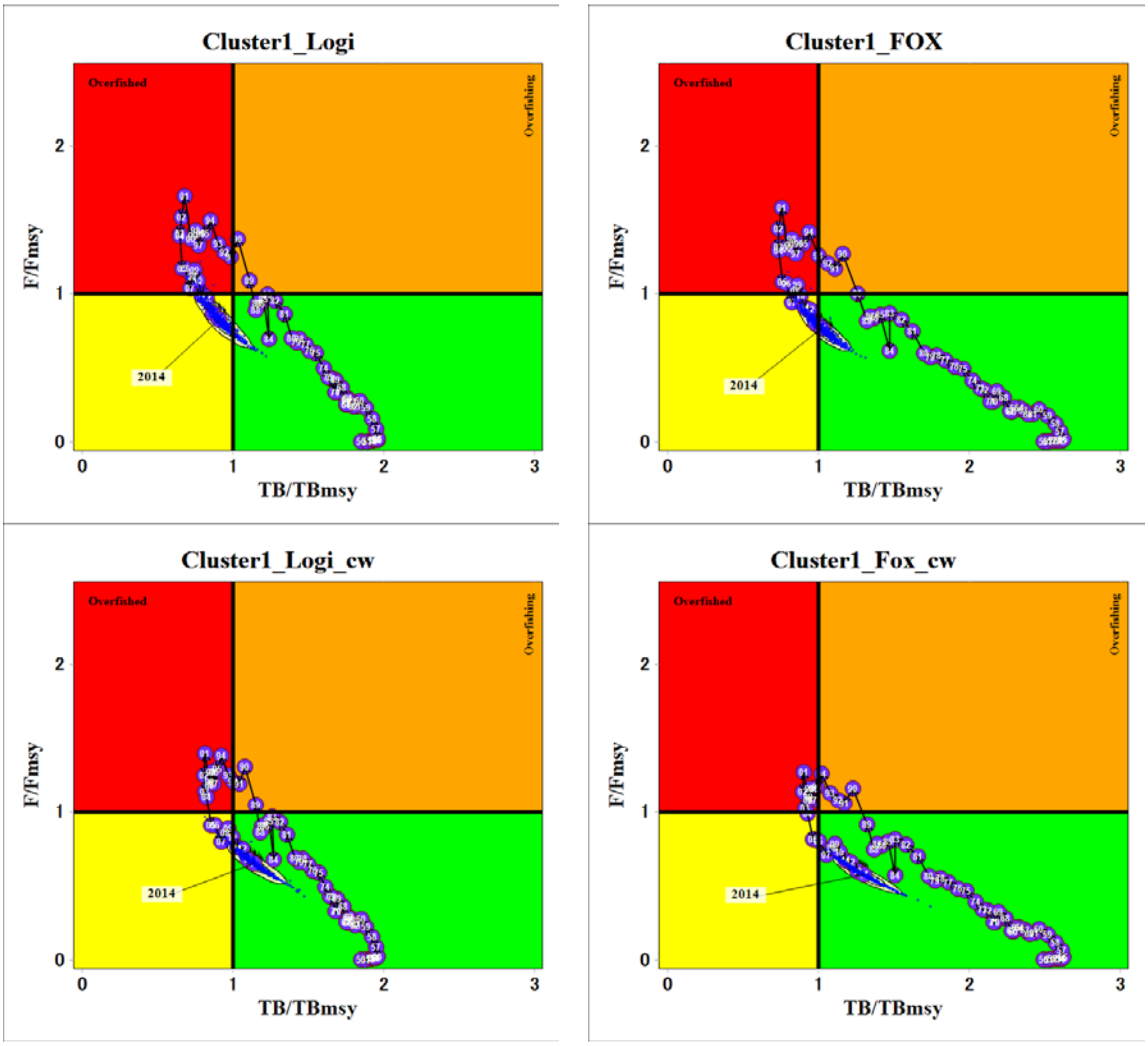

Figure 5. Kobe I plot for 4 ASPIC runs.

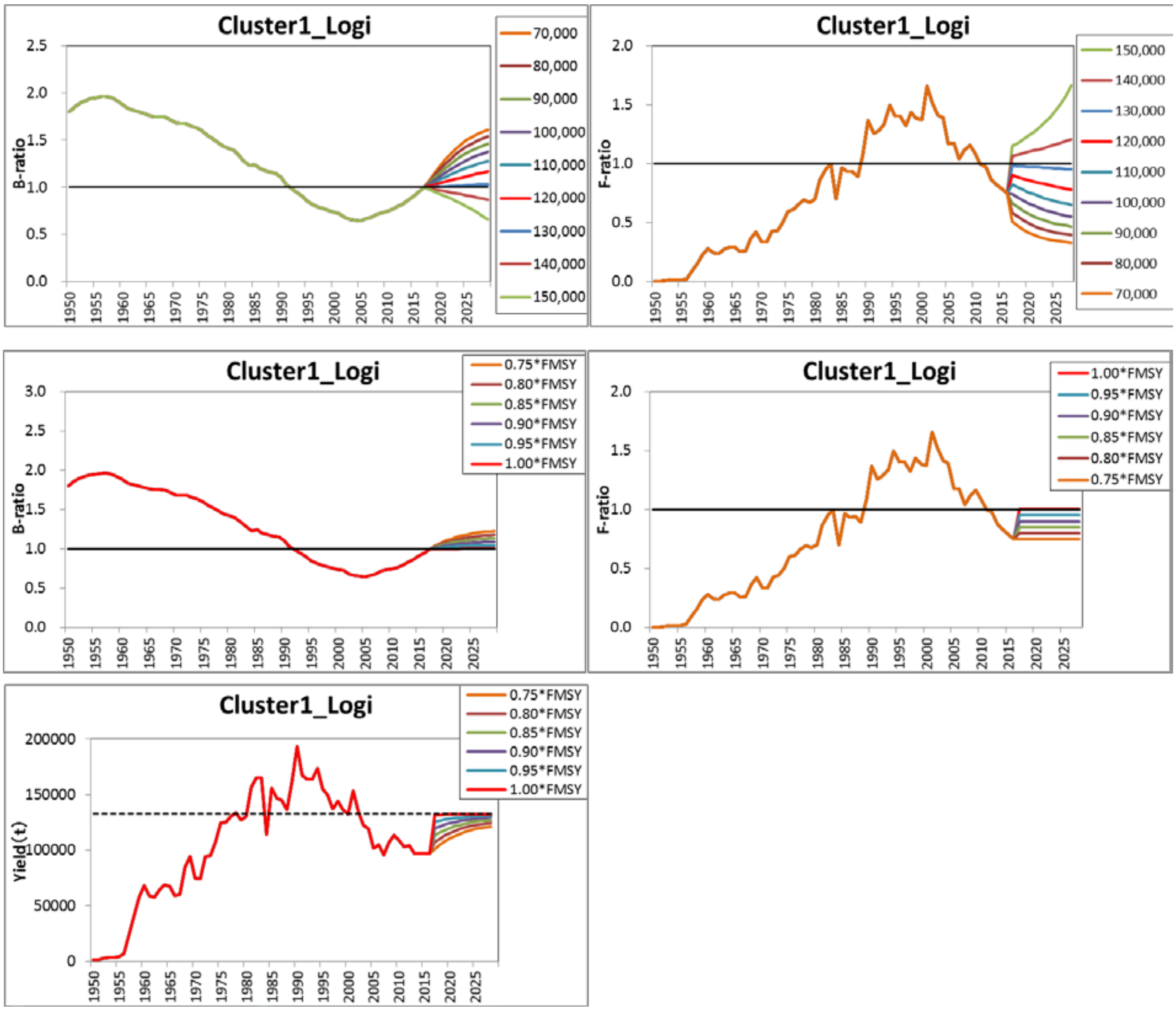

Figure 6. Future projection of B-ratio (B/B_{MSY}), F-ratio (F/F_{MSY}) and predicted yield for one ASPIC run under constant catch or constant F.

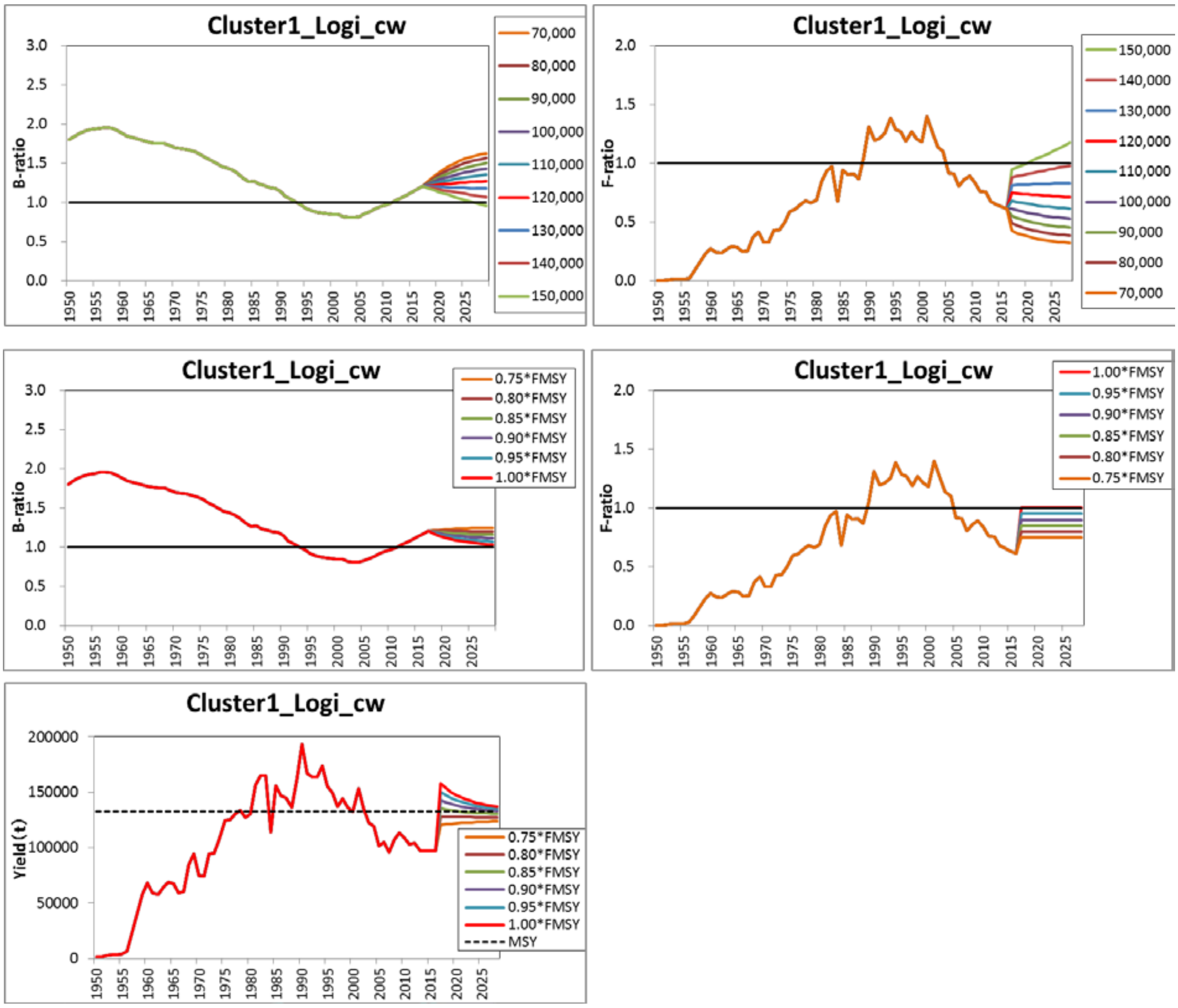

Figure 6. Future projection of B-ratio (B/BMSY), F-ratio (F/FMSY) and predicted yield for one ASPIC run under constant catch or constant F. (continued)

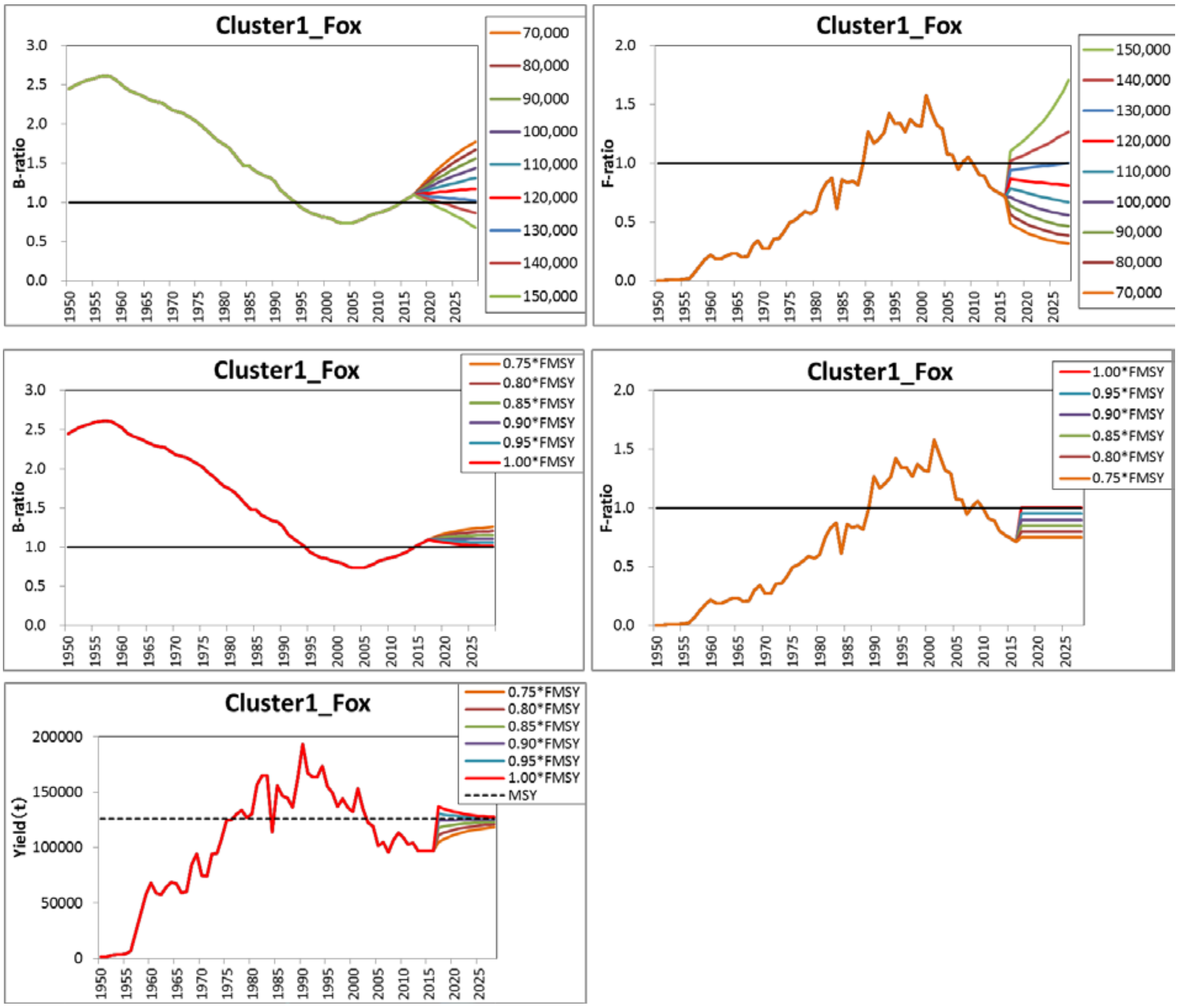

Figure 6. Future projection of B-ratio (B/BMSY), F-ratio (F/FMSY) and predicted yield for one ASPIC run under constant catch or constant F. (continued)

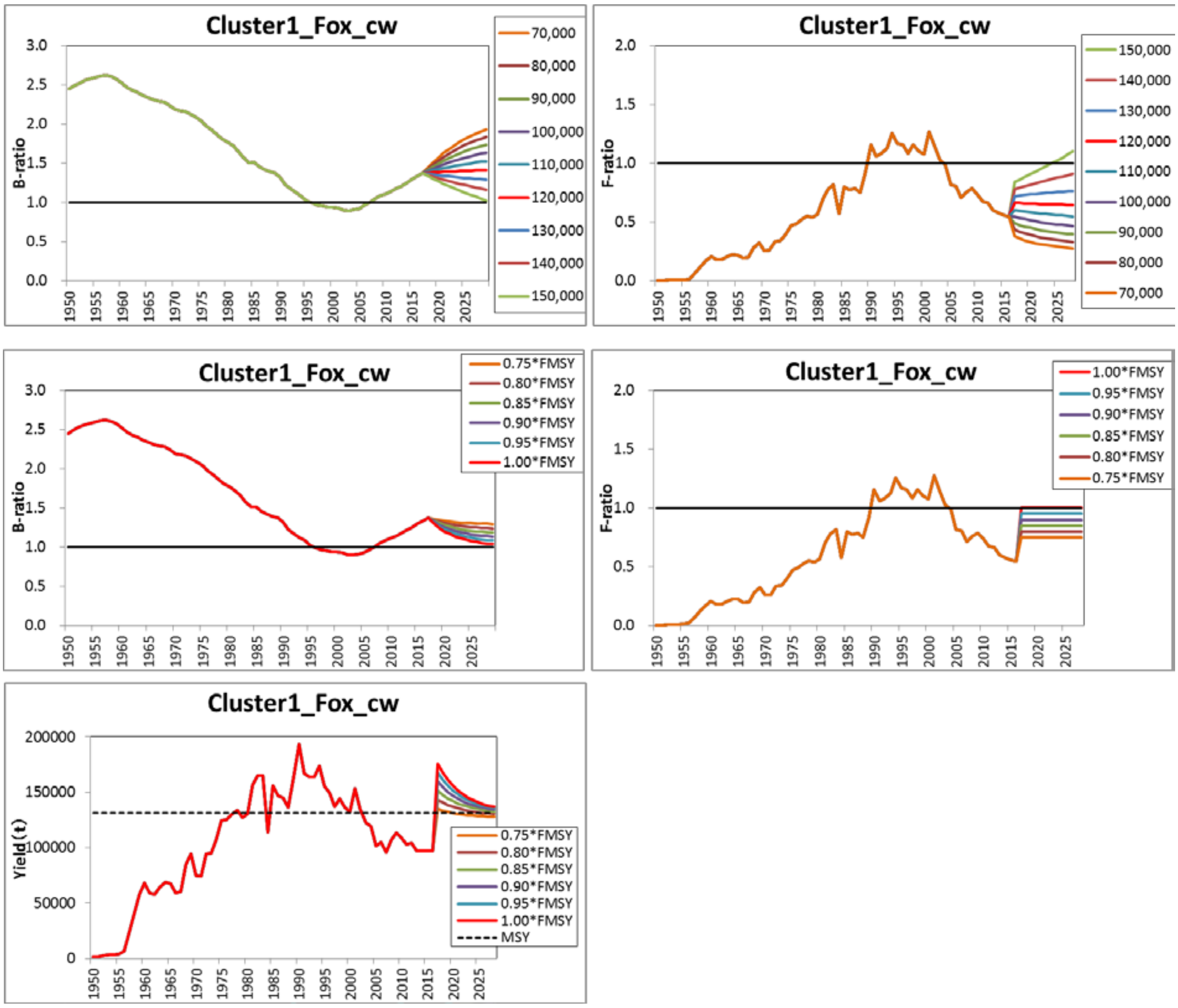

Figure 6. Future projection of B-ratio (B/BMSY), F-ratio (F/FMSY) and predicted yield for one ASPIC run under constant catch or constant F. (continued)

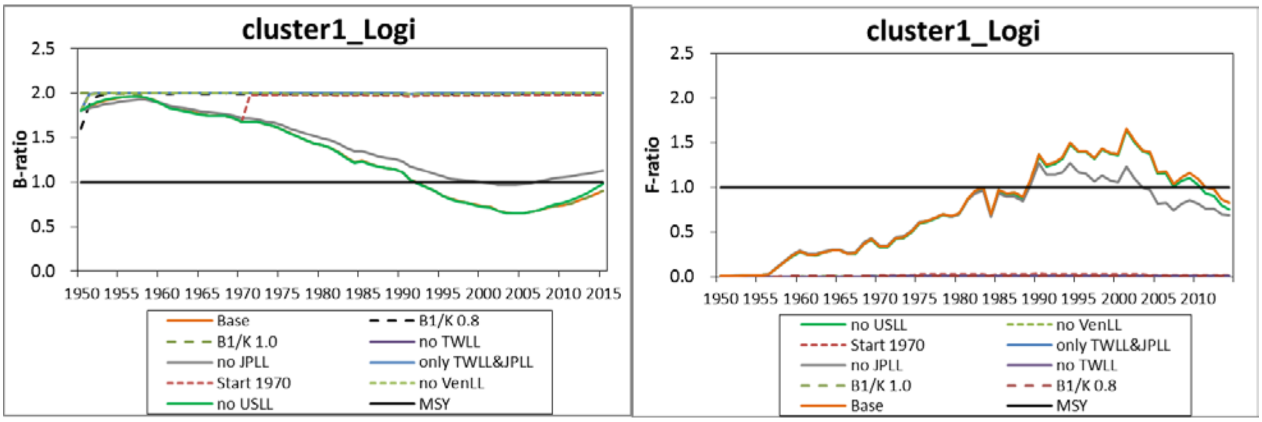

Figure 7. Results of sensitivity analyses for ASPIC model one scenario for yellowfin tuna.

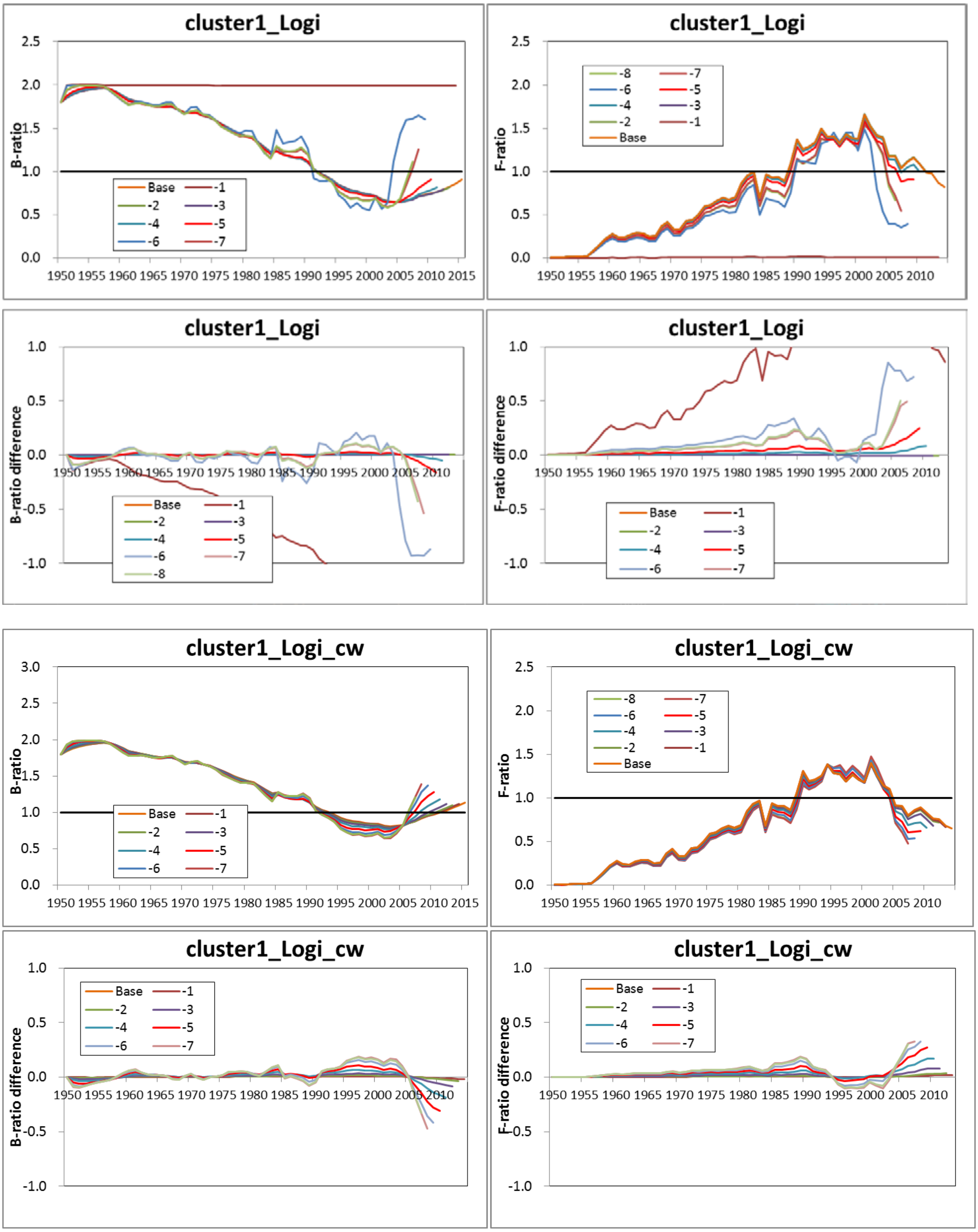

Figure 8. Results of retrospective analyses for ASPIC model for yellowfin tuna.

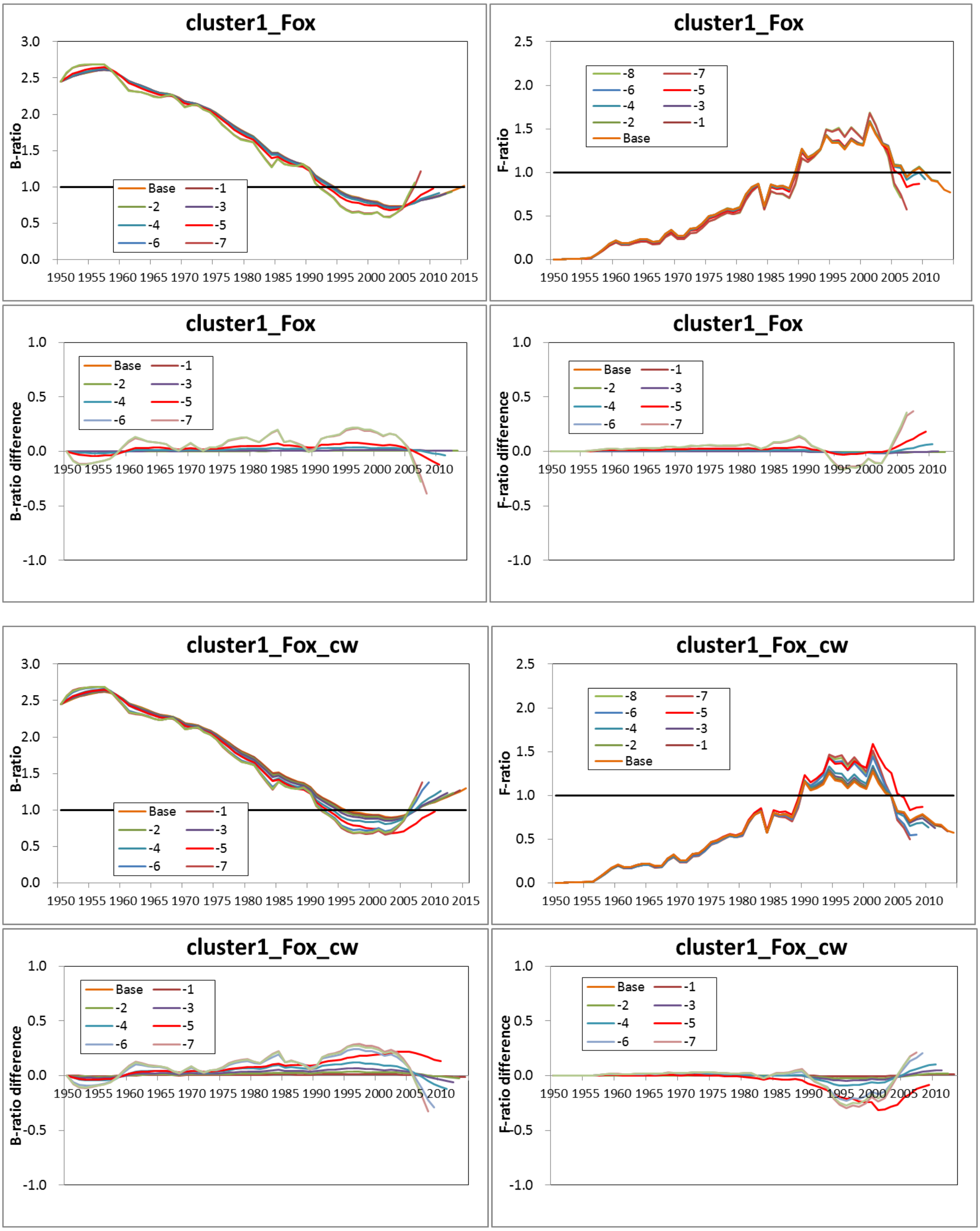

Figure 8. Results of retrospective analyses for ASPIC model for yellowfin tuna. (continued)