An Evaluation of the TAI Candidate Management Procedure Rules for Southern Bluefin Tuna Based on the Updated Reference Set and Robustness Trails

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Abstract

Based on the updated reference set generated after the Seattle 2005 meeting, there is a high tendency that the biomass will totally collapse after 2014 if we didn't adjust TAC soon enough. It is a clear and present call to initiate the Management Procedure which would ensure the recovery of the biomass in the long run with the decision rule that could prevent a dramatic reduction of the common wealth of the industry in the short run.

In order to identify the impact to the industry as a whole and to provide the exact TAC path for the industry to follow, the best decision rules should be accepted by CCSBT with the required biomass tuning parameters. Based on the updated reference set and robustness trails, this paper tries to update and refine the performance of candidate TAI-decision rules, which were proposed by Sun (2004) and were used to specify a simple empirical CPUE-based model with a negative built-in feedback component using the inverse demand relationship between price and TAC. Under the condition that the stock will recover, a moderate MP with a preferable performance which will minimize the percentage change of TAC in the early years and prevent overcapitalization again in the long run is recommended to the Commission.

Introduction

The CCSBT has agreed to initiate a meeting to steer the Commission's course on a management strategy workshop started in 2000 and the following management procedure (MP) workshops I to III were held from 2002 to 2004, respectively. The MP will have three components: (1) a list of data inputs, (2) an algorithm or a model to process the data, and (3) rules to translate the data and algorithm into a total allowable catch. It is agreed by the CCSBT members that MP should be developed as a set of rules, to dictate how a total allowable catch for the southern bluefin tuna (SBT) fishery should be adjusted as data becomes available.

The goal of MP workshop IV is to evaluate the performance of the final four candidate MPs with the updated 2001 to 2003 data with new trials specified at the Special Management Procedure Technical Meeting (SMPTM) held in Seattle in February 2005. Final decisions about the implementation issues of candidate MPs, specified the input data needed to define the exceptional circumstances that would result in triggering a meta-rule, and other considerations for sustainability of SBT will be made by the CCSBT12 in October 2005.

The performance of each decision rule using the biomass ratio based on the median biomass in 2022 under three recovery ratios, i.e., B2022/B2004 at 0.9, 1.1 and 1.3 will be compared. Under the assumption that each rule can be “tuned” to fall almost anywhere on the catch-biomass trade-off curve surface, the MP specifies the structure of the operating models for the SBT fishery, identifies various fisheries and the data sets required for conditioning of the model, agrees with the principles for selecting candidate management procedures, and agrees with the initial identification of objectives and related performance measures (maximizing catches, safeguarding the resource, minimizing inter-annual variation in catch and effort).

During evaluation of the results from all decision rules presented to the MP workshop III, the final four candidate MPs, FXR_01, HK5_01, D&M_03 and TAI_03, were selected to represent different behavior of adjusting TAC in the future. The TAI_03 rule was proposed by Sun (2004) to specify a simple empirical CPUE-based model with a negative built-in feedback component in terms of the percentage change in TAC, based on theoretical economic consideration of the inverse relationship between price and demand.

In addition to provide the performance of candidate TAI_decision rule with the updated reference set generated after the 2005 SMPTM, this paper will review and compare performances of the updated reference set and the previous reference set. The previous reference set was utilized during MP workshop III with CON_99, such as proposed in Sun (2004) and CON_01 rules, and was demonstrated by CSIRO. This paper also refines the TAI_03 rule and provides alternative TAI_decision rules to for the Commission to select with a decision rule that has preferable performance.

Review and Compare Performances of the Updated Reference Set

1. CON_99: constant catch in all years at current TAC

During MP III meeting, Sun (2004) proposed to use the results of CON_99 decision rule to set up the minimum biomass ratio criteria which would show us the risk if we didn't initiate MP soon enough. The CON_99 rule simply sets the TAC to a constant value in all years. Constant catch can be served as a reference point for evaluating the performance of the Operating Model; the current 2004 TAC catch (TAC = 14,930) is used in this regard.

For year t, $TAC_t = 14{,}930$ MT $\qquad t = 2004$ to $2032 \qquad (1)$

If a period of stable harvest for the next 10 years would be highly desirable, it is interesting to know how the media of the biomass ratio (B2022/B2004) under 2000 integrated replications would be if we hold the TAC unadjusted for all years at 14,930 MT.

Figure 1a shows the wormplot projections for both biomass and catch with CON_99 applied to 2005 updated reference set. Results show that there is a high tendency that the biomass would be totally collapsed after 2014, i.e., there is a clear and present danger that we won't be able to promise a sustainable fishery if we didn't adjust TAC soon enough. It is worthwhile to know that the biomass ratio would reach 0.0528676, which is dramatically lower than the result, 0.78056, shown in Sun (2004) during MP III (Figure 1(ii)). The updated reference set, which applied to the newest updated reference, tends to give us a more pessimistic case than the reference set specified in MP III meeting.

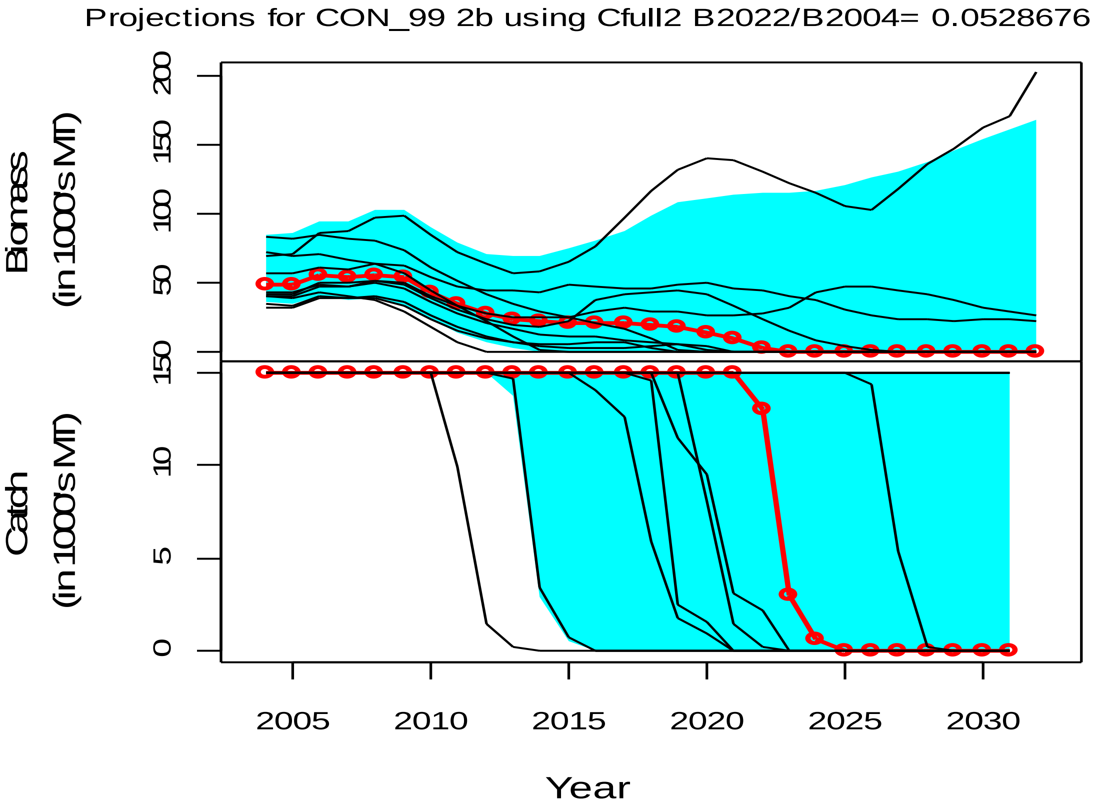


Figure 1a CON_99 wormplot projection of biomass and catch (maintaining the TAC at 14,930 MT from 2004 based on the reference set specified in 2005 SMPTM)

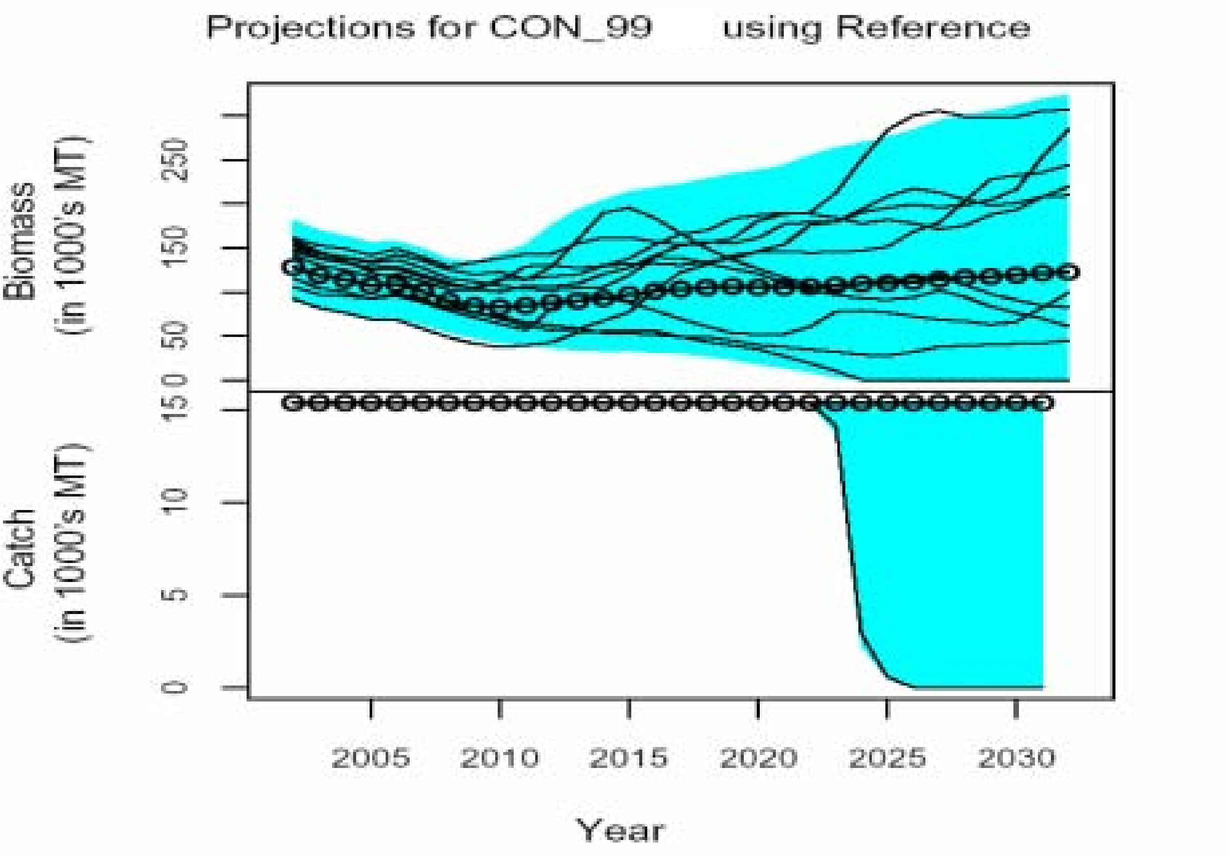


Figure 1b CON_99 worm plot projection of biomass and catch (maintaining the TAC at 15,385.7 MT from 2001 based on the reference set specified in MP III)

2. CON_01

CON_01 is defined both in Polacheck et. al. (2004) and Sun (2004) as the maximum short-run reduction scheme, where TAC is a tuning parameter of the rule, with a tuning level (either 1, 2, or 3) suffixed with a, b or c. The tuning level for the median of B2022 to B2004 biomass ratios under criteria 1, 2, or 3 are defined as B2022/B2002=0.7, 1.1 and 1.5, respectively. The maximum reduction of TAC is suffixed as "a" which regulates TACs beginning in 2006 with a maximum change of 5000 MT every three years; suffixed as "b" which regulates TACs beginning in 2008 with a maximum change of 5000MT every three years; or suffixed as "c" which regulates TACs beginning in 2008 with a maximum change of 8000 every five years.

The results of CON-01 under various schemes are shown as in Figures 2 as (i) CON_01_1b, (ii) CON_01_2a, (iii) CON_01_2b, (iv) CON_01_2c, and (v) CON_01_3b.

If the TACs are regulated to change from 2008 with a maximum change of 5000 MT every three years, the constant catch was tuned to three different TAC levels such as 10,112 MT, 8,650.1 MT, and 7,163.5 MT, which means 67.72%, 57.94% and 47.98% of the TAC in 2004, respectively, in 1b, 2b and 3b schemes, then the biomass ratio scheme of 0.9, 1.1 and 1.3 could be reached, see Figure 2 (i), Figure 2 (iii), and Figure 2 (iv).

The shaded area in the catch window of the above five figures show that even though the 2022/2004 biomass ratios could be tuned to 0.9, 1.1, and 1.3, respectively, there is a great risk after 2022 that the biomass would be totally collapse. The CON_01 rule shows a drawback that there is no mechanism to further adjust TAC after 2022 and there is no consideration of possibility of various adjusting path under various biomass status.

It is interesting to know that there is also a high tendency that the biomass would be totally collapsed after 2020, i.e., there is a clear and present danger that we won't be able to promise a sustainable fishery if we didn't adjust TAC wise enough.

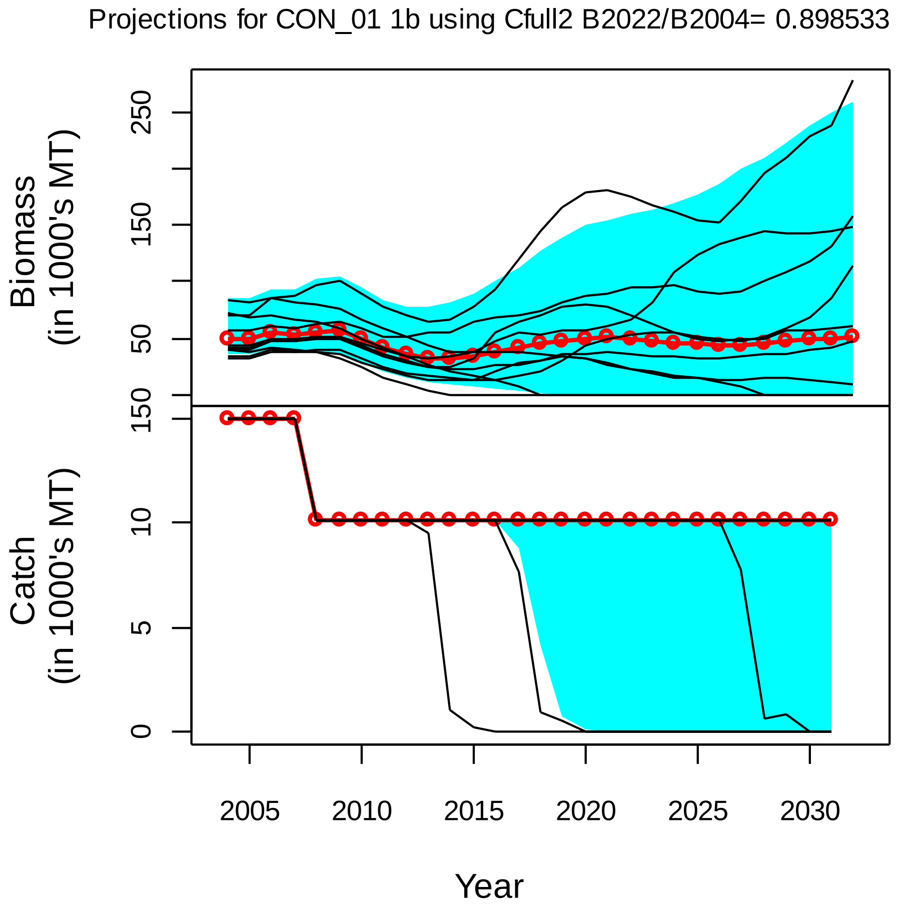


Figure 2(i) CON_01 1b with B2022/B2004=0.9 (TAC$_{2006}$=10,112)

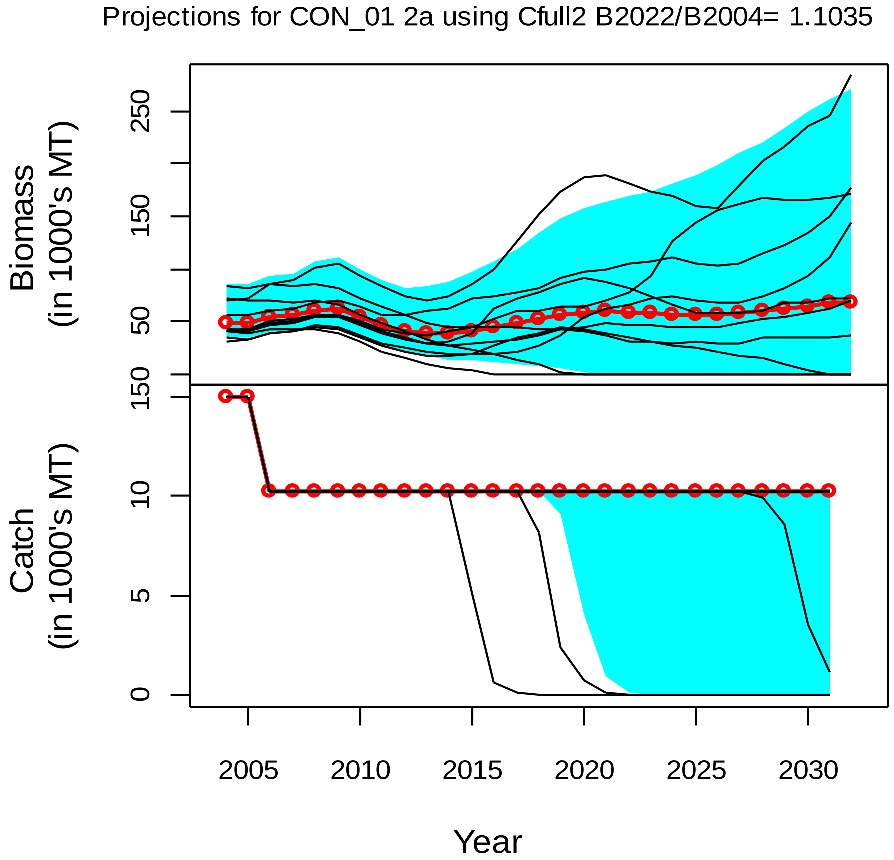


Figure 2 (ii) CON_01 2a with B2022/B2004=1.1 (TAC$_{2008}$=10,210)

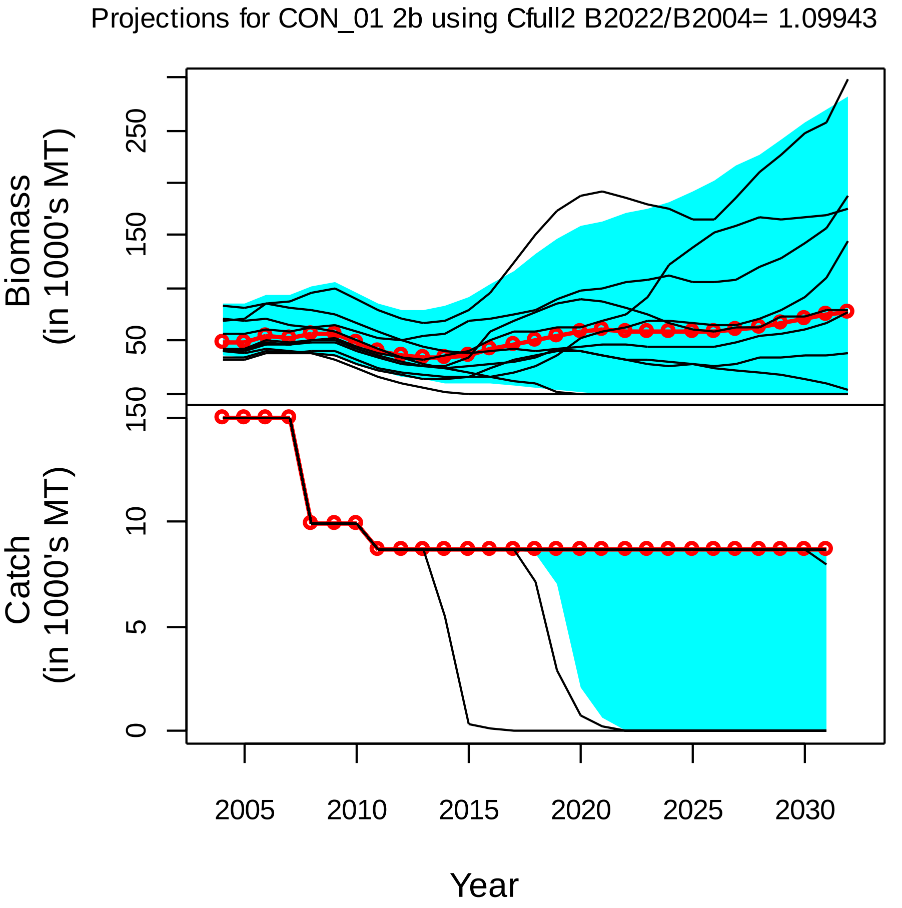


Figure 2 (iii) CON_01 2b with B2022/B2004=1.1 (TAC_{2011}=8,650.1)

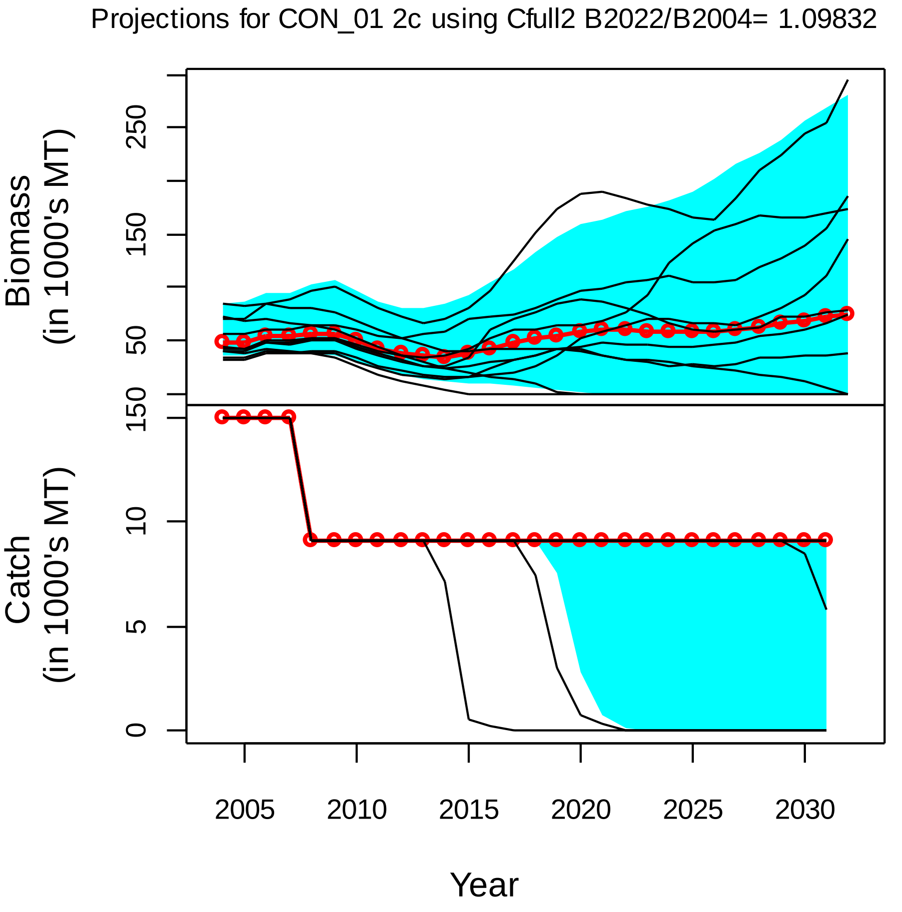


Figure 2 (iv) CON_01 2c with B2022/B2004=1.1 (TAC_{2008}=9,047.4)

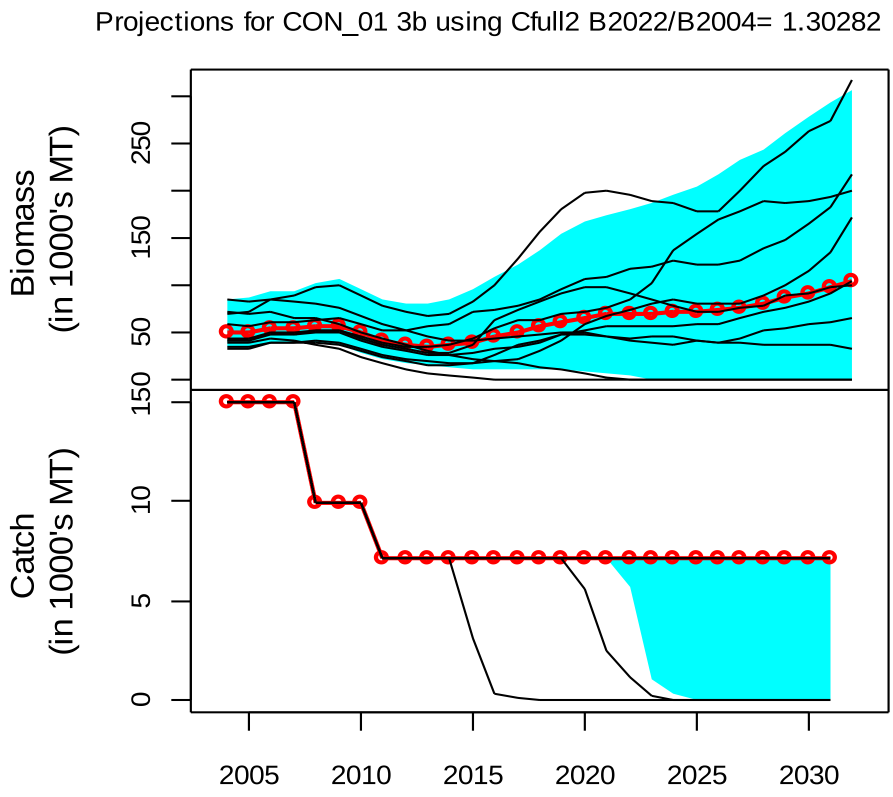


Figure 2 (v) CON_01 3b with B2022/B2004=1.1 (TAC_{2011}=7,163.5)

Outlook of the Japanese Market

It is agreed that the welfare of the bluefin fisheries sectors in all member countries is sensitive to price and the member countries had expressed their concerns that increases in global TAC could result in lower prices, as stated in the paragraph 14 in Agenda item 6 of the Report of the 4th Meeting of the Stock Assessment Group. Hence, the market constraint should be imposed to reflect the adverse effect caused by a change in TAC. If the TAC is increased under the optimistic case, the price of SBT would be reduced under the equilibrium condition, or vice versa, such as shown in Figure 3.

If there are plenty of substitute for consumers to choose, the reduction of TAC won't promise an increase of price, i.e., if TAC decreases from Q_0* to Q_1*, the equilibrium price will hold steadily at P_0* instead of P_1* in Figure 3.

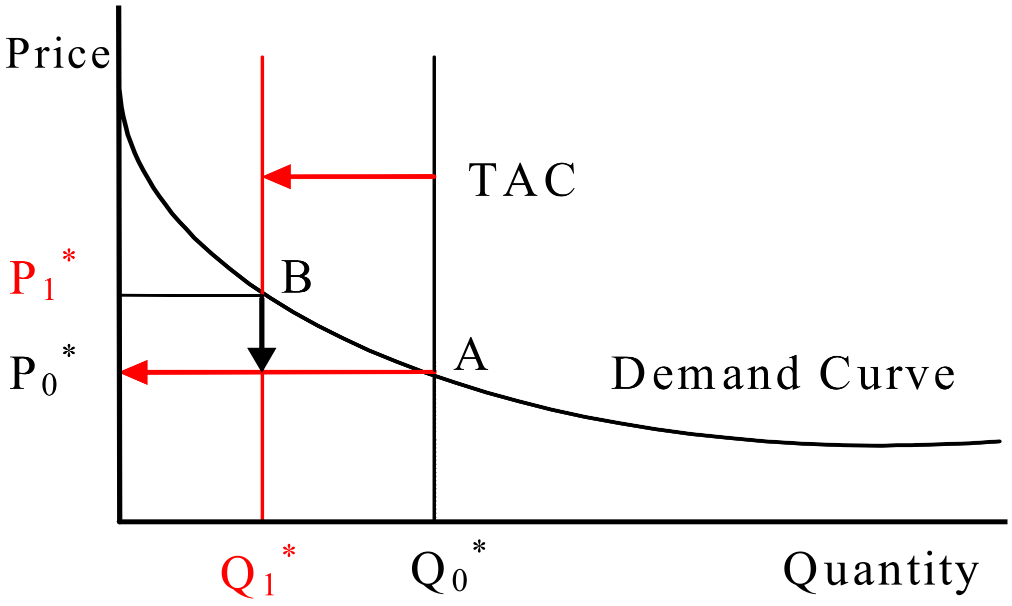


Figure 3 Demand and Supply Equilibrium Relationship under TAC Management Scheme

Figure 4a and 4b show that the total imports and average import price of frozen SBT and NBT in Japan between 1993 and 2004. The import price fluctuates almost on a monthly basis. Figure 4a and 4b show that after the total imports increased in 1999, a downward trend on the import price can be easily observed.

As shown in Table 1, during the peak season from in 2003 (Sept.-Nov.) to 2004 (Aug.-Oct), the quantity of SBT imported in Japan increased 34.19% and import prices decreased 27.44%, i.e., the inverse demand elasticity is about -0.8. It is also interesting that during 2002 to 2003, there is a 40.45% reduction in the quantity of SBT imports, however the price also experienced a 19.97% reduction, i.e., there is a strong indication that there are plenty of substitutes for consumer to choose, the import price cannot increase even when there is a shortage of SBT in the short run. The price of SBT is highly depending upon the price of other sashimi grade tuna species.

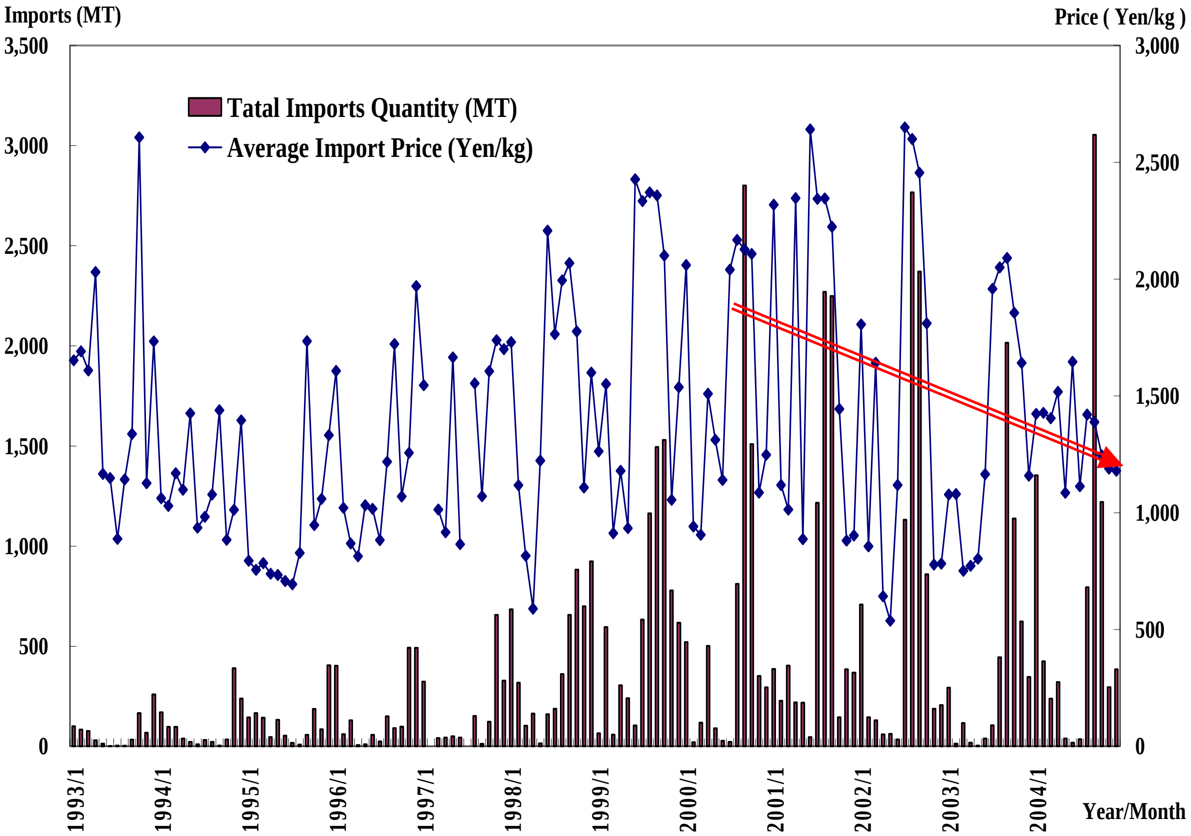


Figure 4a Total Imports and Average Import Price of Frozen SBT in Japan(1993/1~2004/12)

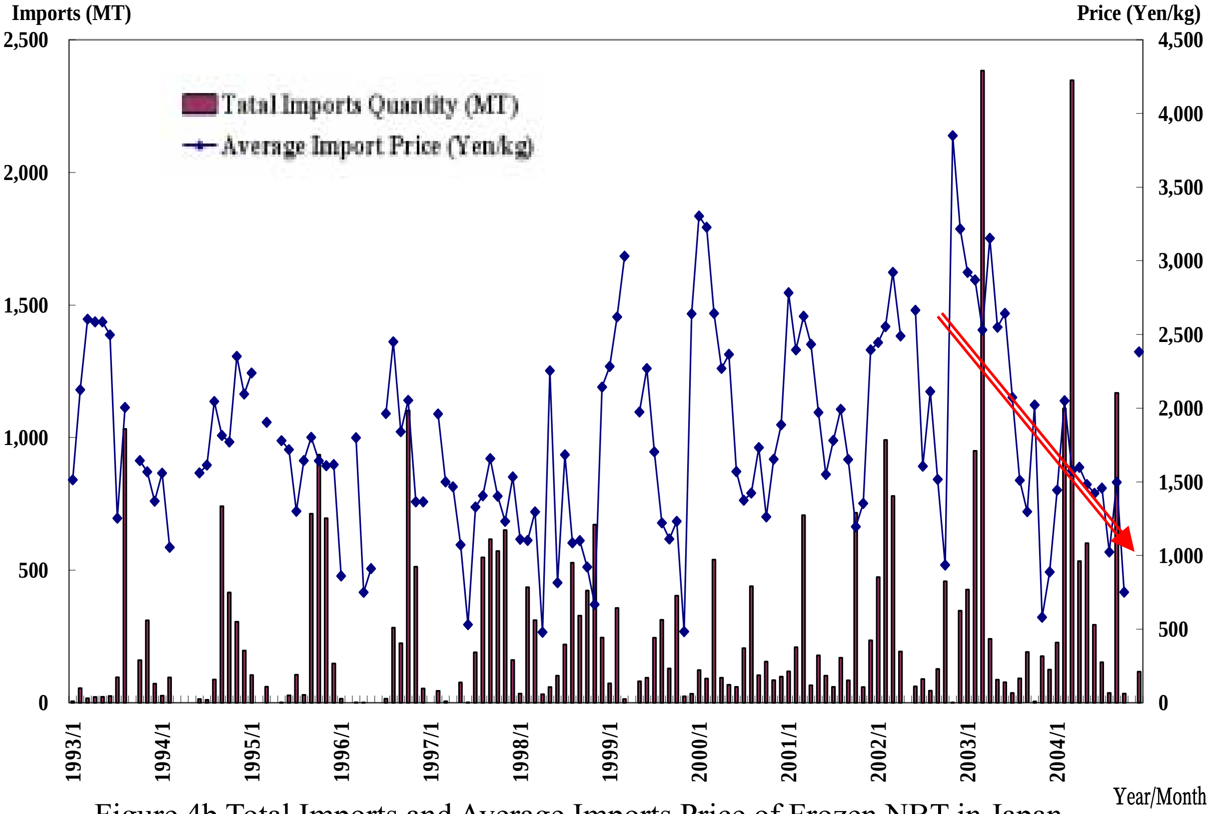


Figure 4b Total Imports and Average Imports Price of Frozen NBT in Japan (1981/1~2004/12)

Table 1 Import Quantity and Price of Frozen SBT and NBT in Japan

Imports of Frozen SBT in Japan					
Year	Quantity (MT)	Price (Yen/kg)	Month	Quantity (MT)	Price (Yen/kg)
1999	7,582.07	1,930	Jun..-Sep.	4,185.82	2,428
2000	7,065.40	1,953	Aug.-Oct.	5,121.28	2,111
2001	8,130.07	2,022	Jun.-Sep.	5,733.11	2,389
2002	8,658.59	2,264	Jul.-Oct.	6,269.43	2,379
2003	5,155.62	1,812	Jul.-Oct.	3,775.85	1,989
2004	8,174.30	1,364	Jan.-Apr.	5,066.90	1,443
Imports of Frozen NBT in Japan					
1999	1,769.22	1,731	Jan.-Mar.	4,185.82	2,644
2000	2,064.71	2,038	Jan.-Apr.	5,121.28	2,860
2001	2,707.48	2,010	Jan.-Apr.	5,733.11	2,559
2002	3,567.98	2,409	Jan.-Apr.	6,269.43	2,602
2003	4,792.36	2,479	Jan.-Apr.	3,775.85	2,869
2004	6,625.81	1,627	Feb.-May.	5,066.90	1,676

Source: Japan Customs, http://www.customs.go.jp

According to Josupeit and Catarci (2004), the maximum auction price in the Tsukiji Market, Japan for fresh and frozen SBT originated from Australia peaked in 1996-1997 at average year quotations of ¥11,100/kg and ¥11,292/kg, respectively. In the following years, SBT import prices declined to a low of ¥7,508/kg in 2000 and fluctuated around similar values over the 2000-2003. In 2003, maximum prices of Southern bluefin tuna reached ¥7,651/kg.

The peak prices of SBT reported in Japan in 1996 and 1997 were due to reduced supplies from imports amid strong demand. In subsequent years, the decline in Japanese prices was a reflection of the market penetration by cheaper *sashimi* preparations from farmed bluefin tuna.

Since the Atlantic and Pacific Bluefin tunas are close substitutes of the SBT, it is important for us to know the price trends of Atlantic and Pacific Bluefin tunas. The maximum prices of Atlantic and Pacific bluefin tunas increased from ¥6,917/kg in 1986 to ¥10,717/kg in 1991 Then declined to a low of ¥4,906/kg in 2003, while low prices of Atlantic and Pacific bluefin tunas increased from ¥3,642/kg in 1986 to ¥3,881/kg in 1991 and declined in the following years until they reached ¥2 555/kg in 2003. In 1999, ITN started to report quotations of farmed Atlantic and Pacific bluefins.

Prices of farmed Atlantic and Pacific bluefin tuna decreased from ¥4,000 (low price) and ¥5,000 (high price), origin Spain to ¥1,800 and ¥3,000 in December 2003, respectively. For the past two years, these quotations have been responsible for lowering the average bluefin quotations in the Tsukiji market.

Even though the percentage change in the price of SBT is negatively related to the percentage change in quantity, because there are many close substitutes, such as farmed Atlantic and Pacific bluefins and bigeye, the reduction of TAC may not ensure an increase of price in SBT market. Under the market constraint, a reduction of the TAC may not increase the price of SBT and will post a dramatic threat to the fishing industry that will bear the negative effect and won't be able to be economically sustainable in the short run. Based upon the industry will bear a huge sunk cost in the short run, a lesser weight should be given to harvest reduction in the first period's TAC adjustment.

A moderate adjustment measure should be incorporated into the rule as a bio-economic consideration in stead of using the most rapid approach way or a bang-band control way which ignore the value of time without discounting the future value of harvest.

Specification and Performance of the Candidate TAI_decision Rules

Based on the updated reference set and robustness trails, this paper tries to update and refine the performance of candidate TAI-decision rules, which were proposed by Sun (2004) and were used to specify a simple empirical CPUE-based model with a negative built-in feedback component using the inverse demand relationship between price and TAC. Under the condition that the stock will recover, a moderate MP with a preferable performance which will minimize the percentage change of TAC in the early years and prevent overcapitalization again in the long run is recommended to the Commission.

1. TAI_03:

After consulting the industry and mangers in Taiwan, a CPUE-rule is easy to understand intuitively and less of a 'black-box'; therefore, it is preferable to an MSY-based rule that may be very sensitive to parameter settings. The decision rule was named TAI_03 by Sun (2004) and defined as follows:

$$\mathrm{TAC}_{t+1} = \alpha \cdot \left(w \cdot \mathrm{TAC}_t + (1-w) \cdot \mathrm{TAC}_t \cdot (1 + k_1 \lambda_5) \cdot (1 - k_2 \% \Delta \mathrm{TAC}_t) \right) \qquad (2)$$

where α is the tuning parameter;

w is the carryover percentage which has values between 0 and 1, i.e., w = 1 for the grandfathered-in right for the industry to protect their long-term planning in investment. To be meaningful in the economic sense, the carryover percentage should be greater than 0 and less than 1.

k_1 is the weight given to the log(CPUE) slope;

k_2 is the weight given to $\%\Delta\mathrm{TAC}$;

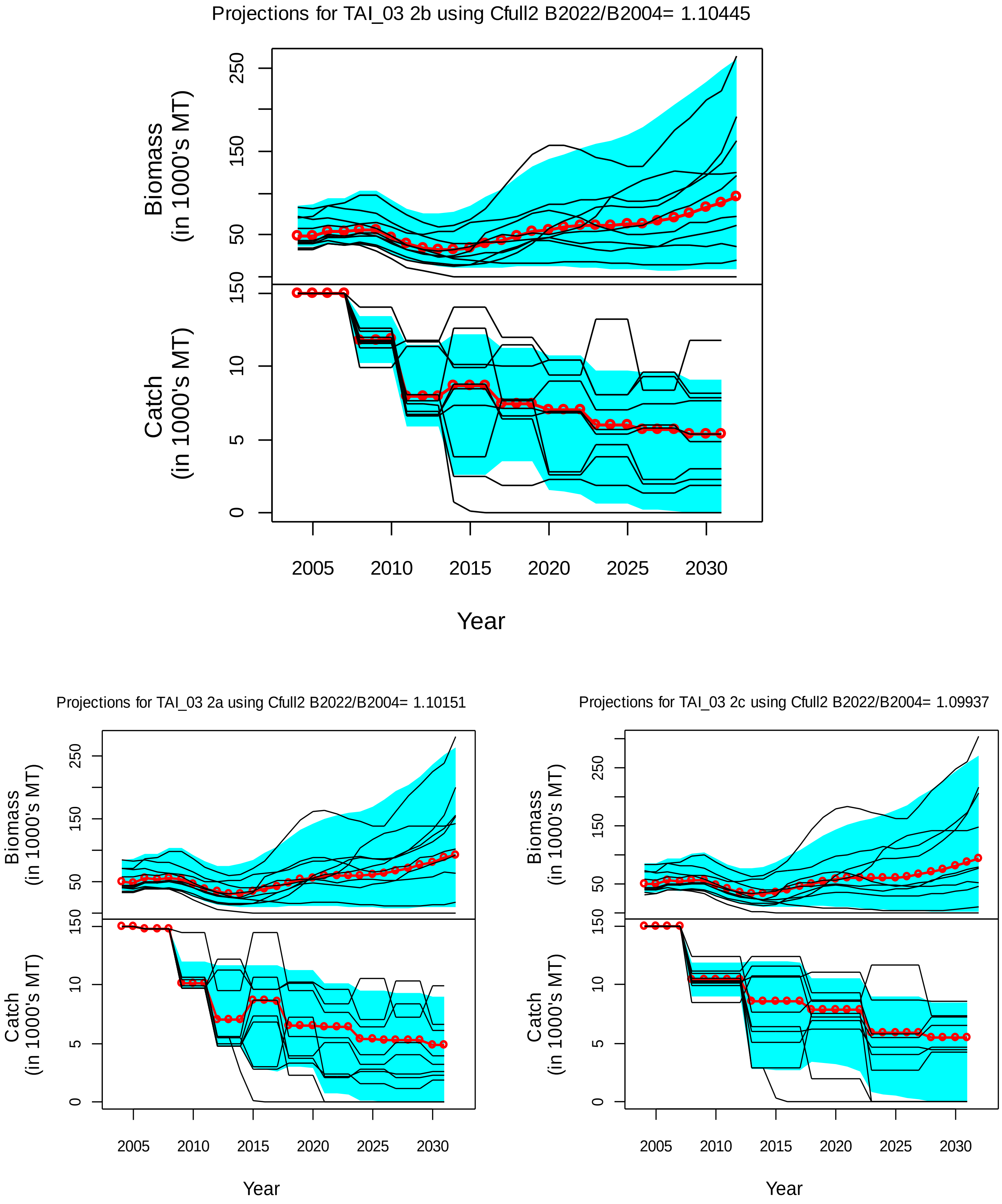
λ_5 is the slope of the regression of log (CPUE) vs. time over the last 5 years;

$\%\Delta\mathrm{TAC}_t = (\mathrm{TAC}_t - \mathrm{TAC}_{t-i}) / \mathrm{TAC}_{t-i}$ for i = 3 or 5, $\%\Delta\mathrm{TAC}_t$ is the percentage change from the experience of TAC change in previous three-year or five-year blocks.

The percentage change of price penalty equals -k_2 times $\%\Delta\mathrm{TAC}$, which should be considered as one of the factor influences the TAC in next period.

Based upon the carryover percentage is set to 0.85, k_1 equals 10, k2 equals 7, and the various levels of tuning parameters α in equation (1), the wormplot projections of TAI_03 are shown in Figure 5 under the biomass ratio equals 1.1 with three adjustment scheme a, b, and c, respectively.

It is interesting to know the characteristics of TAI_03 decision rule shows the self-adjusting ability especially under TAC schedule a, b and c. For example, if there is a huge drop of the TAC in this period caused by the downward CPUE trend, then there is a tendency to increase the price, and then the self-adjustment process kicks in to soften the reduction of TAC in the next period to compensate for the loss in the previous period. Hence, the wormplot of TAI_01 tends to exhibit a zip-zap path for TAC. This drawback is caused by the slope of the regression of log(CPUE) vs. time-window over the last 5 years is sensitive to the annual CPUE data.



Projections for TAI_03 2b using Cfull2 B2022/B2004= 1.10445

Projections for TAI_03 2a using Cfull2 B2022/B2004= 1.10151

Projections for TAI_03 2c using Cfull2 B2022/B2004= 1.09937

Figure 5 TAI_03 worm plot projections of biomass and catch

As shown in Figure 6, the slope of the regression of log (CPUE) vs. time-window over the last 5 years are too sensitive to new data included and it is desirable to increase the robustness of the slope with wider time-window, i.e., set the time-window to 10 years to represent a confident estimate of the change of log (CPUE), λ_{10}, and the TAI_03 rule is renamed as TAI_13 and defined in equation (3). Such as shown in Figure 7, the worm plot of TAI_13 shows a more consistent trajectory over time than that of TAI_03.

$$TAC_{t+1} = \alpha \cdot [w \cdot TAC_t + (1-w) \cdot TAC_t \cdot (1+k_1\lambda_{10}) \cdot (1-k_2\%\Delta TAC_t)] \qquad (3)$$

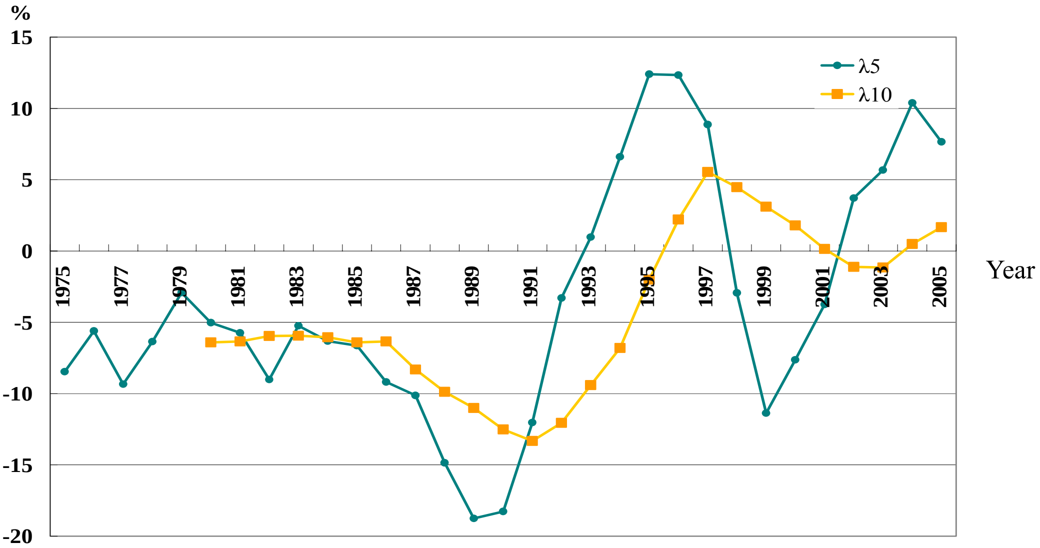


Figure 6 Slope of the regression of log (CPUE) vs. time-window over the last 5 years and 10 years

3. Modified TAI_01 (TAI_13 if k2=0)

A simple CUPE based rule is proposed in Sun (2004) since it is easier for the member countries to follow. Following the argument to redefine the slope in the log (nominal CPUE) over the last 10 years is used to adjust the TAC, the TAI_01 decision rule is modified as follows,

$$TAC_{t+1} = \alpha \cdot [w \cdot TAC_t + (1-w) \cdot TAC_t \cdot (1+k_1 \cdot \lambda_{10})] \qquad (4)$$

Based on the wormplot of TAI_01 in Figure 8, there is a delay of adjusting TAC upward even the biomass shown a strong recovery after 2022. It is too strong to set the carryover rate 85% for all period and the TAC adjustment behavior will lack of flexibility in the long run.

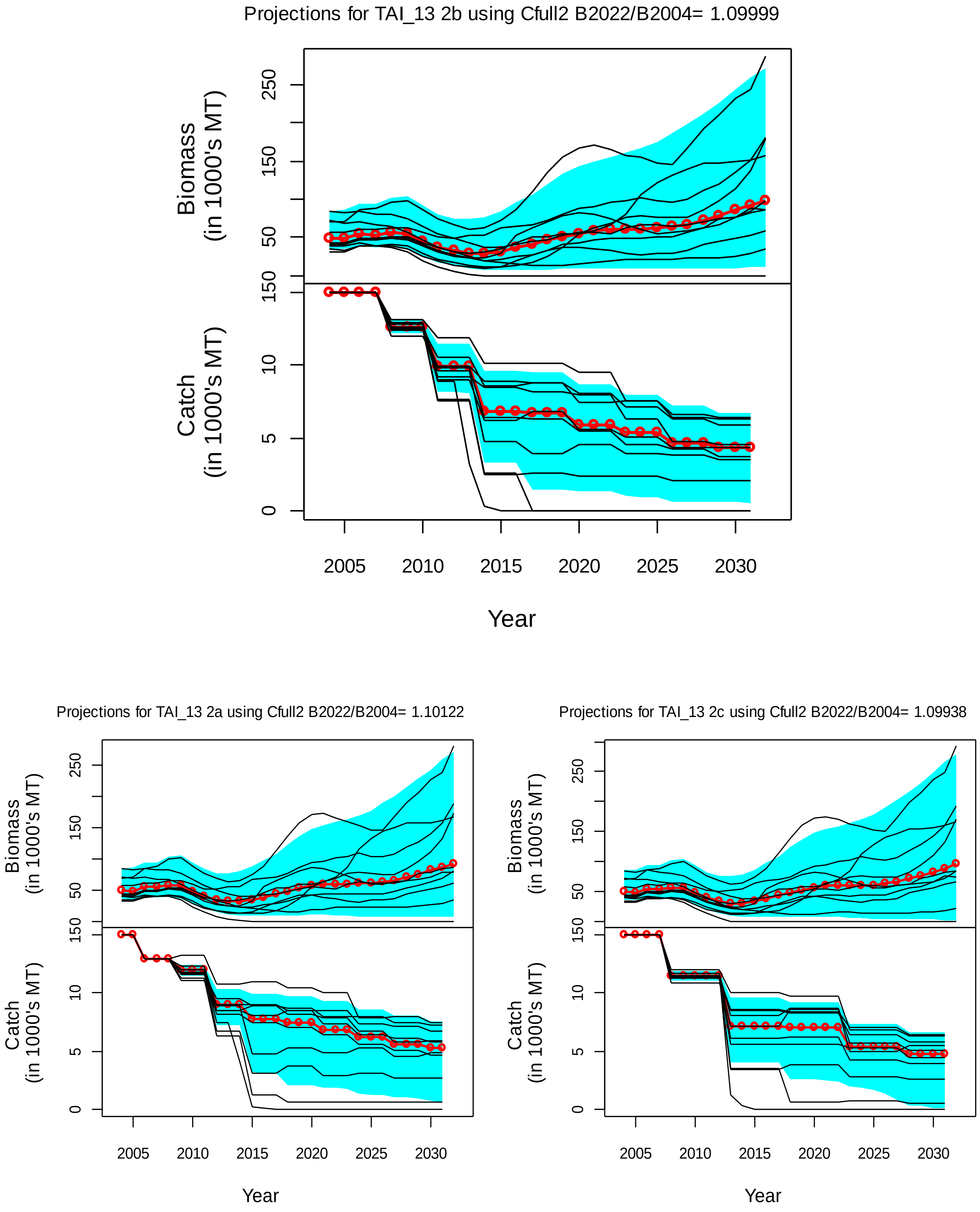
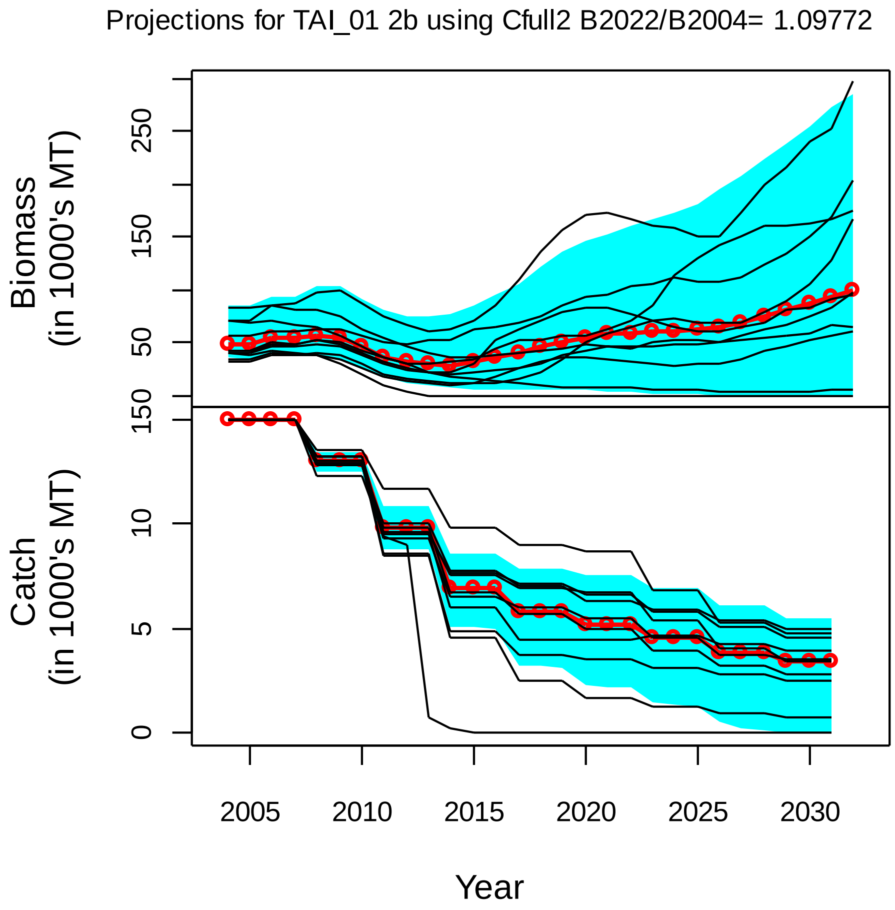
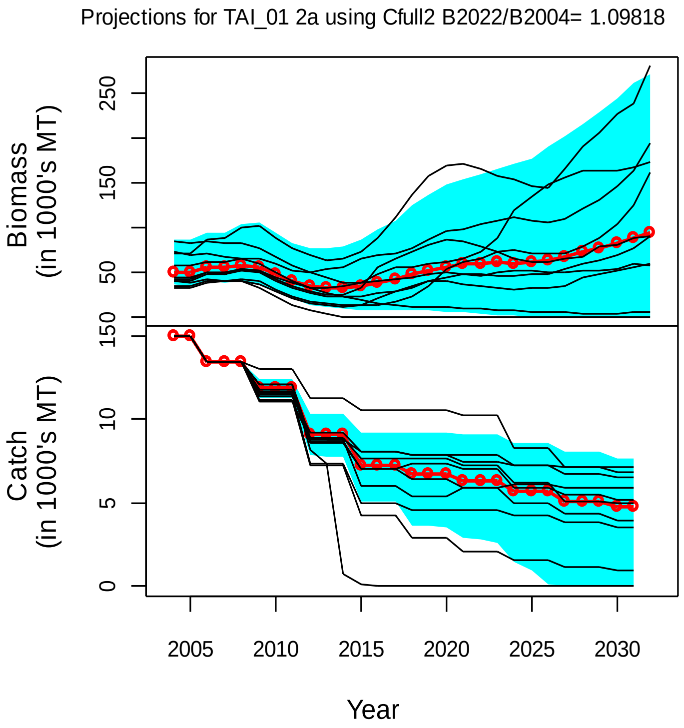


Figure 7 TAI_13 worm plot projections of biomass and catch





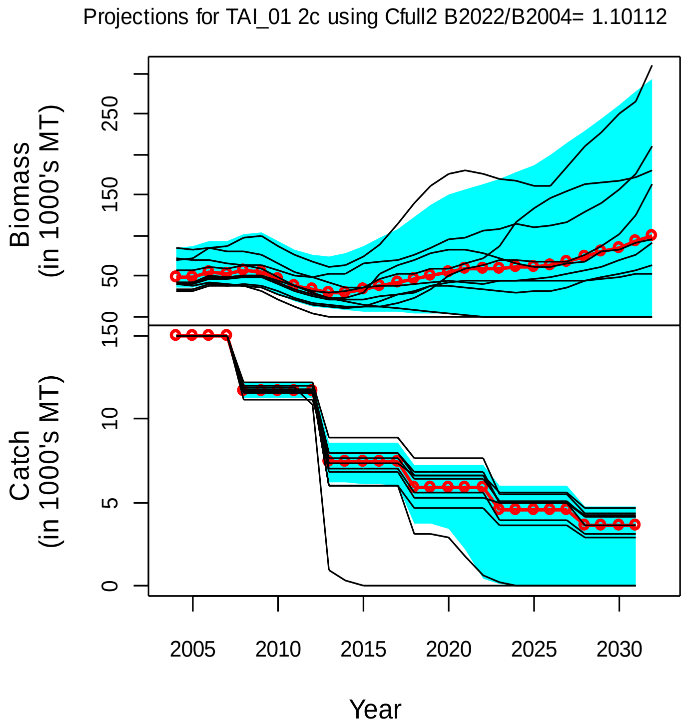


Figure 8 TAI_01 worm plot projections of biomass and catch

4. Rational Expectation of Next Period's TAC:

4a. TAI_04

Since the TAI_13 rule adjust the TAC according to the adjustment occurred in the previous period, there is a lead-lag relationship which causes the self-adjustment process come in to soften the reduction of TAC in the next period to compensate for the loss in the previous period. A rational expectation specification was used to model the expected TAC, i.e., $\%\Delta TAC_t$ is redefined as the difference between the expectation of next period's TAC, based on the CPUE-rule, and the current TACt,

$$\%\Delta TAC_{t+1} = ((w \cdot TAC_t + (1-w) \cdot TAC_t \cdot (1 + k_1\lambda_{10})) - TAC_t) / TAC_t \qquad (5)$$

The TAC in the next period is decided by equation (5) and the wormplot projections of TAI_04_2b are shown as Figure 9 and a full set of wormplot results is shown in Appendix 1.

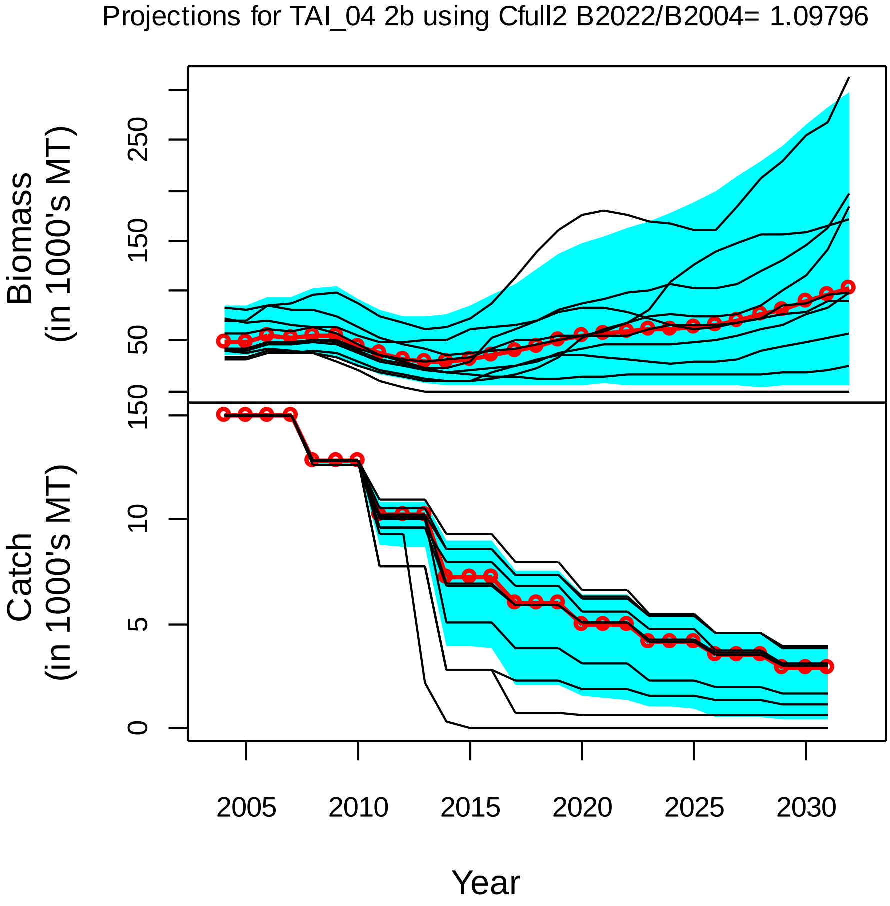


Figure 9 TAI_04 worm plot projections of biomass and catch

4b. TAI_94 (Modified from TAI_04)

As shown in the worm plot of TAI_04, the biomass ratio B2032/B2004 equals 1.7698 under 2b scheme where B2022/B2004 equals 1.1. It is reasonable to adjust the TAI_04 rule to show the flexibility after 2020 to allow the TAC adjust according to the slope of CPUE directly. TAI_94 is specified to have carryover reset to zero after 2020 to reflect the recovery of the biomass in the long run, i.e., it is necessary to release the constraint of 85% of carryover after 2022 where the biomass shown a strong recovery, such as follows,

w=0.85 if year < 2020; w=0 if year >= 2020

k2 =7 if year <2020; and k2 =0 if year >= 2020

The wormplot projections of TAI_94 are shown in Figure10 and a full set of wormplot results is shown in Appendix 1.

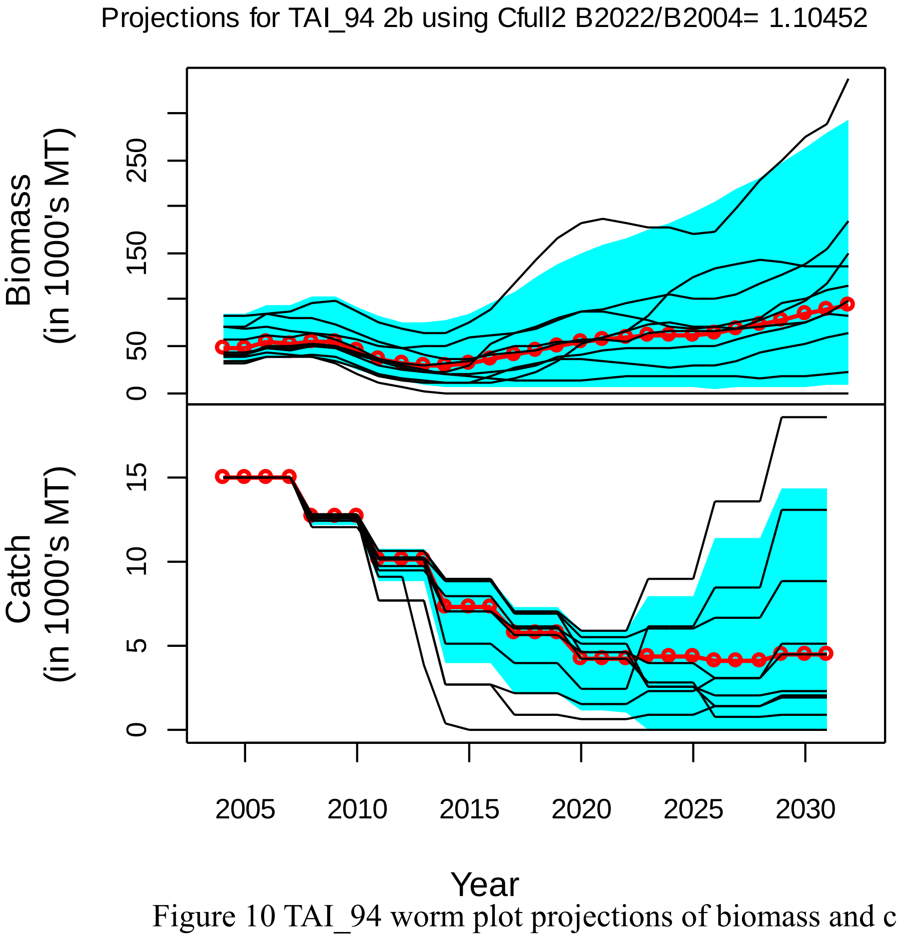


Figure 10 TAI_94 worm plot projections of biomass and catch

5. Rational Expectation without Carryover Constraints:

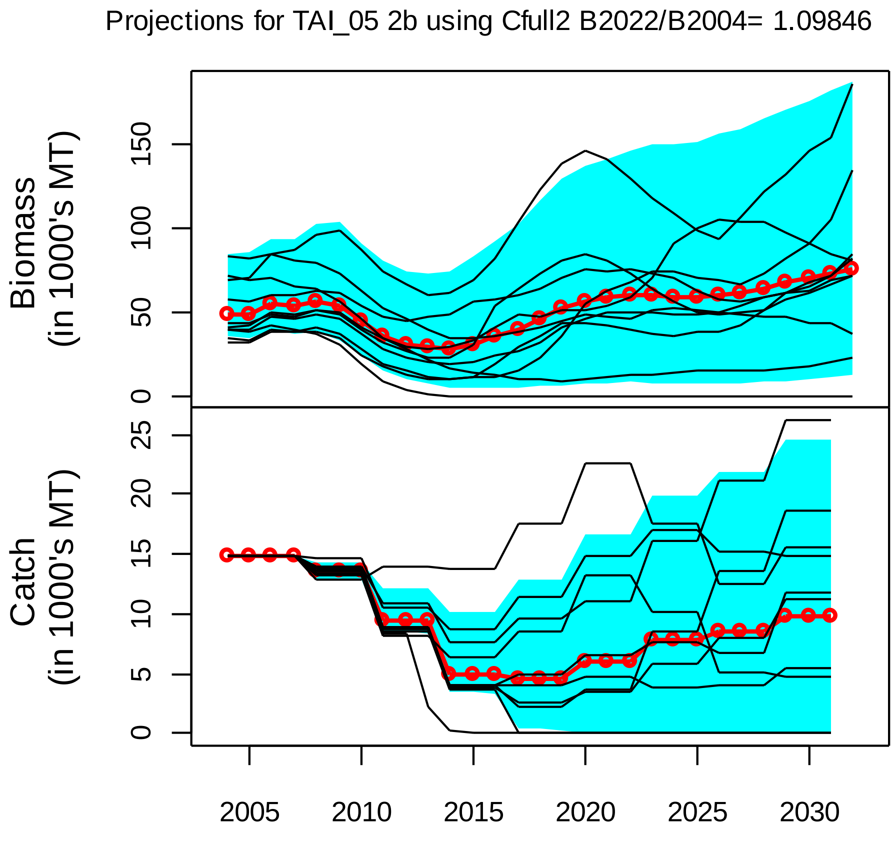
5a. TAI_05

Since the carryover parameter serves as a constraint in equation (6), it would be interesting to leave the carryover parameter as zero and let the rational expectation to work fully. Parameter k1 is hold as the same, but parameter k2 is adjust to 1.2 in the short-run during the first adjustment period, 0.5 for the following adjustment period before 2022, and zero after year 2022.

A refined specification is proposed to rewrite the TAI_03 rule defined in equation (3) into TAI_05 as follow,

$$TAC_{t+1} = \alpha \cdot [w \cdot TAC_t + (1-w) \cdot TAC_t \cdot (1 + k_1 \lambda_{10} - k_2 \% \Delta TAC_{t+1})] \qquad (6)$$

where w=0; k2 =1.2 if year <2010; k2 =0.5 if 2010<year <2020; and k2 =0 if year >2020. The wormplot projections of TAI_05 are shown as Figure 11 and a full set of wormplot results is shown in Appendix 1.



Projections for TAI_05 2b using Cfull2 B2022/B2004= 1.09846

Figure 11 TAI_05 worm plot projections of biomass and catch

5b. TAI_95

In order to provide a more predictable TAC path for the industry to follow, the TAI_05 is modified to follow the setting of TAI_94, which specified carryover rate in two stages as 0.85 and 0, to set the carryover rate as 0.85 before 2020 and zero afterward. The result is shown in Figure 12 and also in Appendix 1.

The behavior of TAI_95 has a narrower range of TAC variation than TAI_05, i.e., the interannual changes in TACs are deliberately constrained by carryover rate.

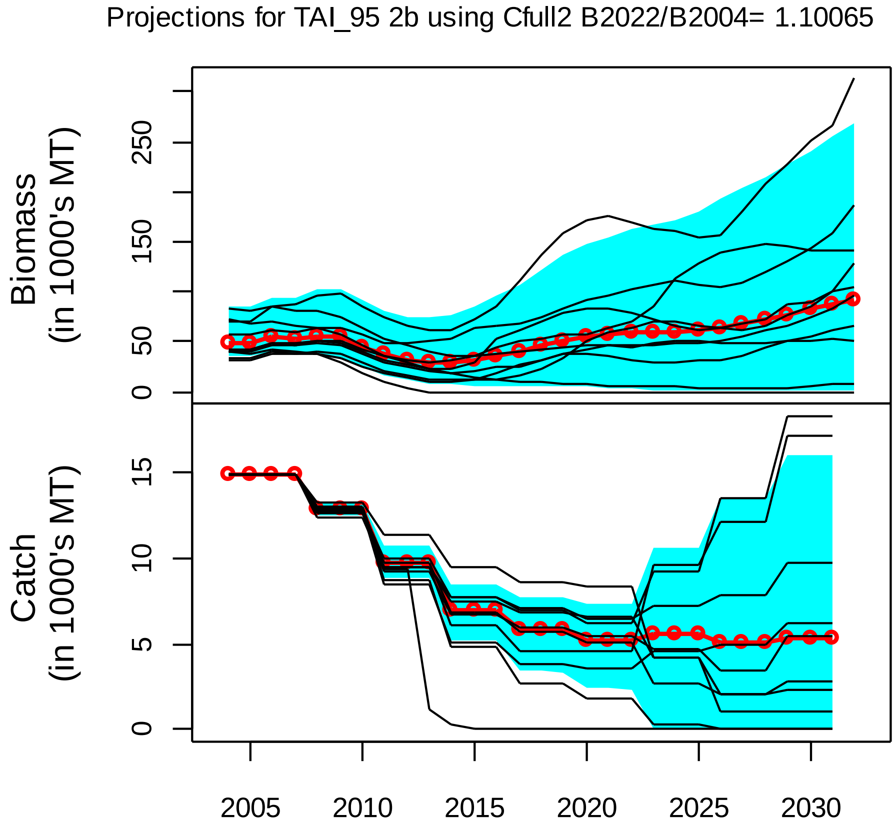


Figure 12 TAI_95 worm plot projections of biomass and catch

5c. TAI_35

It is also interesting to know the performance of TAI_05 under the carryover rate that could be classified into three stages, i.e.,

w=0.85 if year < 2010; w=0.3 if 2010 =< year < 2020; and w=0 if year >= 2020

The result is shown in Figure 13 and Appendix 1 is similar to TA_05 which could serve as an alternative to provide the Commission a choice with different weighting scheme.

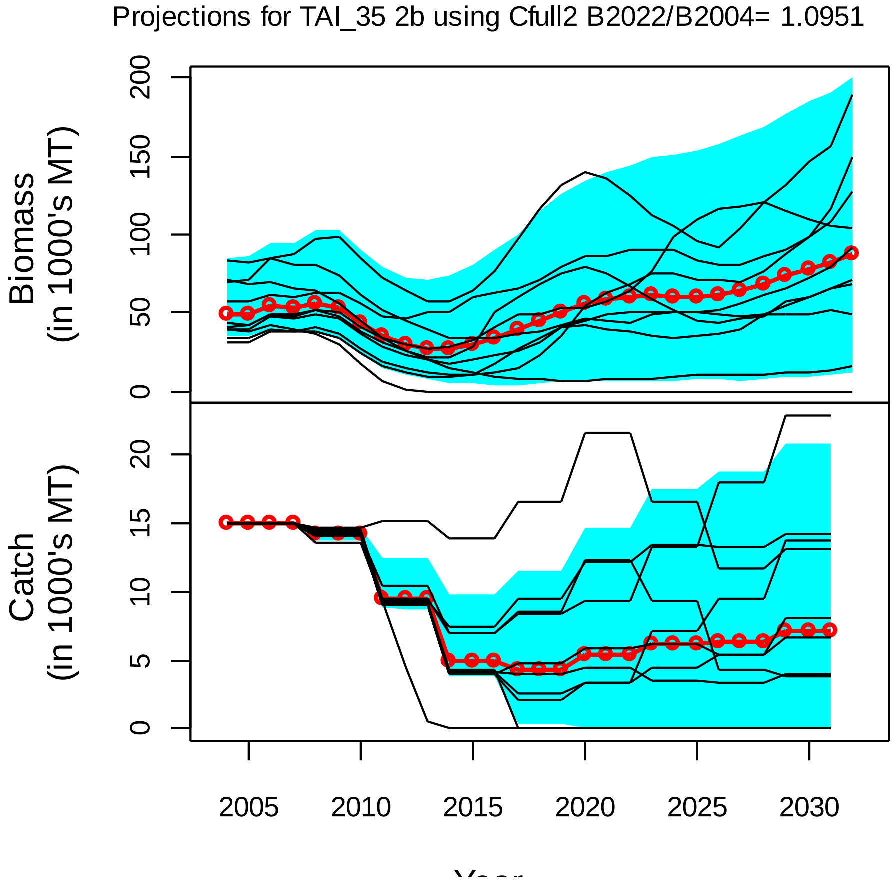


Figure 13 TAI_35 worm plot projections of biomass and catch

5d. TAI_A4

As shown in the wormplot of TAI_05, the biomass ratio B2032/B2004 equals 1.3827 under 2b scheme where B2022/B2004 equals 1.1. It is necessary to re-tune TAI_04 after 2022 to increase it's flexibility by increasing the turning parameter α to the ratio of B2032/B2004 of TAI_04 with respect to TAI_05, i.e.,

(TAI_04_B2032/B2004=1.7698) /(TAI_05_B2032/B2004=1.3827)=1.2799 and

$\alpha_{year} = 1.3 * \alpha_{2020}$ if year >= 2020

It is interesting to notice the result in Figure 14 and also in Appendix 1, a recovery of the Biomass B2032/B2004 is maintain at 1.51104 with TAC that could recover to around 10,000 MT after 2029.

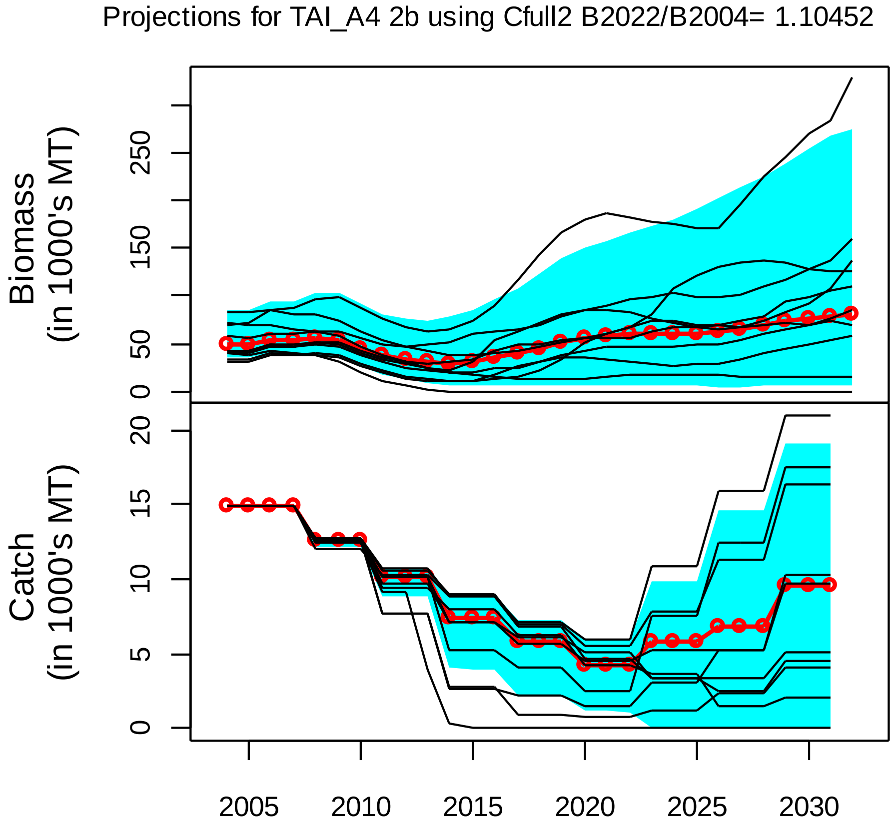


Figure 14 TAI_A4 worm plot projections of biomass and catch

The tuning parameters of various TAI_decision rules under various TAC adjustment scheme are show in Table 2.

Table 2 Tuning parameters of TAI_decison rule under various scheme

α	1b	2a	2b	2c	3b
TAI_04	0.89012	0.88405	0.84525	0.77587	0.79638
TAI_94	0.90404	0.88966	0.85859	0.79013	0.80938
TAI_05	1.02870	0.94697	0.96907	0.89308	0.90727
TAI_95	0.88072	0.87494	0.83141	0.75190	0.78277
TAI_35	0.98070	0.92611	0.92048	0.83654	0.86312
TAI_A4 (α_{2020})	0.90404	0.88645	0.85859	0.79013	0.80938

Performance Measure

The performance measures for various rules proposed in the paper are shown in Figure 15. Since the risk of low SSB, change in this risk over time, and the length of time spent at low SSB were considered to be important, this paper recommend to report the risk percentages of various rules is defined as the percentage of trails that would show the biomass in various years are lower than the lowest biomass in 2004 out of 2000 trials. The risk percentages of various TAI_decision rules is shown in Figure 16. It shows that all of the TAI_decision rules show the risk less than 5% before 2009 but would face the highest risk around 2014.

Based on the setting of reference and robustness trails, the biomass ratio (B2022/B2004) of each TAI_Decision rule under 2b scheme are shown in Table 3. The flowchart ranking of biomass ratio (B2022/B2004) of TAI_04, TAI_05 and TAI_94 under single-cell robustness tests are shown in Figure 17a, 17b and 17c, respectively.

One needs to decide how to chose a moderate MP with a preferable performance and recommend it to the Commission. TAI_05 and TAI_94, which show distinct behavior, represent flexibility vs. carryover stability, such as shown in Figure 18. These MPs, have preferable performance (i.e., they will minimize the percentage changes of TAC in the early years under the condition that the stock will recover) are recommended to the Commission.

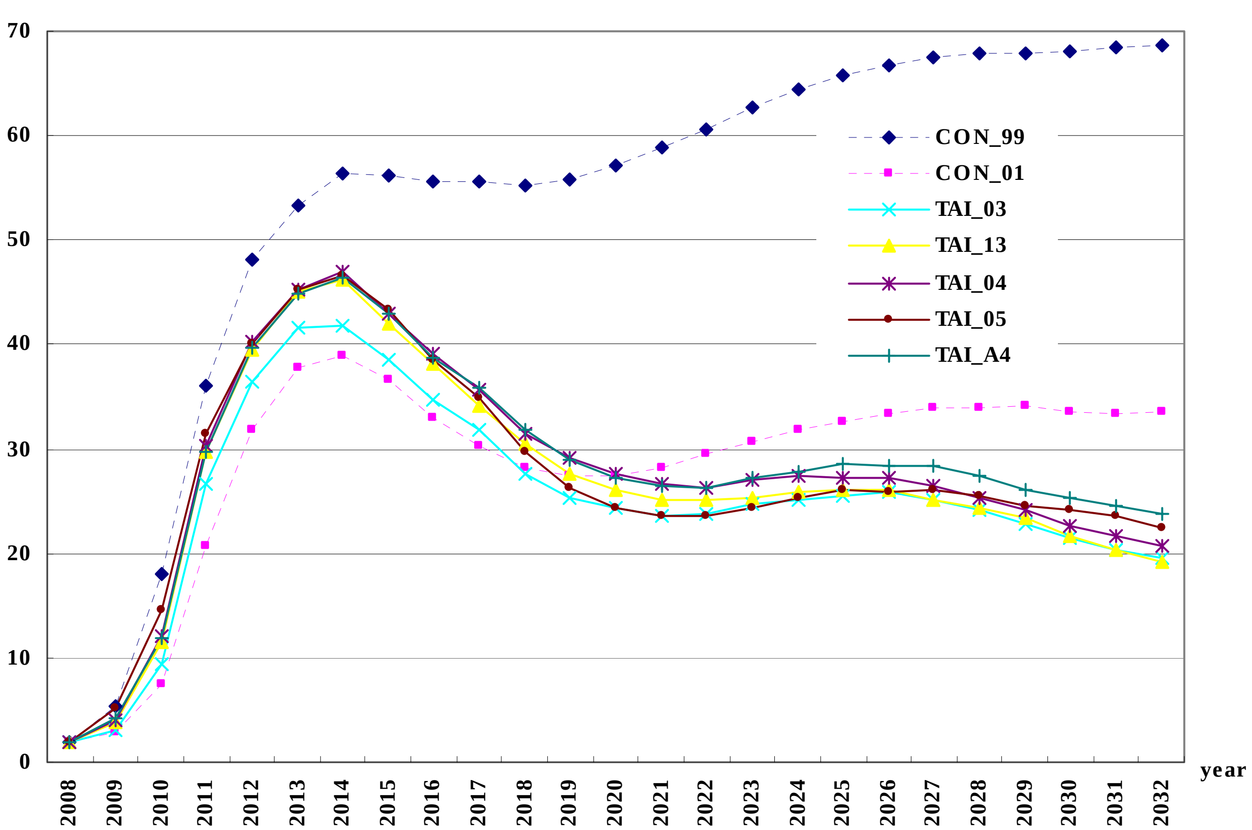


Figure16 Risk percentage of the biomass in various years which are lower than the lowest biomass in 2004 under 2b scheme

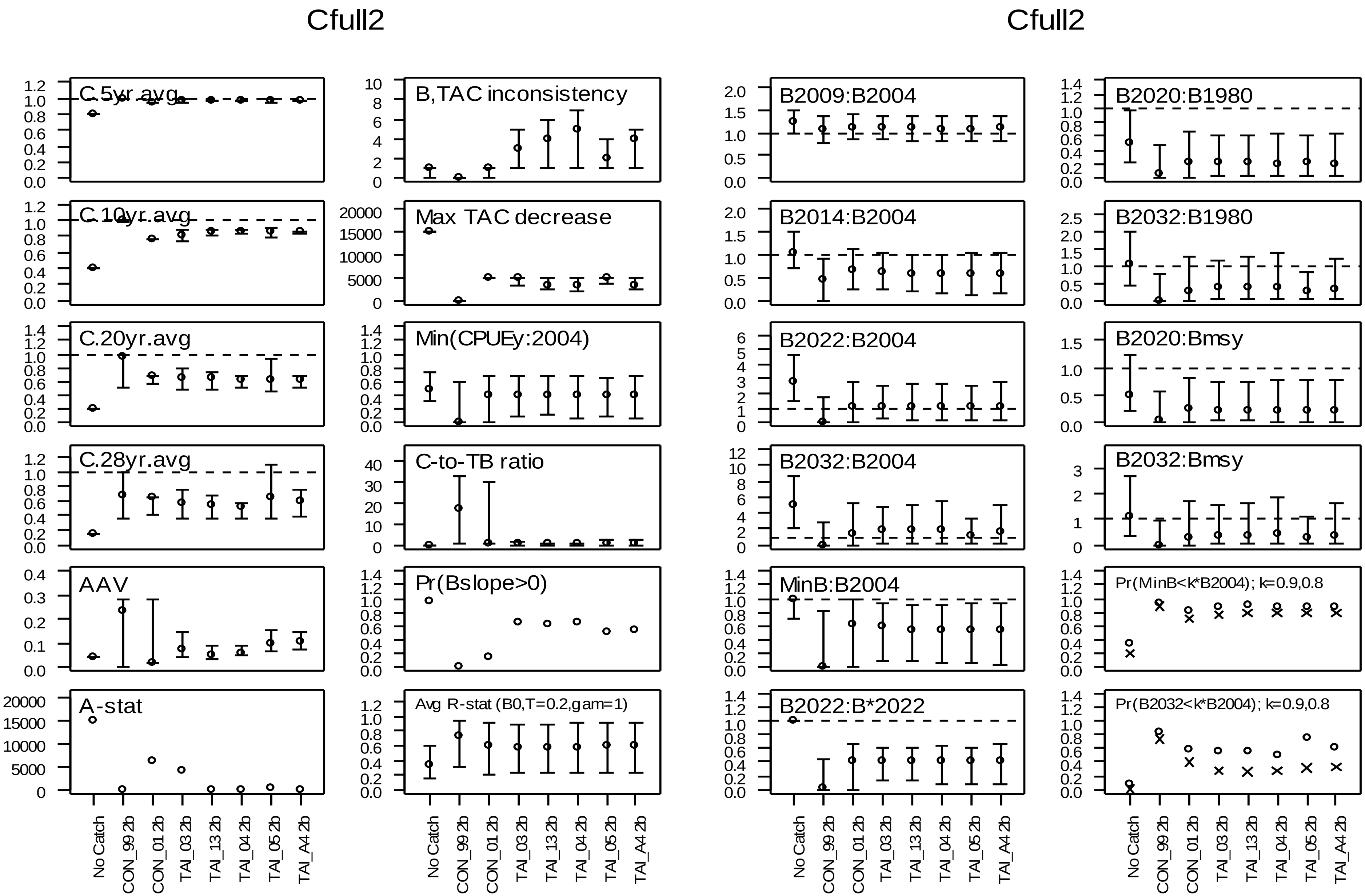


Figure 15 Performance Measure under Reference Set

Table 3 Biomass ratio (B2022/B2004) of TAI_decision rules under reference and robustness trails

Decision Rules / No. and Trial Sets		Option b: first TAC Change in 2008 then every 3 years with maximum change = 5000 and tuning level = 1.1					
		TAI_04	TAI_94	TAI_05	TAI_95	TAI_35	TAI_A4
1	**Cfull2**	1.0980	1.1045	1.0985	1.1007	1.0951	1.1045
2	Cfull3Mnotag	0.8486	0.8460	0.8753	0.8451	0.8506	0.8460
3	Cfullsqrt	1.0378	1.0421	1.0493	1.0579	1.0368	1.0421
4	Cfull2_noAC	1.2869	1.2968	1.1722	1.3299	1.2147	1.2968
5	Cfull2_lowR2	0.9423	0.9481	0.9591	0.8873	0.9161	0.9481
6	Cfull2_lowR4	0.6270	0.6306	0.6461	0.5495	0.5932	0.6306
7	Cfull2_noAC_tripleR	1.4967	1.5368	1.2839	1.5156	1.2815	1.5368
8	Cfull2_expl	1.7322	1.7719	1.4587	1.7398	1.4592	1.7719
9	C1h1m2M3O2a1sqrt_ind18	0.2223	0.2137	0.1303	0.1053	0.1746	0.2137
10	C1h2m2M3O2a1sqrt_ind18	0.9571	0.9559	1.0115	0.9186	0.9937	0.9559
11	C1h1m2M2O2a1sqrt_up20	0.6166	0.6170	0.6294	0.6260	0.6318	0.6170
12	C1h2m2M2O2a1sqrt_up20	0.9671	0.9782	0.9079	0.9775	0.8876	0.9782
13	C1h1m2M2O2a1sqrt_cc	0.6910	0.6881	0.7260	0.6965	0.7209	0.6881
14	C1h2m2M2O2a1sqrt_cc	0.9978	1.0057	0.9856	1.0193	0.9937	1.0057
15	C1h1m2M2O2a1sqrt_CU	0.5906	0.5912	0.6387	0.5834	0.6216	0.5912
16	C1h2m2M2O2a1sqrt_CU	0.9272	0.9411	0.9638	0.9242	0.9281	0.9411
17	C1h1m2M2O2a1sqrt	0.6531	0.6563	0.7022	0.6532	0.6852	0.6563
18	C1h2m2M2O2a1sqrt	1.0088	1.0300	1.0304	1.0161	1.0047	1.0300
19	C1h1m2M3O2a1sqrt	0.5983	0.5871	0.6460	0.5606	0.6362	0.5871
20	C1h2m2M3O2a1sqrt	1.2403	1.2697	1.2648	1.2463	1.2520	1.2697

*no.1 is the reference set, no. 2 to 8 are grid robustness tests, no. 9 to 20 are single-cell robustness tests.

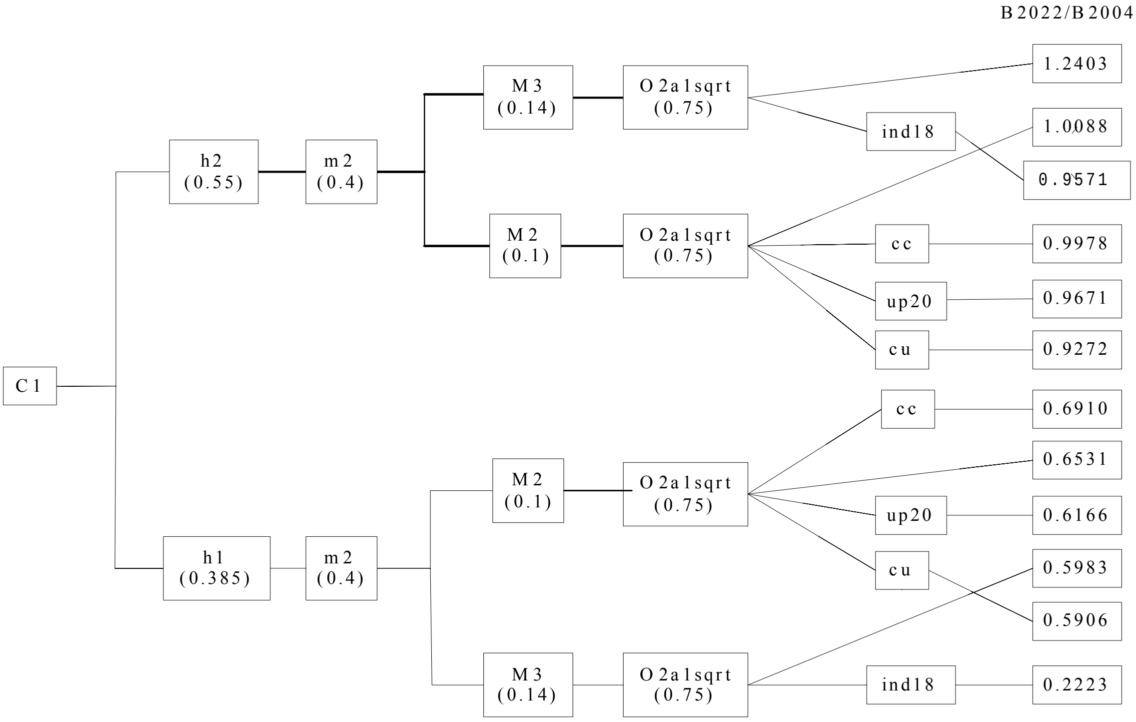


Figure 17a Biomass ratio (B2022/B2004) of TAI_04 under single-cell robustness tests

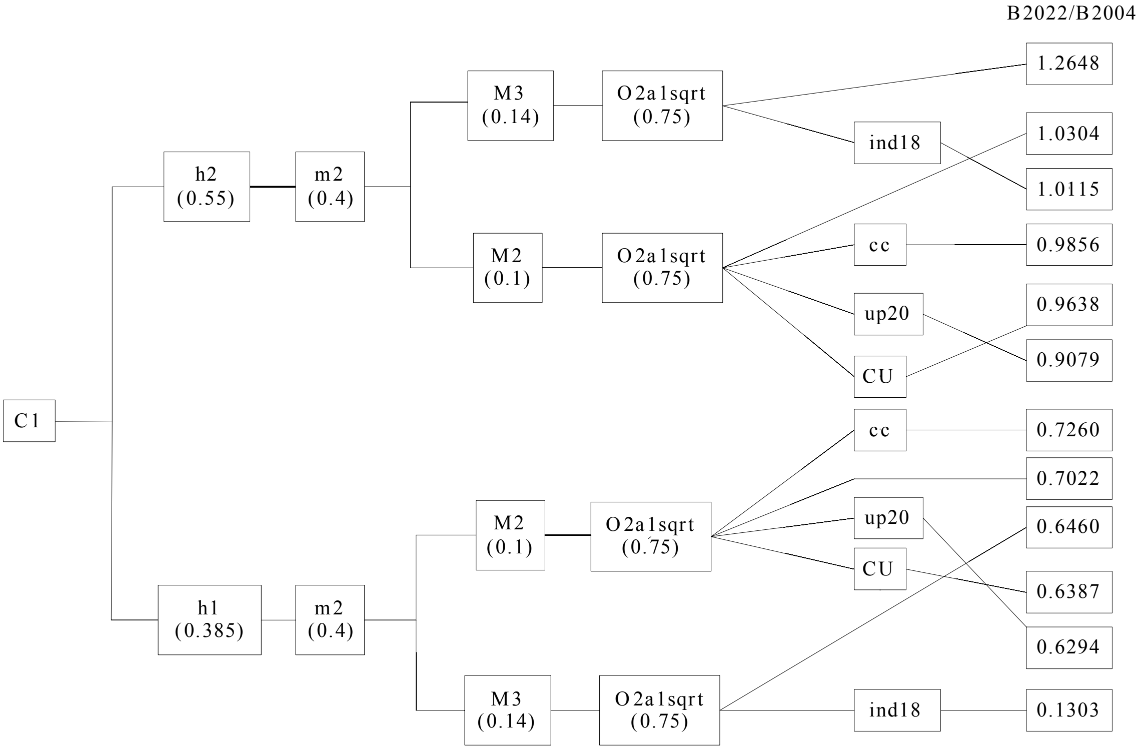


Figure 17b Biomass ratio (B2022/B2004) of TAI_05 under single-cell robustness tests

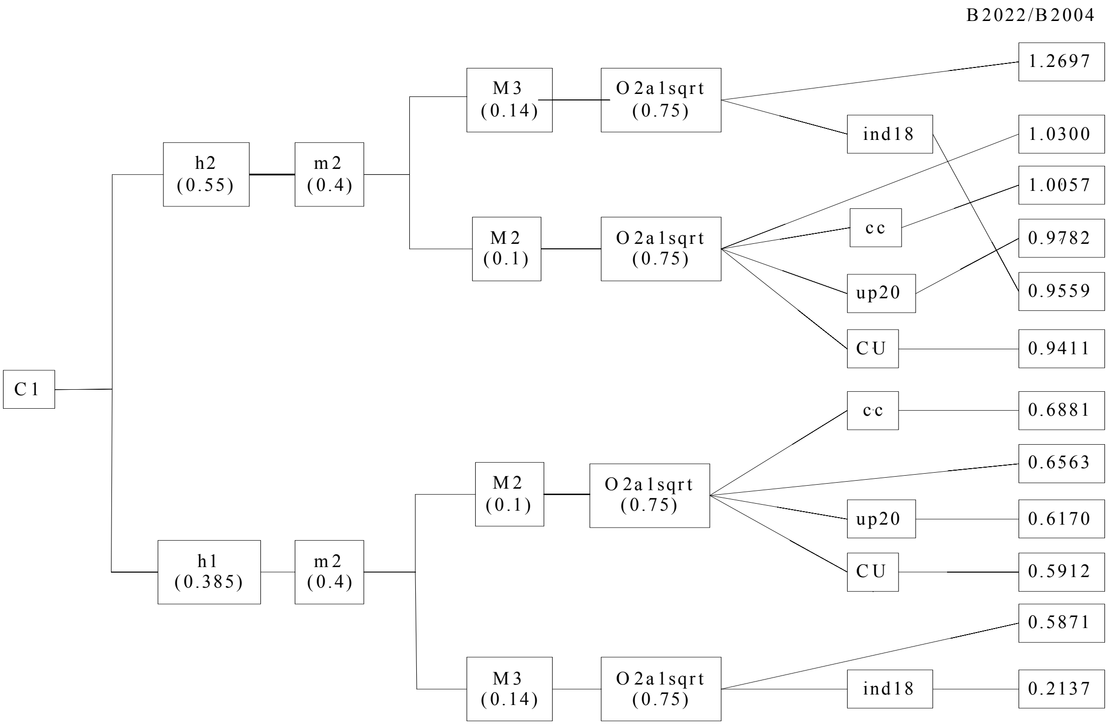


Figure 17c Biomass ratio (B2022/B2004) of TAI_A4 under single-cell robustness tests

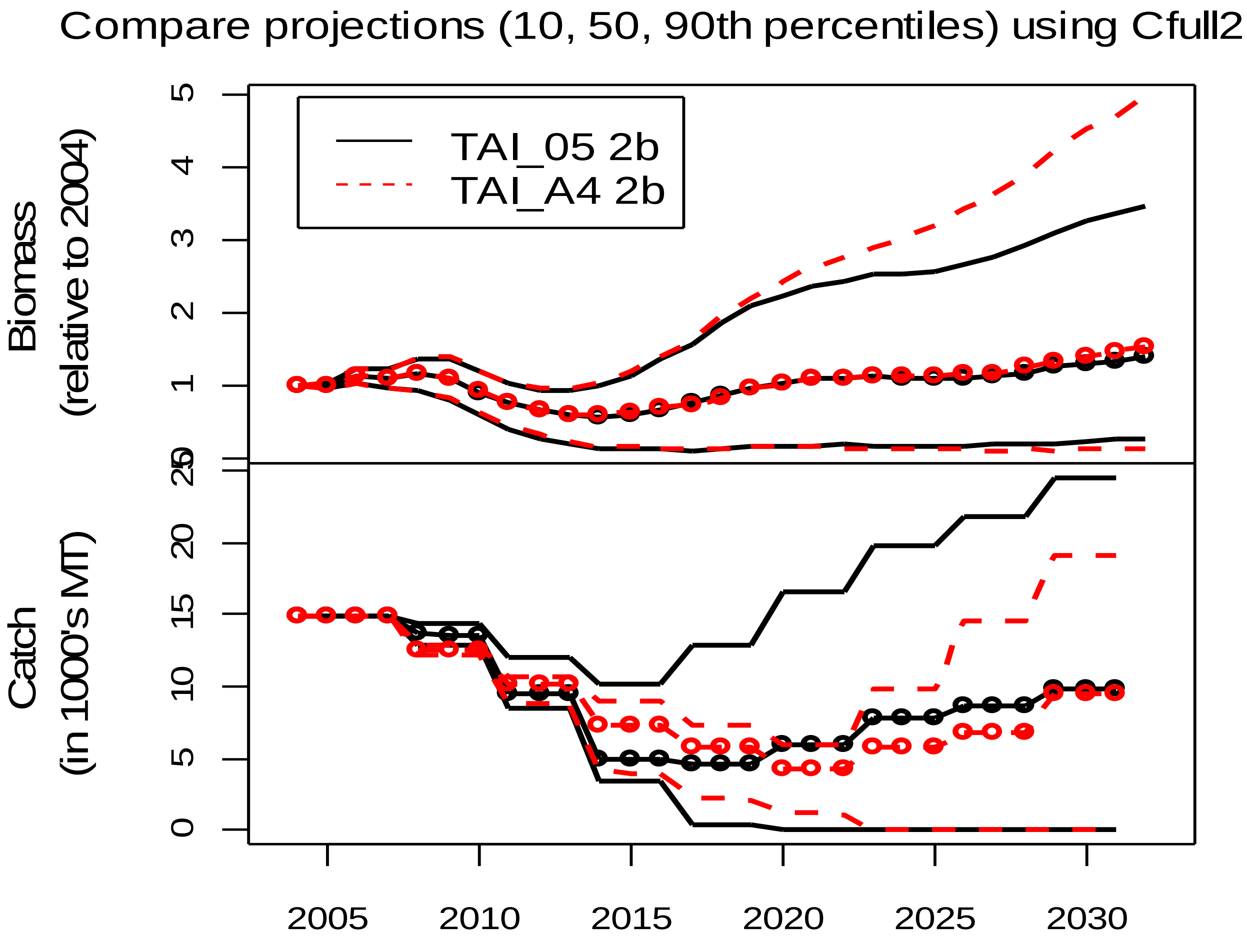


Figure 18 Median and 10th and 90th percentiles for the preferred candidate MP (TAI_05 and TAI_A4) under the B2022/B2004 = 1.1

Conclusion and Discussion

Based on the updated reference set applied to the Seattle 2005 trials, the biomass in 2022 would accounts for only 5.29% of the biomass in 2004 if the TAC was not adjusted soon, i.e., by assuming the "operating models" are true and the mother nature of the SBT will respond accordingly, the median biomass ratio would lower to 0.0528676, if we hold the TAC at 14,930 MT. It is clear that the updated reference set tends to give us a more pessimistic scenario than the reference set specified in the MP III meeting, which didn't include the updated data from 2001 to 2003.

As expressed in the Special Meeting of the Extended Commission meeting in April 2004, the objective in rebuilding the stock is supported under MP in general. From a manager's point of view, the need for developing a management procedure soon indicates an early minor adjustment would prevent dramatic losses in the future, i.e., the stability of TAC in the short run is more desirable than shut down the fishery instantly. Therefore, the objectives of the MP should be set differently based on different time periods.

In the short run, the objective of the MP is to minimize the percentage change of TAC that would reduce the deadweight loss of the industry and consumers and had already considered the recovery of the biomass in the long run.. For example, under the three-year TAC adjusting frequency setting, the sunk cost is too high to the industry that could not decommission their vessels in the short run, i.e., first couple adjusting periods.

Since the biomass ratio tuning target is set as B2022/B2004, it is recommended to adjust fully during the intermediate run, i.e., from around 2014 to 2022 which will represent the third and forth adjusting periods if we adjust TAC starting from 2008.

In the long run, it is not meaningful to compare the median biomass ratio after 2022, since there are too much uncertainty accumulated over time and the confidence interval of both biomass and catch are too big to conclude how high/low of the median biomass ratio. If the biomass will recover after 2022, it is wise that we should try to discuss a fair and efficient way to avoid overcapacity again.

By comparing various candidate management procedures, it is not a wise choice to set a dramatic reduction of TAC in the first period. For example, under the CON_01 rule, even though the biomass in 2022 could be tuned to 0.9, 1.1, and 1.3, respectively, of the biomass in 2004, there is a greater risk after 2022 that the biomass would totally collapse. The CON_01 rule shows a drawback that there is no mechanism to further adjust TAC after 2022 and there is no consideration of possibility of various adjusting path under various biomass status.

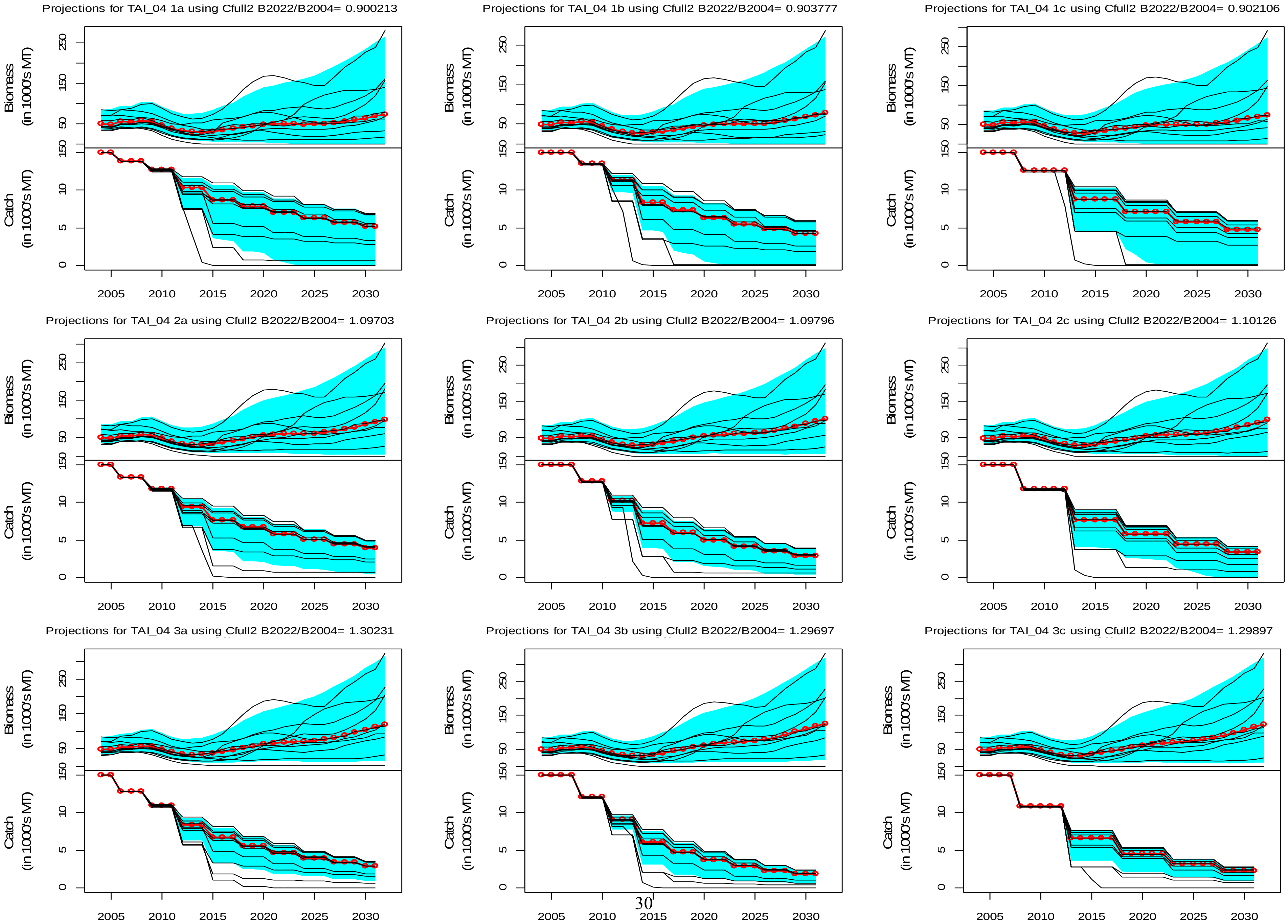
Risk of low SSB, change in this risk over time, and the length of time spent at low SSB were considered to be important. Under the condition that the stock will recover to the tuning target level, the TAI_05 and TAI_A4 decision rules, which minimize the percentage change of TAC in the early years and to prevent overcapitalization again in the long run, are recommended as a moderate MP with a preferable performance to recommend to the Commission. TAI_05 and TAI_94 show distinct behavior that represent flexibility vs. carryover stability are recommended to the Commission and it is urgent to initiate Management Procedure as soon as possible to prevent dramatic losses in the near future.

Reference

Polacheck, T., P. Eveson, J. Hartog, M. Basson, and D. Kolody, 2004, Comparison of the performance of tuned candidate management procedures for southern bluefin tuna based on the final trial specifications and testing procedures, CCSBT-04/MP/0404/07

Sun, Chin-Hwa, 2004, Selection of the decision rules of management procedures for southern bluefin tuna, CCSBT-04/MP/0404/07.

APPENDIX 1. Results from TAI_decision Rules under Updated Reference Set



Projections for TAI_04 1a using Cfull2 B2022/B2004= 0.900213

Projections for TAI_04 1b using Cfull2 B2022/B2004= 0.903777

Projections for TAI_04 1c using Cfull2 B2022/B2004= 0.902106

Projections for TAI_04 2a using Cfull2 B2022/B2004= 1.09703

Projections for TAI_04 2b using Cfull2 B2022/B2004= 1.09796

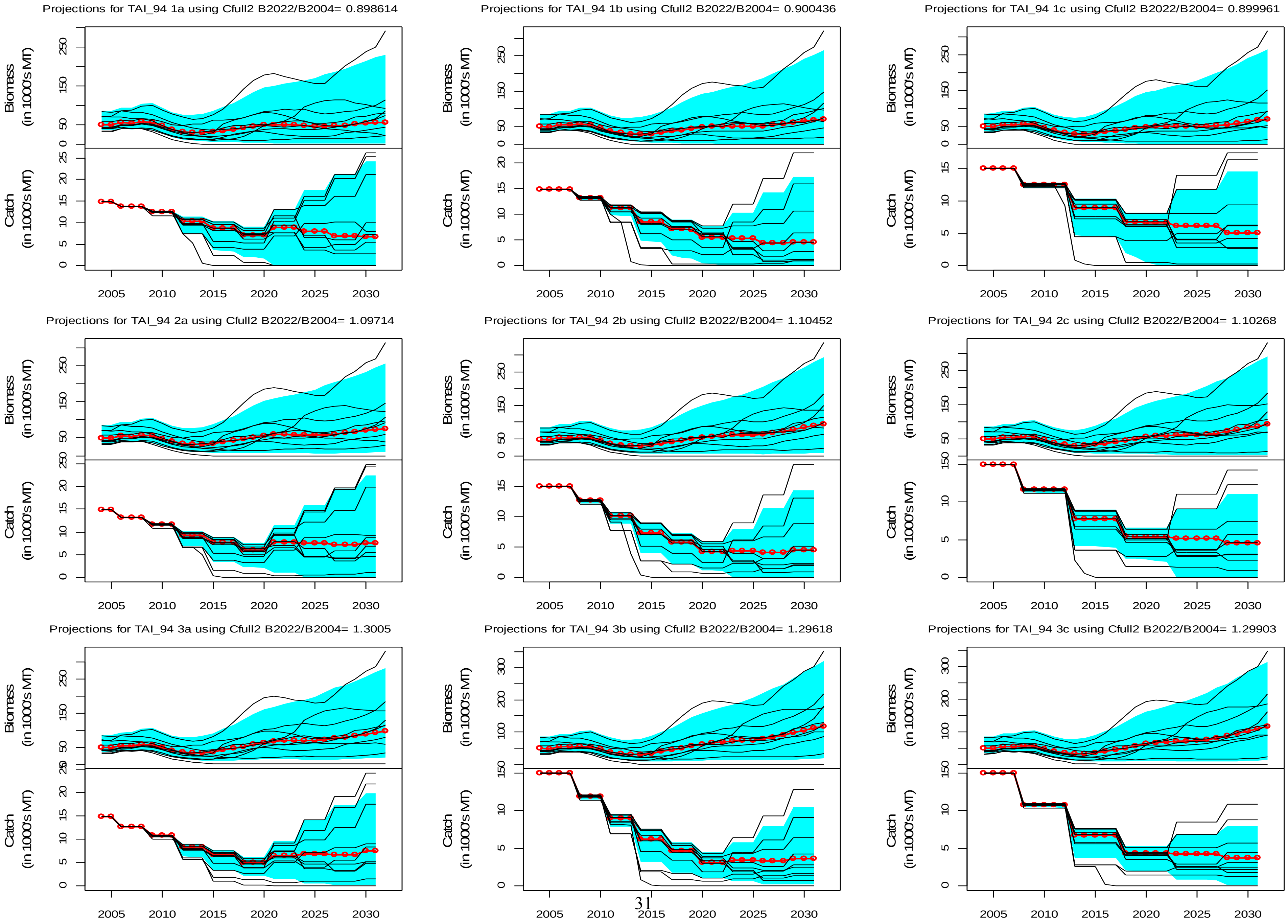
Projections for TAI_04 2c using Cfull2 B2022/B2004= 1.10126

Projections for TAI_04 3a using Cfull2 B2022/B2004= 1.30231

Projections for TAI_04 3b using Cfull2 B2022/B2004= 1.29697

Projections for TAI_04 3c using Cfull2 B2022/B2004= 1.29897

Figure A1 TAI_04 worm plot projections of biomass and catch



Projections for TAI_94 1a using Cfull2 B2022/B2004= 0.898614

Projections for TAI_94 1b using Cfull2 B2022/B2004= 0.900436

Projections for TAI_94 1c using Cfull2 B2022/B2004= 0.899961

Projections for TAI_94 2a using Cfull2 B2022/B2004= 1.09714

Projections for TAI_94 2b using Cfull2 B2022/B2004= 1.10452

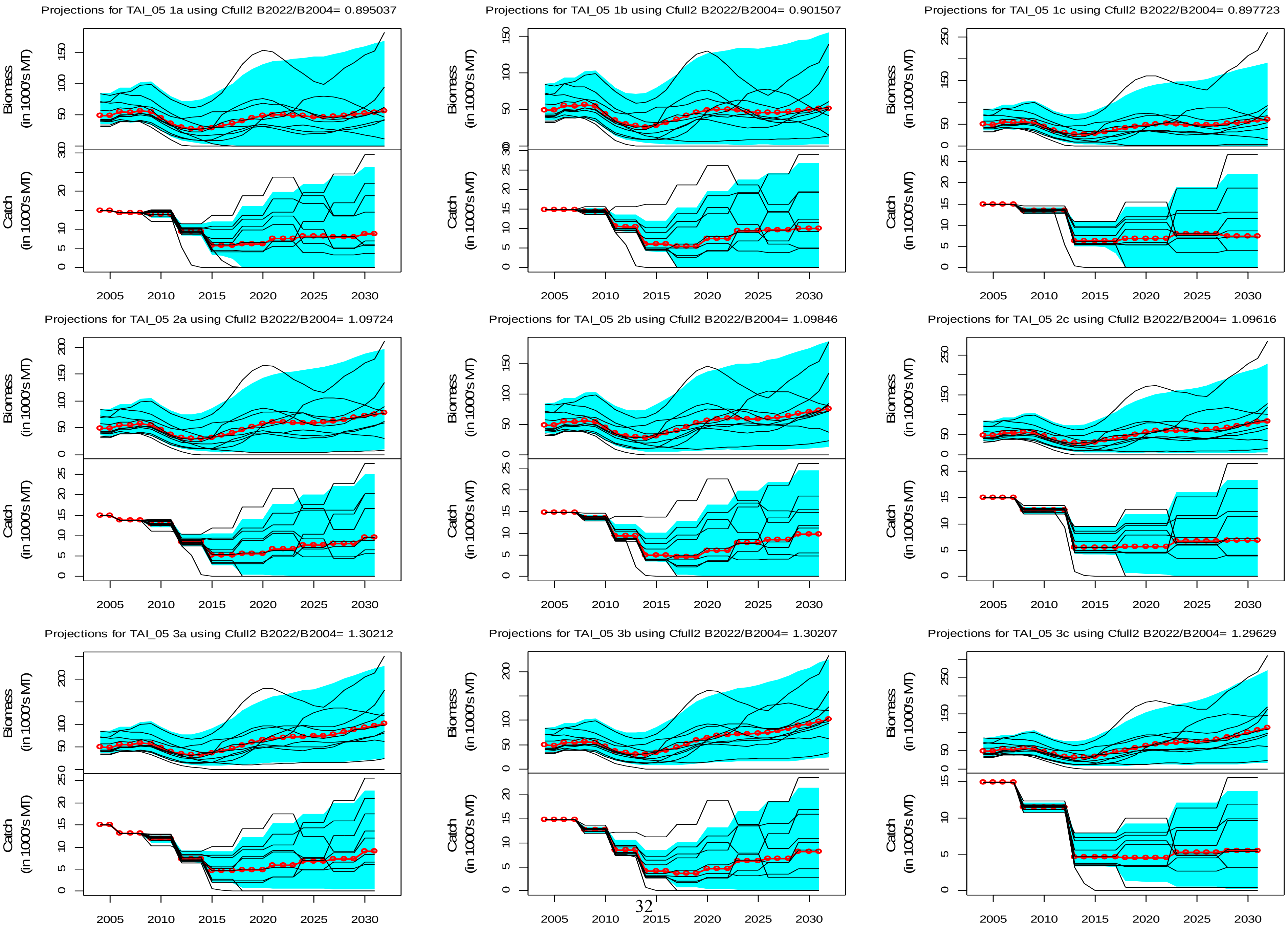
Projections for TAI_94 2c using Cfull2 B2022/B2004= 1.10268

Projections for TAI_94 3a using Cfull2 B2022/B2004= 1.3005

Projections for TAI_94 3b using Cfull2 B2022/B2004= 1.29618

Projections for TAI_94 3c using Cfull2 B2022/B2004= 1.29903

Figure A2 TAI_94 worm plot projections of biomass and catch


Projections for TAI_05 1a using Cfull2 B2022/B2004= 0.895037

Projections for TAI_05 1b using Cfull2 B2022/B2004= 0.901507

Projections for TAI_05 1c using Cfull2 B2022/B2004= 0.897723

Projections for TAI_05 2a using Cfull2 B2022/B2004= 1.09724

Projections for TAI_05 2b using Cfull2 B2022/B2004= 1.09846

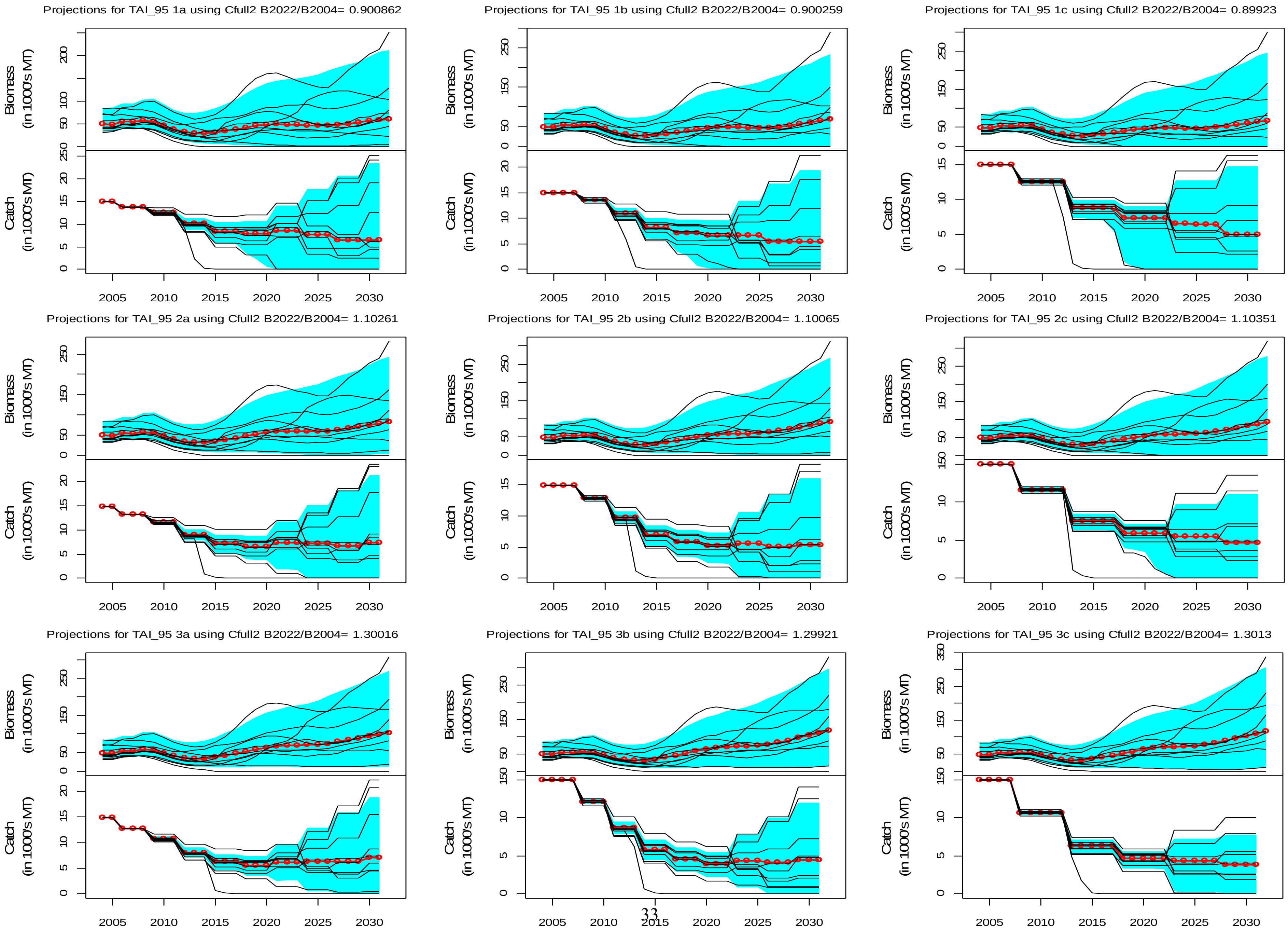
Projections for TAI_05 2c using Cfull2 B2022/B2004= 1.09616

Projections for TAI_05 3a using Cfull2 B2022/B2004= 1.30212

Projections for TAI_05 3b using Cfull2 B2022/B2004= 1.30207

Projections for TAI_05 3c using Cfull2 B2022/B2004= 1.29629

Figure A3 TAI_05 worm plot projections of biomass and catch



Projections for TAI_95 1a using Cfull2 B2022/B2004= 0.900862

Projections for TAI_95 1b using Cfull2 B2022/B2004= 0.900259

Projections for TAI_95 1c using Cfull2 B2022/B2004= 0.89923

Projections for TAI_95 2a using Cfull2 B2022/B2004= 1.10261

Projections for TAI_95 2b using Cfull2 B2022/B2004= 1.10065

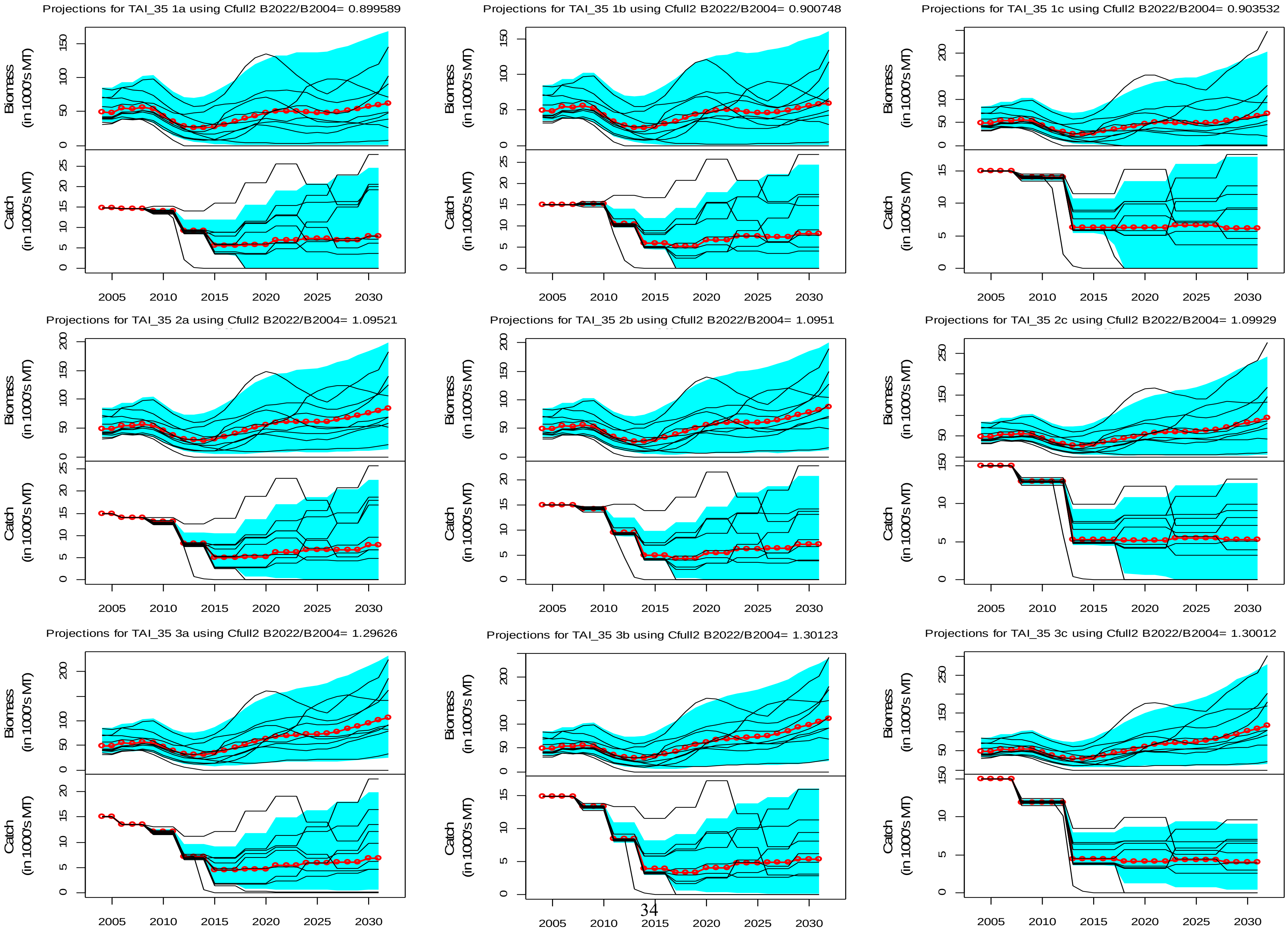
Projections for TAI_95 2c using Cfull2 B2022/B2004= 1.10351

Projections for TAI_95 3a using Cfull2 B2022/B2004= 1.30016

Projections for TAI_95 3b using Cfull2 B2022/B2004= 1.29921

Projections for TAI_95 3c using Cfull2 B2022/B2004= 1.3013

Figure A4 TAI_95 worm plot projections of biomass and catch



Projections for TAI_35 1a using Cfull2 B2022/B2004= 0.899589

Projections for TAI_35 1b using Cfull2 B2022/B2004= 0.900748

Projections for TAI_35 1c using Cfull2 B2022/B2004= 0.903532

Projections for TAI_35 2a using Cfull2 B2022/B2004= 1.09521

Projections for TAI_35 2b using Cfull2 B2022/B2004= 1.0951

Projections for TAI_35 2c using Cfull2 B2022/B2004= 1.09929

Projections for TAI_35 3a using Cfull2 B2022/B2004= 1.29626

Projections for TAI_35 3b using Cfull2 B2022/B2004= 1.30123

Projections for TAI_35 3c using Cfull2 B2022/B2004= 1.30012

Figure A5 TAI_35 worm plot projections of biomass and catch

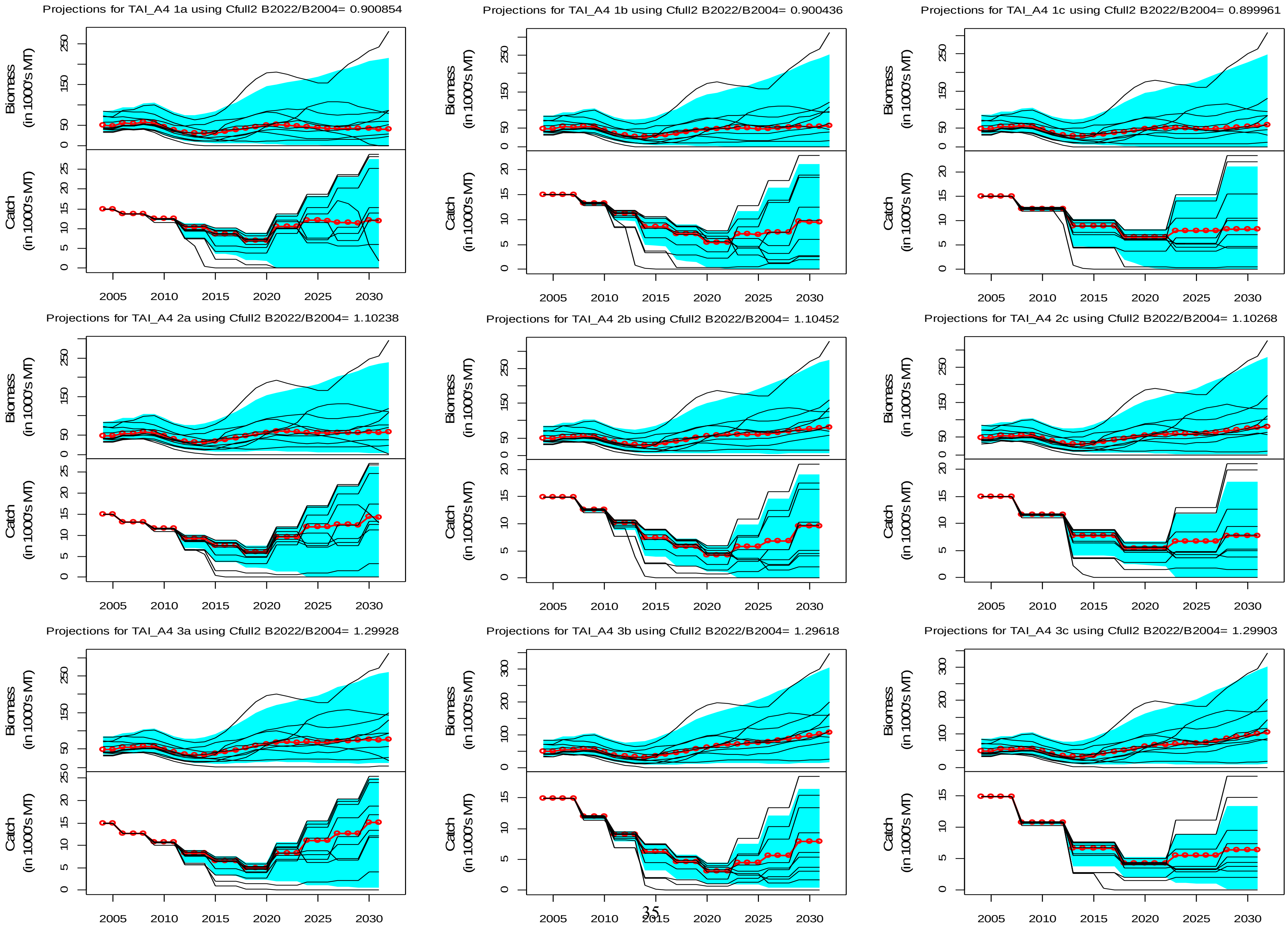


Figure A6 TAI_A4 worm plot projections of biomass and catch