Commission for the Conservationof
Southern Bluefin Tuna

みなみまぐろ保存委員会

Report of the Third Operating Model and Management Procedure Technical Meeting

21 – 25 June 2010
Seattle, USA

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Opening

1. The Chair of the Third Operating Model and Management Procedure Technical Meeting (OMMP), Dr. Ana Parma opened the meeting and welcomed participants.
2. Participants introduced themselves. The list of participants is at **Attachment 1**.
3. The chair drew the attention of the meeting to the Terms of Reference of the OMMP and asked for any changes to the proposed agenda. The draft agenda was adopted (**Attachment 2**).
4. No additional documents had been received to those listed in **Attachment 3**. By prior agreement the meeting was paperless with all documents available on the CCSBT website. Dr. James Ianelli agreed to co-ordinate the preparation of the report.

Agenda Item 1. Discuss input from the Strategy and Fisheries Management Working Group meeting in April

1.1 Tuning options and short-term check points

5. The second meeting of the CCSBT Strategy and Fisheries Management Working Group (SFMWG) held in April 2010 proposed six tuning options defined in terms of the probability of achieving an intermediate rebuilding target established at 20% of SSB_0 in 25 or 30 years. The SFMWG also set short-term check points to evaluate the probability of rebuilding to 10% of SSB_0 and to twice SSB_{2009} as projected by the OM.
6. The specific tuning options and short-term check point years are:

Tuning option	Tuning Year	$P(SSB \geq 0.2\ SSB_0)$	Short-term check-point year
1	2035	60%	2022
2	2035	70%	2022
3	2035	90%	2022
4	2040	60%	2025
5	2040	70%	2025
6	2040	90%	2025

1.2 Maximum - minimum TAC changes

7. The SFMWG requested examination of two options for maximum TAC changes: 3000 t and 5000 t, with minimum changes of 100 t.

1.3 Schedule of TAC changes and lags

8. The OMMPWG noted that the SFMWG proposed 3 year changes to the TAC and agreed to explore the difference between 2 and 3 year TAC changes in terms of the implications for TAC cuts.

9. Examination of a lag of one year in addition to no time lag option between calculation of a TAC and implementation was requested by the SFMWG. The control file provides four options for how frequently TACs are changed:

   Option (a): first TAC for 2012, then every year with no lag;
   Option (b): first TAC in 2012, then every other year with no lag;
   Option (c): first TAC in 2012, then every three years with no lag.
   Option (d): first TAC in 2013, then every three years with one-year lag.

   The SFMWG requested MP testing under options (c) and (d).

10. In all cases, the first TAC would be calculated in 2011, using CPUE data up to year 2010 and aerial survey data to year 2011.[1] All data up to year 2008 correspond to actual historical data. In addition the actual catch up to 2009 and the TAC for 2010 and 2011 is available (see paragraph 26). The table below shows the schedule and data available for the two new options requested:

	Year of data availability				Option c		Option d	
Decision year	Catch data from OM	Anticipated catch from TACs	CPUE data from OM	Aerial survey data from OM	TAC Year	TAC change?	TAC Year	TAC change?
			2007	**2008**	2009	hardwired	2009	hardwired
			2008	**2009**	2010	hardwired	2010	hardwired
2010	2009	2010	**2009**	**2010**	2011	hardwired	2011	hardwired
2011	2010	2011	2010	2011	2012	Yes	2012	average of 2010-2011
2012	2011	2012	2011	2012	2013	No	2013	Yes
2013	2012	2013	2012	2013	2014	No	2014	No
2014	2013	2014	2013	2014	2015	Yes	2015	No
2015	2014	2015	2014	2015	2016	No	2016	Yes
2016	2015	2016	2015	2016	2017	No	2017	No

* Years in boldface type indicate actual data (i.e. not the data generated by OM). In the tests conducted prior to the meeting the 2010 aerial survey index and the CPUE for 2009 were simulated by the OM. These data are available now (based on RTMP in the case of CPUE) and will be used in future testing.

1.4 Further issues and requests

11. The report from the SFMWG states that "MP testing of early TAC changes were preferred over late TAC changes."

12. A request was made to the Extended Scientific Committee (ESC) to estimate the level of available (replacement) yield when the interim reference rebuilding target (20% SSB_0) is reached, while noting that SSB_{msy} is the long term target. The meeting discussed alternatives for evaluating the replacement yield at 20%SSB_0 within the MP evaluation framework. A possible approach is to

[1] In this document CPUE refers to catch rates conventionally calculated from longline data for Japanese, NZ charter vessels and Australian joint venture operations.

conduct constant-catch projections using the OM reference set for an additional 100 years after the tuning year (2035 or 2040).

13. A request was also made for an estimate of MSY. The OMMPWG noted that code is available to calculate deterministic MSY using current growth, selectivity, and allocations, and was used at SC14 (2009) to report MSY reference points. However, it was noted that accurate MSY reference points are affected by changes in growth, selectivity, and TAC allocations. As a result calculations are complex. Consequently, given the amount of work involved in MP development member scientists would be unable to satisfy these requests to report results at the next ESC.

Agenda Item 2. Operating model and data inputs

2.1 Changes to scientific aerial survey specifications in conditioning

14. In the past, the scientific aerial survey data were standardised with respect to the mean of the series which was inconsistent with the assumed likelihood formulation. A decision was made to use the raw data (not standardised by the average), and the indices used for conditioning the OM and their covariances were re-computed accordingly.

15. The meeting reviewed the operating model specification for the aerial survey and found that the Tau parameter estimate (i.e., the additional process error variance parameter) was too high. This effectively downweighted the information from the aerial survey relative to the more heavily weighted CPUE index. This process-error parameter was subsequently fixed at 0.18 in conditioning, corresponding to a standard deviation of 0.30 on average when combined with the pre-specified sampling errors for each year.

16. This increased weight given to the aerial survey data tended to reduce the instability in the marginal distributions of the steepness parameter as new data were added (see paragraph 40 below).

2.2 CPUE data used in conditioning

17. A discussion section of the CPUE Working Group is presented in **Attachment 5**.

18. As agreed at the March CPUE web meeting an updated CPUE series based on the basecase model and two robustness series were provided (1986-2009 Japanese and NZ longline). The longline CPUE data for age 4+ are used in conditioning the Operating Model (OM) and form the main abundance index for operation of the management procedures (MPs).

19. At this meeting the WG discussed the choice of final model for the CPUE series and a number of outstanding issues that needed to be resolved:

- Being able to explain the high 2008 (and 2009) CPUE value by further investigation of the data and model used for standardisation
- Investigations of possible post 2006 changes in longline fleet behaviour with respect to the spatial distribution and amount of effort deployed
- The development of a set of meta-rules to indicate when the CPUE model used for the MP needs to be reviewed.

20. The participants reviewed a variety of considerations affecting the CPUE data based on results presented in WP08, WP09, and WP11. There was concern that

the selected CPUE model included interaction terms (year x area) that contributed substantially to the increase in the standardized LS-mean CPUE index in 2008. Since this indicated that the increase was primarily derived from the way the model was specified, the meeting requested that a stepwise presentation of model complexity be conducted to examine which terms contributed to the large differences seen between the nominal CPUE and that from the model (Fig. 1 in WP11).

21. It was agreed that the basecase CPUE series would be used for testing MPs. This model cannot, however, be used before 1986. Currently, the pre 1986 CPUE W0.8 and W0.5series are based upon the GLM model (Nishida and Tsuji 1998) and the new series calibrated to this.

22. It was noted that replacing the old series by one fitted using the base model applied to all vessels between 1986-2008 would be more consistent and the implications of such a substitution will be investigated intersessionally.

23. In either case it was agreed that the pre-1986 series used in MP implementation will be fixed at the values estimated based on data to 2008 only. Calibration would thus in future always be based upon the 1986-2008 points of this series.

24. Members were requested to provide papers to the ESC on meta-rules for CPUE series.

2.3 Availability of 2009 catch and CPUE data, and 2010 scientific aerial survey index to replace simulated data in MP testing

25. The 2009 CPUE and 2010 aerial survey data are available and are to be used to replace the simulated data.

26. The following catches were used in the tests conducted prior to the meeting. The 2009 TAC will be replaced by actual 2009 catches. The actual 2010 scientific aerial survey index and CPUE for 2009 will also be included in revised MP testing by the end of June.

Year	Total TAC	LL1	LL2	Spawning	Surface
2009	11810.00	4645.40	1133.55	789.03	5242.02
2010	9363.44	3666.15	1020.20	679.62	3997.48
2011	9534.56	4164.17	688.09	684.82	3997.48

2.4 Other issues encountered during preparation of OM scenarios

2.4.1 Assumptions about steepness

27. CCSBT-OMMP/1006/12 was presented to the WG. In this paper, the conditioning process for the Operating Model (OM) was updated with two changes from 2009 by (1) the inclusion of longline CPUE data from 2007 and 2008; and (2) a revision of the aerial survey index. The updated reference set showed a shift towards higher values of steepness which resulted in more optimistic projections.

28. It was noted that the results of WP12 indicated that the marginal distribution of steepness (critical in the projected stock productivity in simulations) may have been sensitive to the addition of one data point. However, it was also noted that the revised treatment of the aerial survey data affected steepness.

29. The interaction between the 2008 CPUE data point and the treatment (in terms of statistical weightings; see paragraph 15) of the aerial survey data, and its impact on the marginal distribution of the stock recruitment steepness parameters was discussed at length.

30. The WG investigated changes in the marginal distribution of steepness (using the 5 steepness values agreed in 2009) associated with the addition of the 2008 CPUE data point and how much weight is given to the aerial survey. When a fixed and lower variance for the aerial survey data (as described in paragraph 15) was used in conditioning, the resulting reference set did not show an appreciably different preference for higher steepness.

31. In an effort to stabilize the likelihood weights related to steepness, a set of retrospective conditioning runs (ending in 2006 and 2007) was suggested to more closely examine the effect of adding new data. The goal was to come up with a way of stabilizing estimation by averaging over a series of imprecise estimates. The retrospective analyses showed little variability to the removal of either the last 1 year or 2 years of data (Figure 1). The WG decided that the 5 steepness values agreed in 2009 (0.385, 0.55, 0.64, 0.73 and 0.82) should remain in use, and that likelihood weighting should be used as the basis for the sampling of steepness values.

2.4.2 Simulation of CPUE and aerial survey data

32. Scientific aerial survey data are simulated by adding lognormal deviations to values predicted by the OM. The initial plan was to use the empirical variance and autocorrelation of residuals to simulate future deviates. Conditioning results showed very high estimates of error (SD in the order of 0.50-0.60) and low estimates of autocorrelation (although the time series of residuals is short and discontinuous). By contrast, empirical estimates of CPUE residuals are much lower and close to the lower bound of 0.20. The estimates of process error around the aerial survey may be biased upwards by conflict with heavily weighted CPUE in the model fit. Data simulated using the high aerial survey variance would be very noisy and uninformative, perhaps resulting in poor performance of the MPs.

33. An additional problem noted during the web meeting of 9 February 2010 in relation to the high value of CPUE in 2008 was that due to autocorrelation, if the last residual is high and positive, simulated future data would continue to be high when there is substantial uncertainty around the 2008 value. To avoid this problem, web-meeting participants decided that the first simulated CPUE data point would be uncorrelated to the most recent observed value.

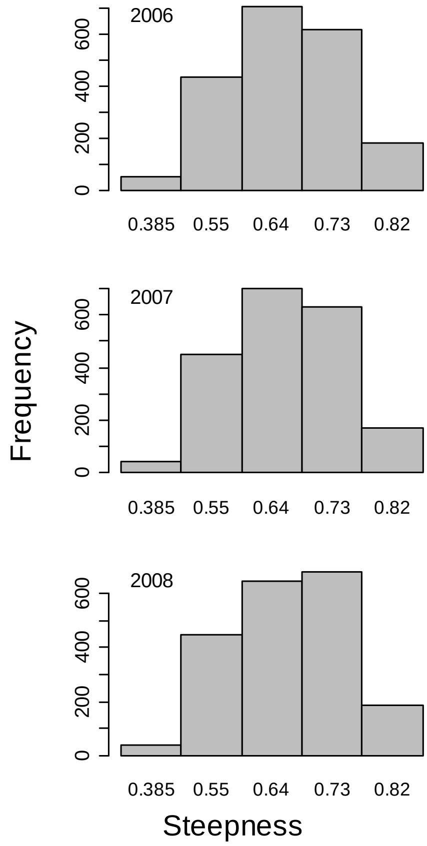


Figure 1. Marginal distribution (over the grid) of steepness for the retrospective analyses performed during the meeting.

34. For the tests conducted prior to the meeting, the following combinations of standard deviations of the two indices were used:

	SD cpue	SD aerial	ρ_{cpue}	ρ_{aerial}
Base	0.20	0.30	Empirical, uncorrelated to last residual	0
highAerialCV	0.20	0.50	Empirical, uncorrelated to last residual	0
highCpueCV	0.30	0.30	Empirical, uncorrelated to last residual	0

35. The value of SD aerial was chosen as intermediate between the estimates from sampling and model residuals. The decision to simulate future CPUE uncorrelated to past data was reversed during the OMMPWG after examination of the updated CPUE series which also showed an even higher CPUE in 2009, indicating that it was justified to have simulations take account of serial correlation between the historical and simulated data.

2.4.3 Changes in aerial survey observation

36. Australia reported that in future there will be changes to the scientific aerial survey that require modification to the analyses methods. In past, two observers have flown in each plane (a spotter-pilot and a dedicated spotter). This year, two planes have been used for the survey, one with two observers (as in past) and the other with one observer (a dedicated spotter only). In future it is most likely that there will only be one observer in each plane. Data from one-observer planes

need to be calibrated in order to make it comparable to data from two-observer planes. Calibration experiments were conducted in 2007, 2008 and 2009 for these purposes, and revised analysis methods for including the one-observer plane data have been developed and will be presented at the September ESC meeting. In the 2010 survey, there was sufficient coverage with two-observer planes such that it is possible to use a consistent set of data across all years (i.e., use only data from planes with 2 observers) in the analysis. If the proposed methods for calibrating the one-observer plane data into the analysis are accepted at the ESC, then the results from using all data in the analysis (i.e., including data from one-observer planes) will replace the results from the current analysis methods in future.

37. A paper will be presented to the ESC in September 2010 outlining the method used and a standardised series of indices. Whether this is required to be part of the Data Exchange will be determined in consultation with the CCSBT Secretariat.

Agenda Item 3. Evaluate results from MP testing

3.1 Review results of initial MP trials

38. An overview of the specification of each of the candidate MPs was provided by the MP developers. The following table summarises the main features of each MP:

Summary of specifications of candidate MPs for SBT.

Name	Type	Data inputs	Target/Slope
HK3_k2	Empirical	10 yr trend in CPUE 4+	Slope
HK3_k4	Empirical	10 yr trend in CPUE 4+	Slope
HK5	Empirical	10 yr trend in CPUE 4+ and rec (CPUE age 4)	Slope
HK6	Empirical	10 yr trend in CPUE 4+ and rec (AS index)	Slope
SAK1	Model[1]	CPUE and Aerial Survey Indices	Target
ASMP	Empirical	4 year moving average of AS Index	Target
BREM1	Model	Rec (AS index) and exploitable biomass (4+)	Target
BREM2	Model	Rec (AS index) and CPUE 4+ as relative biomass	Target
FZ1	Fuzzy	Rec (AS index and CPUE age 4) and relative biomass (CPUE age 4+)	Target

[1]While this MP is “model based”, when the Fox model does not converge the procedure defaults to an empirical rule as described in CCSBT-OMMP/1006/07
Rec = recruitment; AS = aerial survey#

39. CCSBT-OMMP/1006/06 describes the performance of four empirical candidate MPs that all use a slope-based decision rule (longline CPUE over a 10-year period). These include two variants of the same MP, which use CPUE 4+ only (HK3_k2, HK3_k4) and two that include estimates of recruitment from longline CPUE (HK5) or the index from the aerial survey (HK6). The four MPs exhibit a range of behaviours relative to risk of low biomass. See **Attachment 6**.

40. CCSBT-OMMP/1006/07 was presented to the WG. The paper describes a Fox-model based MP using the CPUE from the longline fishery and the aerial survey

index (SAK1). The key concept of this MP is that the TAC is less than the surplus production. There were convergence problems with some runs and unrealistic parameter estimates, which were worst in the extreme optimistic and pessimistic robustness trials. When the Fox model did not converge the TAC was varied by up to 20% based directly on the trends in CPUE and aerial survey indices. See **Attachment 6**.

41. The BREM (Biomass Random Effects Model) model-based MPs use a simple biomass dynamic population model to represent exploitable biomass (CCSBT-OMMP/1006/4). The dynamics of the biomass are split into incoming recruitment (informed mostly by the aerial survey level in the previous year) and growth/decline (a compound effect of fishing mortality, natural mortality, and surplus production) random effects. The CPUE is the primary information source on the exploitable biomass and both this and the aerial survey are fitted simultaneously in a simple integrated framework to estimate the recruitment and growth/decline effects and the exploitable biomass. All three of these variables (recruitment, growth/decline, biomass) are then used in the two BREM candidate MP variants. See **Attachment 6**.

42. CCSBT-OMMP/1006/4 also described a simple empirical MP (ASMP) that uses only the aerial survey data and a four year moving average, relative to a pre-specified relative biomass level. See **Attachment 6**.

43. CCSBT-OMMP/1006/10 was presented to the WG. The paper describes a fuzzy-controlled MP based on 3 indices:

    a. CPUE(age4+) The ratio of the CPUE (4+) for the most recent 3 years to the previous 3-year average – 7 levels;

    b. CPUE(age4) A 3-year average of the CPUE for age 4 only compared to historical minimum and maximum levels – 3 levels;

    c. Aerial Survey Index – the most recent 3-year average, compared to historical minimum and maximum levels – 3 levels

    Empirical or expert knowledge is used to control the system by defining the rules. There are 63 rules depending on the combination of the 3 indices, and these are combined to provide 7 alternative decisions for the TAC in the next 3 years.

    For example, “IF CPUE (age4+) ratio indicates Medium Increase of the stock AND CPUE (age4) is Medium level AND Aerial Index is Strong level, THEN TAC change action is Positive Medium”. See **Attachment 6**.

3.2 Selection of Tuning options as a base for comparisons

44. The meeting agreed to use tuning option 5 (2040/70%) for comparative purposes between MPs at this meeting because results for this were available for most procedures.

45. Tuning option 3 (2035/90%) required large reductions in catch and therefore provided little contrast among MPs. Consequently, judging MP performance using this tuning option was considered uninformative.

46. Later during the meeting to provide more contrast, results for tuning option 2 were calculated and reported.

3.3 Comparison of performance of tuned MPs

47. **Attachment 6** contains the set of figures used to evaluate the candidate MPs presented at the meeting.

48. The meeting agreed that it would be useful to define MP selection criteria based on both the characteristics of the MP and their qualitative performance from the testing, rather than quantitative results against the reference set and robustness trials at this stage. In this respect, it was considered that the short-medium term biomass risk (B_{min}, P(B=0), P(B_{2022}>$B_{2012;}$), P(B_{2025}>B_{2012})) and size and frequency of catch reductions in the first 10-12 years were key considerations given the advice from the Commission and the current state of the stock. B_{min} was uninformative as it is already determined by past recruitment levels and catches for most of the trials.

49. It was also agreed that, for practical and communication purposes, it would be desirable to reduce the number of candidate MPs to two or three, to go forward for further refinement and testing.

50. The following attributes in an MP were considered desirable:

a) Model-based and Empirical MPs
   - In general, the Model-based MPs have the desirable attribute of being able to reduce variation and provide smoother behaviour, if the underlying model is reasonably consistent with the underlying dynamics of the system.
   - Empirical MPs have the advantage of using only the more recent data and, therefore, are less likely to have the "memory" of historical data that damp responses to recent changes in abundance.

b) Inclusion of both main monitoring series (CPUE and aerial survey):
   - Given possible bias in CPUE as an index of abundance (e.g., if catchability changes over time), it is considered desirable to include both monitoring series. In this way, there is the potential for the aerial survey to "buffer" potential biases in the CPUE-based indices, which may result in a more robust MP.
   - The performance of the "aerial survey only" MP (ASMP) indicated that it is possible to construct an MP based on the aerial survey alone and achieve reasonable catch and conservation performance. This demonstrates that, on the basis of the reference set and robustness trials, the aerial survey is providing "reasonable" signal and can be useful as an input to candidate MPs.

Reference Set and Robustness Trials

51. The meeting reviewed earlier definitions of the reference set and robustness trials for the purposes of MP evaluation and selection.

52. The reference set is considered the "most plausible" parameter and assumption set and defines the dynamics and uncertainty associated with the system. It is used to tune and compare performance of MPs under this set of most plausible circumstances.

53. The selection of robustness trials is based on circumstances (parameter values/assumptions) that are considered less likely than those included in the reference set, or likely to have substantial consequences for the performance of

an MP if they occur in reality. The robustness trials are used in the selection of MPs to test their performance, relative to one another, under considerations they are not tuned to meet: i.e. is an MP robust to circumstances it has not been tuned to cope with.

54. Initial performance of individual MPs was compared using the reference set at the agreed tuning option and selected robustness trials. The subset of robustness trials (upq, high CPUECV, omega75, and Laslett) focussed on testing the sensitivity of MPs to assumptions about the relationship between CPUE and biomass. Detailed results are shown in **Attachment 6**.

55. The major contrast in MPs related to the extent to which they reduced catches early in the evaluation period and, correspondingly, the extent of biomass risk in the same period. For example, a number of the HK MPs and the BREM1 MP reduced catches more substantially in the early period, resulting in lower biomass risks while others (e.g. BREM2) were relatively unresponsive, made small reductions in catches in the early period and therefore resulted in higher levels of biomass risk.

56. It was noted that care needed to be taken when interpreting the early reductions in catches resulting in higher catches and CPUE in the later period as generally better performance. It will depend on the extent to which the catch levels at the end of the period are above those that may be sustained at MSY and age-structure effects at the end of the period which will vary among individual runs. Furthermore, due to the time lag between the year classes currently selected by the fishery and their entry into the spawning stock, the effects of these higher catches in the latter part of the period on the SSB will not be reflected in the current performance statistics (i.e. SSB in 2035 or 2040) as these cohorts will not yet have entered the spawning stock. It was suggested that additional performance statistics, for instance, exploitation rate in the latter part of the evaluation period, may better capture this feature of performance. This behaviour is likely to be different between MPs.

3.4 Selection of a reduced set of MPs.

57. The following candidate MPs were chosen to go forward (with variants and options where more can be considered at the ESC in September 2010).

	Model	Empirical	CPUE	Aerial
BREM_1	X		X	X
HK6		X	X	X

58. Default options for testing the reduced set of MPs were chosen: tuning option 5 (70% chance that the biomass will be above $0.2B_0$ by 2040), a maximum TAC change of 3kt, catch option d (time lag of 1 year).

59. These defaults were specified based on discussions and to ensure that comparable results were reported, though this is not to exclude presentation of results for other variants of these specifications as well. Possible modifications of the following MPs were then discussed.

3.4.1 BREM_1 variants

1) Use a hybrid between BREM_1 and the current TAC so that BREM_1 will be adjusted to be less responsive: $TAC_t = w \times TAC_{t-1} + (1-w) \times BREM\_1$.

2) Consider a version with catch subtracted from Eq. 12 of WP04 (will require an additional estimable parameter to scale catch relative to indices).
3) Change gamma-term in Eq. 16 so that it becomes quadratic (2.0) when recruitment part is below average to 1.0 (linear) when above average.
4) Change R term in Eq. 16: use a fixed mean recruitment term as defined over the period when aerial survey data are available for the denominator and compute mean over period (length tau) for the numerator.
5) Use a heavier penalty on larger decreases in relative biomass:

$$TAC_y = \delta\left[\frac{B_{y-2}}{B^*}\right]^{\varepsilon} \qquad \varepsilon \geq 1.0$$

60. It was noted that the simple dynamics model in the MP does not include catch. This is a deliberate feature as the indices included in the MP are used as relative, rather than absolute, abundances. A number of participants considered it would be useful to investigate the impact of including catch in the underlying MP as this might be expected to reduce the variation further.

3.4.2 HK6 variants

The following variants from the selected empirical MP were suggested:

1) Modify HK6 to include a recent recruitment term similar to that of the R term of Eq. 16 of WP04 (as modified in 4) above).
2) Compute slope term (Lambda) over periods less than 10 years but at least 5 years.
3) Try a version with *k*= 1.5 (combined with periods less than 10 years but at least 5 years from which the slope term is estimated; this may provide some intermediate performance and responsiveness)

$$TAC_{y+1}^{CPUE4+} = \begin{cases} TAC_y\left(1-k_1|\lambda|^{\varepsilon}\right) & \lambda < 0 \\ TAC_y\left(1+k_2\lambda\right) & \lambda \geq 0 \end{cases} \qquad \varepsilon \geq 1.0$$

3.4.3 Other general considerations

61. For both MP types, allow some control parameters to change after 10 years. One intent of this suggestion is to provide greater responsiveness early in the projection period and the ability to move to less responsive behaviour later in the period.

Agenda Item 4. Reconsideration of reference set and robustness trials

4.1 Select reference set and robustness trials for final testing.

62. The axis specifications for the reference set is detailed in the following table:

	Levels	Cumul N	Values	Prior	Simulation Weights
Steepness (*h*)	5	5	0.385 0.55 0.64 0.73 0.82	Uniform	Likelihood
M_1	3	15	0.30 0.35 0.40	Uniform	Likelihood
M_{10}	3	45	0.07 0.1 0.14	Uniform	Likelihood
Omega	1	45	1	NA	NA
CPUE series	2	90	W0.5 W0.8	Uniform	Prior
q age-range	2	180	4-18 8-12	0.67, 0.33	Prior
Sample Size	1	180	Sqrt	NA	NA

63. The following changes will be made to the reference set model that will be used for tuning: 1) Increase the weight given to the aerial survey data in conditioning by fixing the value of the process error parameter (τ_{aerial} =0.18) so that the overall standard deviation of the index is 0.30 on average; 2) Make future simulated CPUE correlated to past data using the empirical estimate of ρ_{cpue} derived from CPUE residuals as was done in the past.

64. While the selected MP should eventually be run for all of the robustness trials, for the purposes of selecting MPs the “omega75” and the “upq” were requested for all candidate MPs for the ESC September 2010 meeting. It was noted that the defaults of option 5 tuning (70% chance that the biomass will be above $0.2B_0$ by 2040), a maximum TAC change of 3kt, catch option d (time lag of 1 year) should apply for these two robustness trials.

65. The full list is as follows:

Name	Description
c0s1l1, c2s1l1, c3s1l1	Effects of overcatch on CPUE: S = 0%, 50% and 75%.
c1s1l2	LL1 overcatch scenario based on Case 2 of Market Report.
downwearlysize	Downweight the initial size composition data for LL1 and LL4 (see Polacheck and Kolody, 2003, CCSBT-MP/0304/07).
aerdome, aerflat	Change selectivity of aerial survey (ages 2-4) throughout the series to [0.3,1,0.3] and [1,1,1] (instead of [0.5,1,1] assumed in the reference set). It was noted that it may be possible to reduce the options by closer inspection of the spotter data.
highAerialCV	Increase CV of aerial survey to 0.50 while leaving CV of CPUE at 0.20.
highCPUECV	In conditioning, increase lower bound of CV of CPUE to 0.30 (from 0.20 in base) and fix process error for aerial survey (tau_aerial) to 0.05. In projections use CV of CPUE = 0.30 and aerial CV=0.30.
mixtag	Incomplete tag mixing: assume that season-1 F's (H) (during which the surface fishery occurs) used in the tagging likelihood are 50% higher than the corresponding F's applied to the whole population.
lowR	4 years (from 2009) where recruitment is 50% lower than predicted, uncorrelated with subsequent recruitments.
recuncor	Projected recruitment deviates uncorrelated to historical estimates from conditioning [Note: does not require new grid].
regimeshift	Regime shift: the stock-recruitment relationship changes in 1978. The two relationships share the same steepness parameter but two separate B0 are estimated, one for each period.
troll	Include troll survey data.
omega75	Omega value of 0.75 (CPUE non-linearity factor) or a higher value that is more supported by data (note that the value of that 0.75 has little support relative to the linear relationship).
run3, run6	Substitute alternative CPUE series based on glm models referred to as run3 and run6.
Laslett, STwin	Substitute alternative CPUE series by Laslett and ST-windows (the most extreme trends) to represent alternatives for changes in spatio-temporal distribution of fishing effort.
truncCPUE	Drop first 10 years of CPUE data.
downq	Step function change in catchability 20% down between 2006 and 2007 unknown to the MP.
downupq	Catchability goes down by 20% in 2007 and returns to normal in 5 years as fishermen adjust to new management regime. Coding to be as for above, but with ramp back to "normal" in 5 years.
updownq	Catchability goes up by 50% in 2009 and returns to normal in 5 years as fishermen adjust to new management regime. Uncorrelated with subsequent CPUE observations.
upq	Step function change in catchability 30% up between 2006 and 2007 unknown to the MP.

Agenda Item 5. Testing protocols and performance statistics

5.1 Time horizon for simulations

66. The time horizon of 31 years from 2009 through 2040 was selected for simulations.

5.2 Schedules for TAC changes and lag

67. Comparisons for alternative TAC change schedules based on the reference set showed no improvement when TACs were allowed to change every two years contrasted with changes allowed every three years. This may be different for low-recruitment robustness and hence the option for two-year TAC changes should be retained for such scenarios.

68. Regarding lags for implementation, results with a one year lag for the TAC adjustment had no appreciable effect on the performance for the MPs that tested this impact. This may be different for low-recruitment robustness trial.

5.3 Allocations between fisheries

69. The fractions of TAC (catch) by **simulated** fisheries were fixed at:

Fleet	Fraction
LL1	0.4087
LL2	0.0886
Indonesia	0.0167
Surface	0.441

These fractions were calculated based on the following TAC allocation levels (t) by country, as specified at the 2009 Commission meeting:

Japan	3000
Australia	5665
Korea	1140
Taiwan	1140
New Zealand	1000
Indonesia	750
Philippines	45
South Africa	40
EC	10

5.4 Tuning options

70. The tuning options were presented under agenda item1.1. The meeting noted that MPs should be tuned to within $\pm$1 percentile about the level. For example, for option 2, the probability of the 2035 spawning biomass level being between 69% and 71% is acceptable.

5.5 Performance statistics, tables and graphics

71. The group reviewed the performance statistics and presentation approaches (see **Attachment 6**).

Agenda Item 6. Workplan and timetable

6.1 Update code of OM and associated graphics files if needed

72. Participants discussed intersessional activities including the exchange of MP code. In particular, there was concern that time would be limiting to review and re-code MPs prior to the September meeting.

73. A naming convention was developed during the meetingin order to facilitate comparison of results.

6.2 Develop intersessional workplan

74. The table below presents the intersessional work and issues to be presented at the 2010 ESC:

Task	Due Date	Responsibility
Inter-sessional technical meeting to review results of initial MP testing and possibly introduced a few further robustness trials	June 2010	
Provide historical data series for use in MP testing: 1) CPUE series up to 2009, 2) aerial survey series up to 2010 and 3) 2009 catches	June 30th 2010	Itō-san, Paige, CCSBT
Distribute modified projection code, R-code for figures, and input files for base runs (new grid with 5h values) and new robustness trials (old robustness grids will not be changed)	June 30th 2010	Ana
Scientists conduct final MP testing		Member scientists
Exchange MP code—to check reproducibility of some of the results	August 27th2010	Consultant, members, Secretariat
Preparation of draft appendices specifying computational details for CPUE and aerial survey data for input to MP in actual implementation		
ESC15 (2010) Tasks - Finalise MP selection to recommend to the CCSBT - Finalise computational details for CPUE and aerial survey data for input to MP in actual implementation - Refine Metarule process definition by tabling a discussion paper at ESC15 - Calculate replacement yields corresponding to 20% B_0 - Specifying ongoing monitoring requirements to support selected MPs (i.e., CPUE series and Aerial surveys) - Clarify actions should anticipated future data be unavailable - Possible consultation with Commissioners to demonstrate trade-offs	Sept 2010	

Agenda Item 7. Future developments related to OM and MPs

7.1 Alternative approaches to deal with the aerial survey data (CSIRO proposal about survey selectivity)

75. Presently, there are robustness trials that include alternative options for "selectivity" of the aerial survey. A proposal was made to use an integration technique to better account for this source of variability since doing so may provide a better accounting of parameter correlations. Such an approach was recognized as having promise and should be evaluated when more fully developed.

7.2 Coding issues (version control, etc.)

76. This was not discussed

7.3 Other

77. The meeting reviewed CCSBT-MP/0404/05 and CCSBT-MP/0505/05, which provided an introduction to the concepts of exceptional circumstances and associated meta-rules. Five types of exceptional circumstances were identified

    1. Observations in monitoring series outside the range tested in the OM;
    2. New knowledge;
    3. New stock assessment changes range of uncertainty;
    4. Missing data; and
    5. Clear exceptional circumstances (e.g., recruitment failure).

78. An initial list of issues for the development of meta-rules is provided in **Attachment 4** and it was agreed that a discussion paper on this topic would be at ESC15.

Agenda Item 8. Close of meeting

8.1 Adoption of report

79. The meeting adopted the report.

8.2 Close of meeting

80. The meeting closed at 14:30, 25 June, 2010.

References

Nishida, T., and S. Tsuji. 1998. Estimation of abundance indices of southern bluefin tuna (*Thunnusmaccoyii*) based on the coarse scale Japanese longline fisheries data (1969-97). Paper submitted to the Commission for the Conservation of Southern Bluefin Tuna, Scientific Meeting. CCSBT/SC/9807/13.27 pp.

List of Attachments

Attachment

1	List of Participants
2	Agenda
3	List of Documents
4	Small Group discussion on Exceptional Circumstances and Meta-rules
5	CPUE modeling group notes 21–25 June 2010
6	Subset of figures presented at the CCSBT meeting in Seattle, June 2010

Attachment 1

List of Participants
Third Operating Model
and
Management Procedure Technical Meeting

CHAIR

Dr Ana PARMA
Centro Nacional Patagonico
Pueto Madryn, Chubut
Argentina
Phone:+54 2965 451024
Fax:+54 2965 451543
Email:parma@cenpat.edu.ar

ADVISORY PANEL

Professor John POPE
The Old Rectory
Burgh St Peter Norfolk, NR34 0BT
UK
Phone:+44 1502 677377
Fax:+44 1502 677377
Email:popeJG@aol.com

Dr James IANELLI
REFM Division
Alaska Fisheries Science Centre
7600 Sand Pt WayNE Seattle, WA98115
USA
Phone:+1 206 526 6510
Fax:+1 206 526 6723
Email:jim.ianelli@noaa.gov

CONSULTANT

Dr Trevor BRANCH
20504 86th Pl W
EdmondsWA98026
USA
Phone: +1 206 450 2830 (cell)
Email: tbranch@gmail.com

AUSTRALIA

Dr Gavin BEGG
General Manager A/g
Bureau of Rural Sciences, Department of Agriculture, Fisheries and Forestry
GPO Box 858Canberra ACT 2601
Australia
Phone:+61 2 6272 4277
Fax:+61 2 6272 3882
Email:Gavin.Begg@brs.gov.au

Dr Fiona GIANNINI
Scientist
Bureau of Rural Sciences, Department of Agriculture, Fisheries and Forestry
GPO Box 858Canberra ACT 2601
Australia
Phone:+61 2 62723503
Fax:+61 2 62722346
Email:fiona.giannini@brs.gov.au

Dr Campbell DAVIES
Group Leader
CSIRO Marine and Atmospheric Research
Castray Esplanade, Hobart 7001
Australia
Phone:+61 3 6232 5044
Fax:+61 3 6232 5012
Email:campbell.davies@csiro.au

Dr Richard HILLARY
Research Scientist
CSIRO Marine and Atmospheric Research
Castray Esplanade, Hobart 7001
Australia
Phone: +61 3 6232 5452
Email:Rich.Hillary@csiro.au

Ms Paige EVESON
Research Scientist
CSIRO Marine and Atmospheric Research
Castray Esplanade, Hobart 7001Australia
Phone:+61 3 6232 5015
Fax:+61 3 6232 5012
Email:paige.eveson@csiro.au

Mr Brian JEFFRIESS
Chief Executive Officer
Australian SBT Industry Association Ltd (ASBTIA)
PO Box 416
Fullarton. SA 5063
Ph: +61 419840299
Fax: +61 886823749
Email:austuna@bigpond.com

Dr Michael SISSENWINE
Visiting Scholar
Woods Hole Oceanographic Institution
86 Water St, Woods Hole, MA02543-1052, US
Phone: +1 508 566 3144
Email: m_sissenwine@surfglobal.net

FISHING ENTITY OF TAIWAN

Dr Sheng-PingWANG
Assistant Professor
NationalTaiwanOceanUniversity
2 Pei-Ning Road, Keelung20224
Taiwan
Phone:+886 2 24622192 ext 5028
Email:wsp@mail.ntou.edu.tw

JAPAN

Dr Tomoyuki ITOH
National Research Institute of Far Seas Fisheries
Fisheries Research Agency
5-7-1 Orido, Shimizu-ku, Shizuoka-shi
Shizuoka 424-8633
Japan
Phone:+81 54 336 6033
Fax:+81 54 335 9642
Email:itou@fra.affrc.go.jp

Dr Norio TAKAHASHI
National Research Institute of Far Seas Fisheries
Fisheries Research Agency
2-12-4 Fukuura, Kanazawa-ku,
Yokohama-shi, Kanagawa 236-8648
Phone: +81457887819
Fax: +81457885004
Email:norio@fra.affrc.go.jp,

Dr Hiroyuki KUROTA
National Research Institute of Far Seas Fisheries
Fisheries Research Agency
5-7-1 Orido, Shimizu-ku, Shizuoka-shi
Shizuoka 424-8633
Japan
Phone:+81 54 336 6034
Fax:+81 54 335 9642
Email:kurota@affrc.go.jp

Mr Osamu SAKAI
National Research Institute of Far Seas Fisheries
Fisheries Research Agency
5-7-1Orido, Shimizu-ku, Shizuoka-shi
Shizuoka 424-8633
Japan
Phone: +81 54 336 6034
Fax: +81 54 335 9642
Email: sakaios@fra.affrc.go.jp

Prof Doug BUTTERWORTH
Department of Mathematics and Applied Mathematics
University of Cape Town
Rondebosch 7701
South Africa
Phone:+27 21 650 2343
Fax:+27 21 650 2334
Email:Doug.Butterworth@uct.ac.za

NEW ZEALAND

Dr Kevin SULLIVAN
Science Manager (Stock Assessment)
Ministry of Fisheries
PO Box 1020, Wellington
New Zealand
Phone:+64 4 8194264
Fax:+64 4 819 4261
Email:kevin.sullivan@fish.govt.nz

REPUBLIC OF KOREA

Dr Jae Bong LEE
National Fisheries Research andDevelopment Institute
Ministry of Marine Affairs and Fisheries
152-1 HaeanroGijangeup/gunBusan 619-902
Repubulic of Korea
Phone:+82-51-720-2296
Fax:+82-51-720-2277
Email: leejb@nfrdi.go.kr, jbonglee@gmail.com

Dr Hyung Kee CHA
National Fisheries Research andDevelopment Institute
Ministry of Marine Affairs and Fisheries
152-1 HaeanroGijangeup/gunBusan 619-902
Repubulic of Korea
Phone:
Fax:
Email:cha1212@nfrdi.go.kr

INTERPRETER

MsYoko YAMAKAGE

Attachment 2

Agenda
Third Operating Model and Management Procedure Technical Meeting

Terms of Reference
Evaluate results of initial MP testing and refine testing protocols.

1. **Discuss input from the Strategy and Fisheries Management Working Group meeting in April**
2. **Operating model and data inputs**
   2.1. Changes to aerial survey specifications in conditioning.
   2.2. CPUE data used in conditioning.
   2.3. Availability of 2009 catch and CPUE data, and 2010 aerial survey index to replace simulated data in MP testing.
   2.4. Other issues encountered during preparation of OM scenarios??
3. **Evaluate results from MP testing**
   3.1. Review results of initial MP trials.
   3.2. Selection of Tuning options as a base for comparisons.
   3.3. Comparison of performance of tuned MPs.
   3.4. Selection of a reduced set of MPs.
4. **Reconsideration of reference set and robustness trials**
   4.1. Select reference set and robustness trials for final testing.
5. **Testing protocols and performance statistics**
   5.1. Time horizon for simulations.
   5.2. Schedules for TAC changes.
   5.3. Allocations between fisheries.
   5.4. Tuning options.
   5.5. Performance statistics, tables and graphics.
6. **Workplan and timetable**
   6.1. Update code of OM and associated graphics files if needed.
   6.2. Develop intersessional workplan.
   6.3. Identify issues to be discussed at ESC.
7. **Future developments related to OM and MPs**
   7.1. Alternative approaches to deal with aerial survey (CSIRO proposal about survey selectivity).
   7.2. Coding issues (version control, etc.).
   7.3. Other.

Attachment 3

List of Document

Third Operating Model and Management Procedure Technical Meeting

(CCSBT- OMMP/1006/)

1. Provisional Agenda
2. List of Participants
3. Draft List of Documents
4. (Australia) Technical specifications and proof of concept analyses for candidate management procedures for southern bluefin tuna. Hillary R, Basson M, Eveson P, Davies C.
5. (Australia) Exploration and initial evaluation of candidate management procedures for southern bluefin tuna. Hillary R, Basson M, Eveson P, Giannini F, Barnes B, Davies C.
6. (Japan) Exploration of empirical management procedures based on longline CPUE index and aerial survey index. Kurota H., Fujioka K., Sakai O., and Butterworth D.
7. (Japan) Trials of Fox-model based management procedure for southern bluefin tuna. Sakai O. and Kurota H.
8. (Japan) CPUE standardization up to 2009 data. Itoh, T.
9. (Japan) Change in operation pattern of Japanese SBT longliners in 2009 resulting from the introduction of the individual quota system in 2006. Itoh T.
10. (Japan) Development and Initial Evaluation of Fuzzy-Controlled Management Procedures for Southern Bluefin Tuna. Norio TAKAHASHI
11. (Australia) Southern Bluefin Tuna. Exploration of catch per unit effort standardization models. Veronica Boero Rodriguez
12. (Japan) Brief examination of conditioning results of the SBT operating model for management procedure evaluation. Hiroyuki Kurota, Osamu Sakai, and Doug Butterworth
13. (Australia) Work requested 23 June 2010. Veronica Boero Rodriguez
14. (Australia) Work requested 24 June 2010. Veronica Boero Rodriguez

(CCSBT- OMMP/1006/Rep)

1. Report of the Second Meeting of the Strategy and Fisheries Management Working Group Meeting (April 2010)
2. Report of the Sixteenth Annual Meeting of the Commission (October 2009)
3. Report of the Fourteenth Meeting of the Scientific Committee (September 2009)
4. Report of the Operating Model and Management Procedure Technical Meeting

(July 2009)

5. Report of the Strategy and Fisheries Management Working Group Meeting (April 2009)
6. Report of the Thirteenth Meeting of the Scientific Committee (September 2008)
7. Report of the Ninth Meeting of the Stock Assessment Group and Fifth Meeting of the Management Procedure Workshop (September 2008)
8. Report of the Thirteenth Annual Meeting of the Commission (October 2006)

Attachment 4

Small Group discussion on Exceptional Circumstances and Meta-rules

The meeting reviewed CCSBT-MP/0404/05 and CCSBT-MP/0505/05, which provided an introduction to the concepts of exceptional circumstances and associated meta-rules. Five types of exceptional circumstances are identified

1. Observations in monitoring series outside the range tested in the OM;
2. New knowledge;
3. New stock assessment changes range of uncertainty;
4. Missing data; and
5. Clear exceptional circumstances (e.g. recruitment failure).

The meeting noted that, given recent observations of very low recruitments, “recruitment failure” can no longer be considered as an unexpected “exceptional circumstance” as described in CCSBT-MP/0505/05. It was considered that the primary concern in terms of “unexpected exceptional circumstances” is likely to relate to substantial changes in the CPUE series relating to unexpected changes in fleet behaviour.

An initial list of issues for each category of exceptional circumstances is provided below.

1. Results outside range tested in OM
    a. CPUE-related
        - Input series goes outside range of base and robustness CPUE series (currently Laslett and ST Windows)
        - Improved CPUE series indicates substantial differences in trend
    b. Aerial Survey
        - Calibration study and design work indicates serious issues with move to one spotter per plane
        - Change in spotters confounded with substantial change in index
2. Planned New knowledge
    - Close-kin estimate of spawning stock abundance
    - Updated growth cut points
    - Incorporation of 2000 tag data
    - Proportion of juveniles in the GAB
    - Troll survey
    - Revised understanding of biology and dynamics
3. New Stock Assessment
4. Missing data
    - Missing months/low number of transects in aerial survey
    - No satisfactory aerial survey (need to have a rule for what is done in the absence of the survey)
    - Reductions/substantial gaps in the data going into CPUE.
5. Clear exceptional circumstances

a. Substantial differences in level and distribution of LL1 effort
b. [consecutive year classes of very low recruitment
c. Disease causes significant increase in natural mortality
d. Changes in environment result in significant changes in distribution
e. Substantial IUU catches]

The meeting agreed that while CCSBT-MP/0505/05 provides the basis for the development of exceptional circumstances and meta-rules for the selected MP, a more specific refinement that is particular to the current OM, robustness trials and MPs is required. Australia agreed to provide an initial draft technical document for consideration at the ESC in September 2010.

Attachment 5

CPUE modeling group notes 21–25 June 2010

The Chair of the CPUE Modelling Group (John Pope) commented on the outcome of the March 9thweb meeting and the subsequent provision of CPUE results to the coordinator of the OMMP studies. He outlined the three remaining issues needing further consideration and discussion:

(1) Being able to explain the high 2008 CPUE value by further investigation of the data and model used for standardisation.
(2) Investigations of possible post 2006 changes in longline fleet behaviour with respect to the spatial distribution and amount of effort deployed.
(3) The development of a set of meta-rules to indicate when reconsideration of the model used for standardization should take place.

Japan presented CCSBT/OMMP/1006/08, which provides the results of CPUE standardisation with 2009 data. The new series using the 2009 data point will not be used for OM conditioning but will be used in MP testing. The data set used included NZ charter vessel data and Japanese data that mostly comprise the RTMP data for 2009. As not all of the Japanese data for 2009 were available, the agreed correction to this value was made. The base standardisation and the robustness models Run R03 and Run R06 were calculated. All three resulting unweighted series show a continuing trend of high CPUE with the 2009 standardised point being higher than that for 2008, though Run R06 shows a less steep increase to the 2009 point. A comparison of the weighted base model using the core fleet to the model using the entire fleet showed little difference in the main trends.

Figure 5 in CCSBT/OMMP/1006/08 shows the nominal CPUE by age, area and year. The group observed that there appeared to be a strong cohort moving through in Area 7 and possible sign of increased recruitment in Area 8. It was noted though that for the CPUE series, only the catch of aged 4+ SBT is included. This figure was discussed in relation to possible desirability of the inclusion of a year*area interaction term in the model.

Japan presented CCSBT/OMMP/1006/09, which investigates the change in operation patterns of Japanese SBT vessels. The main aim in this work was to investigate what might have been the effect of introducing the individual quota system in 2006. In 2009, there was an overall decrease in number of Japanese vessels, effort and SBT caught when compared to the average of 2001-2005.

Tables 1 and 2 in CCSBT/OMMP/1006/09 were discussed by the group. Table 1 shows the number of 5x5 degree cells fished by year, month and area, and Table 2 shows the number of operations over the same factors. It was noted that from 2006-2009 there has been fishing in months that had not shown fishing in 2001-2005 because closed area/season regulation operated prior tothe introduction of IQ’s in 2006. Also for Areas other than 5 and 6, there is an obvious decrease in the number of operations in the later years from the earlier. This decrease is in part due to the decrease in TAC. The spatial and temporal changes of pattern in effort from 2006 could be partly due to the introduction of IQs but the paper notes that this is not clear as there are likely to be many contributing factors to this change.

Australia presented CCSBT/OMMP/1006/11 which explores the model used in the standardisation of CPUE. The paper examines the data for justification of the explanatory variables and interactions used in the base model with the aim of checking if the model chosen is producing an amplification of the standardised 2008 CPUE point. This paper also included exploration of the change in fleet behaviour. The main conclusions of the the paper were: (1) no interaction terms with year should be included in the model as these terms seem to amplify the 2008 increase in CPUE; (2) the interaction term with month and area should be included; (3) a random vessel effect should be included, and (4) a fixed 5x5 cell effect might replace the Area and Lat5 factors.

There was discussion of year trends in Area 7 and Area 4 in relation to the plots and tables in CCSBT/OMMP/1006/09 and CCSBT/OMMP/1006/11. Discussion focussed on trying to understand the scale of increase in the 2008 and 2009 CPUE standardised values. Figure 2 in CCSBT/OMMP/1006/11 shows that Area 7, and to a lesser extent, Area 4, reflect a large increase in nominal CPUE in 2008 (note that this paper does not include the 2009 data). Both Areas though, as shown in Tables 1 and 2 in CCSBT/OMMP/1006/09, have had fewer fishing operations in the most recent four years of data and these have lower spatial coverage within each Area.

Extra runs were requested by the group to investigate the amplification of the 2008 CPUE standardised point in the base model. The runs requested (WPs 13 and 14) were:

- Model V1: year + month + area + Lat5
- Model V2: year + month + area + Lat5 + BET_CPUE + YFT_CPUE
- Model V3: year + month + area + Lat5 + BET_CPUE + YFT_CPUE + month*area
- Model V4: year + month + area + Lat5 + BET_CPUE + YFT_CPUE + year*Lat5
- Model V5: year + month + area + Lat5 + BET_CPUE + YFT_CPUE + year*area
- Model V6: (the base case)
  year+month+area+Lat5+BET_CPUE+YFT_CPUE+month*area+year*Lat5+year*area

This set of model runs allowed the effect of each interaction term on the resulting standardisation to be investigated. It was evident that the year interactions amplified the 2008 standardised value. A further set of runs was requested to examine the effect of including different combinations of the two interaction terms and the effect of using only one area explanatory variable, i.e. removing Lat5:

- Model V7: year +month+area+Lat5+BET_CPUE+YFT_CPUE+month*area+year*Lat5
- Model V8: year+month+area+Lat5+BET_CPUE+YFT_CPUE+month*area+year*area
- Model V9: year+month+area+BET_CPUE+YFT_CPUE+month*area

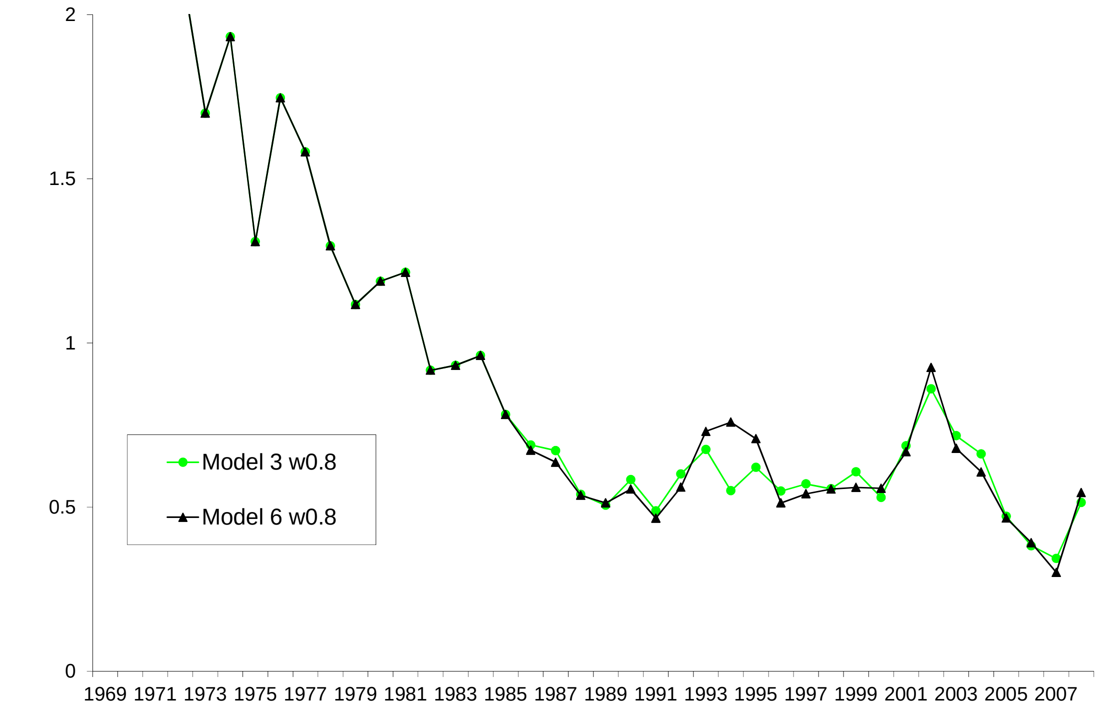
The w0.5 and w0.8 weighted CPUE series generated by model V3 runs were also requested in order to run the OM with these alternative series included in the grid.

The group noted from the extra results that the year*area interaction in particular led to the amplified 2008 CPUE value. The w0.5 and w0.8 weighted CPUE series generated by model V3 were compared to the base case. Though the unweightedstandardised series of the base and model V3 showed considerable differences, the area weighted series of both models showed very similar trends, particularly for the most recent years. Because of this relatively small difference in the weighted models (Fig. 2 below), the group agreed to keep the current base model in the reference set but to produce model V3 (renamed “Reduced base” to distinguish it from the earlier Run R03 robustness series, see CCSBT/OMMP/1006/08) in order to monitor future changes. Further development of the model was encouraged, as it is still possible to change the base model for use in the MP at the ESC meeting in September 2010, especially if the new series does not produce substantial changes in the trends of the recent years. It was noted that while the base model and alternative reduced base model are showing similar trends, this would be a good time to investigate other modifications such as including random effects and considering smaller scale area effects. The chair suggested that Australia and Japan liaise intersessionally to investigate the inclusion of vessel effects into the model to provide further comparisons with the base.

The group noted that the method for intercalibration of pre and post 1986 CPUE series needed to be codified. It was agreed that the base run would be used for testing MPs. This model cannot however be used pre 1986 since core fleet vessels cannot be identified prior to that date. Currently the pre 1986 CPUE W0.8 and W0.5 series are based upon the GLM model(Nishida and Tsuji 1998) used in earlier years for all vessels, which in the past has been refitted up to the most recent year’s data available. The new post 1986 data are then calibrated to the old series using the ratio of the means of the common years of the old and the new series. It was noted that this approach to providing the earlier series and calibration factor has the effect that subtle changes occur in the pre 1986 series each time it is rerun (also minor changes occur in the calibration of common years). Consequently it was agreed that for MP testing the earlier series should be frozen at its fitting up to the 2008 data set. Calibration would thus in future always be based upon the 1986-2008 points of this series. It was noted that replacing the old series by one fitted using the base model applied to all vessels between 1986-2008 would be more consistent and the implications of such a substitution will be investigated intersessionally.

There was discussion on the development of meta-rules that would indicate if the behaviour of CPUE series became anomalous. A previous suggestion had been to consider the interannual variation of the series historically to check if future estimates varied within the same limits. It was also noted that the base series should be checked against the series used in robustness trials to make sure that it remains within the spread of the other series. A further suggestion was to look at the 90% range of predicted CPUE values simulated in the projection code used for the MPs to check that new CPUE values fall within that range. The chair encouraged members to provide papers on meta-rules for monitoring the CPUE series for the ESC meeting.

Australia noted that the Laslett robustness series used a definition of core areas than had not been updated for many years, so that there is a possibility that this series may not be relevant for recent years. It was however noted that the current series had value as a “what if” series for robustness trials. However all authors should be encouraged to provide further improved series as part of the ongoing effort to improve CPUE for the future..While it is necessary to choose a specific methodology for use for testing the current generation of OMPs, in the final form of OMPs improvements to the current base CPUE series will be considered.



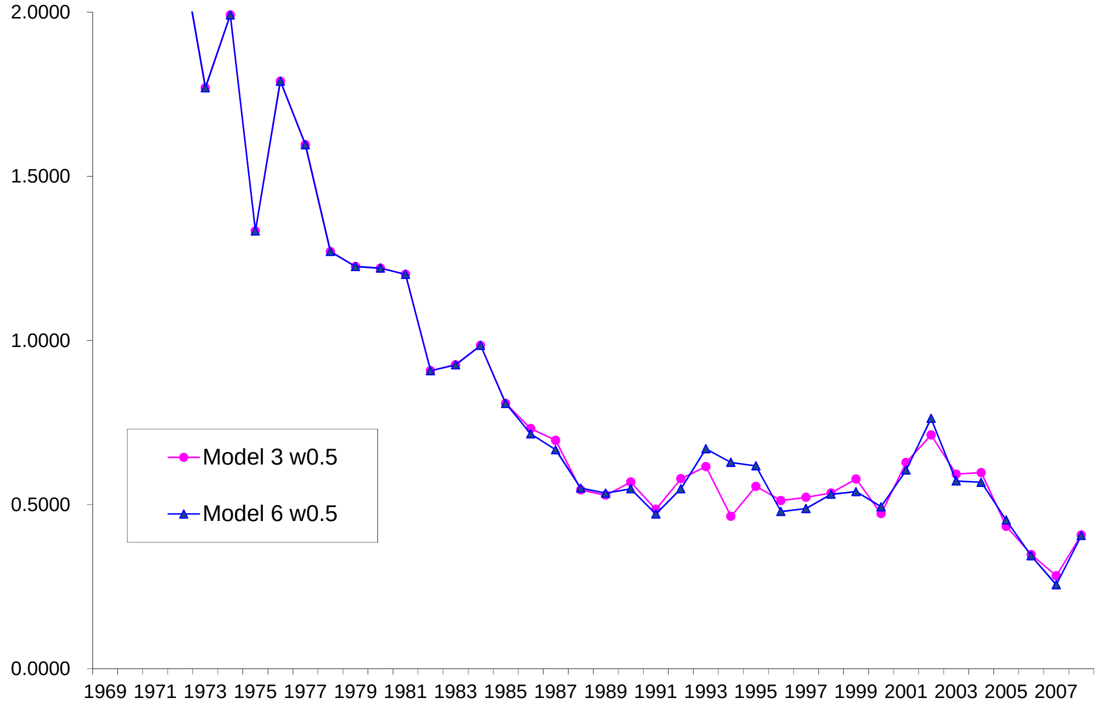


Figure 2. Alternative models for CPUE evaluated during the meeting where Model 6 refers to the basecase.

Attachment 6

Subset of figures presented at the CCSBT meeting in Seattle, June 2010

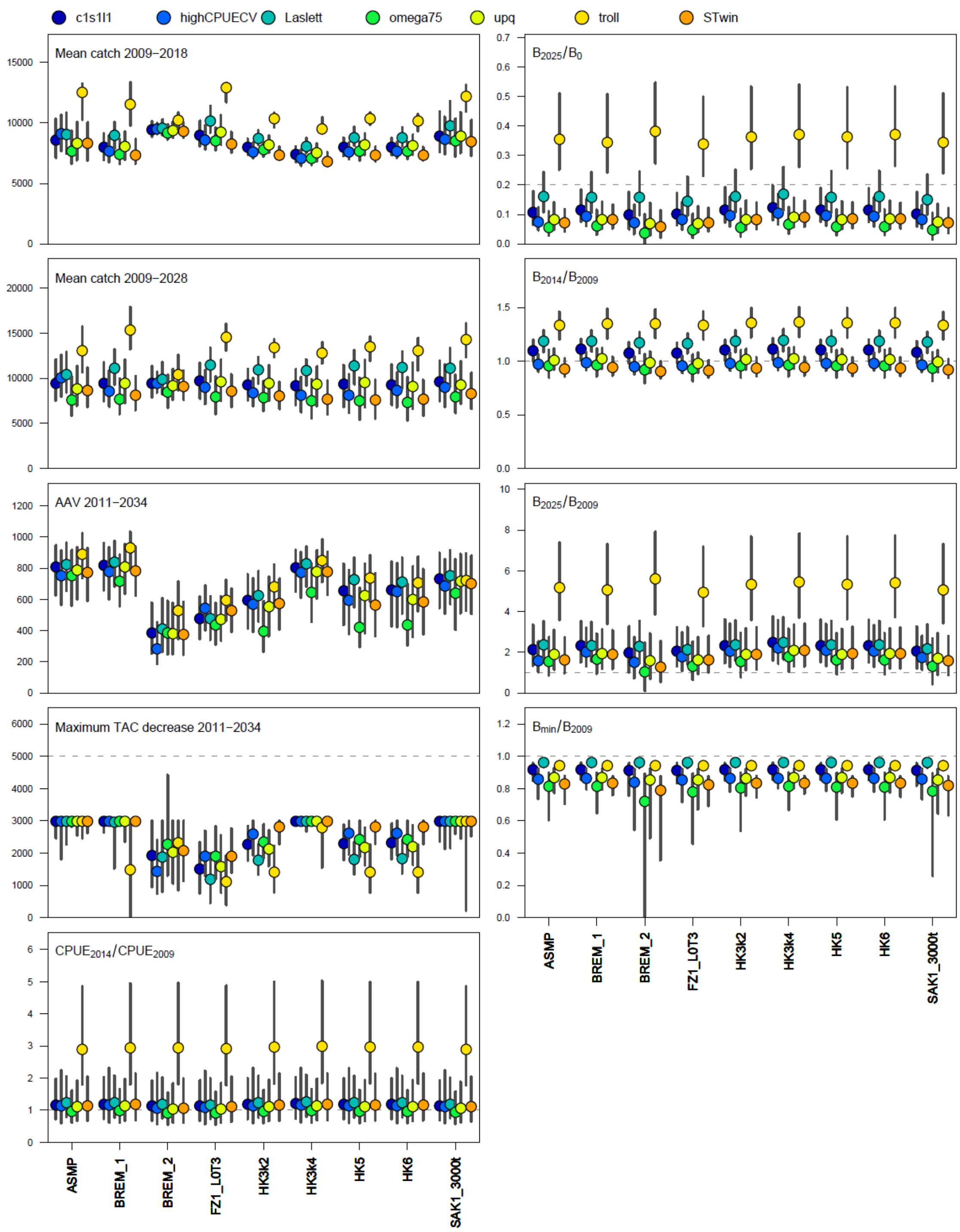


Fig.3. Comparison of MP performance, **grouped by MPs**, with all MPs subject to a constraint of changing the TAC by no more than 3000 mt (up or down), under tuning 5, catch schedule c. The base case is c1s1l1, and different robustness trials are represented by different colors.

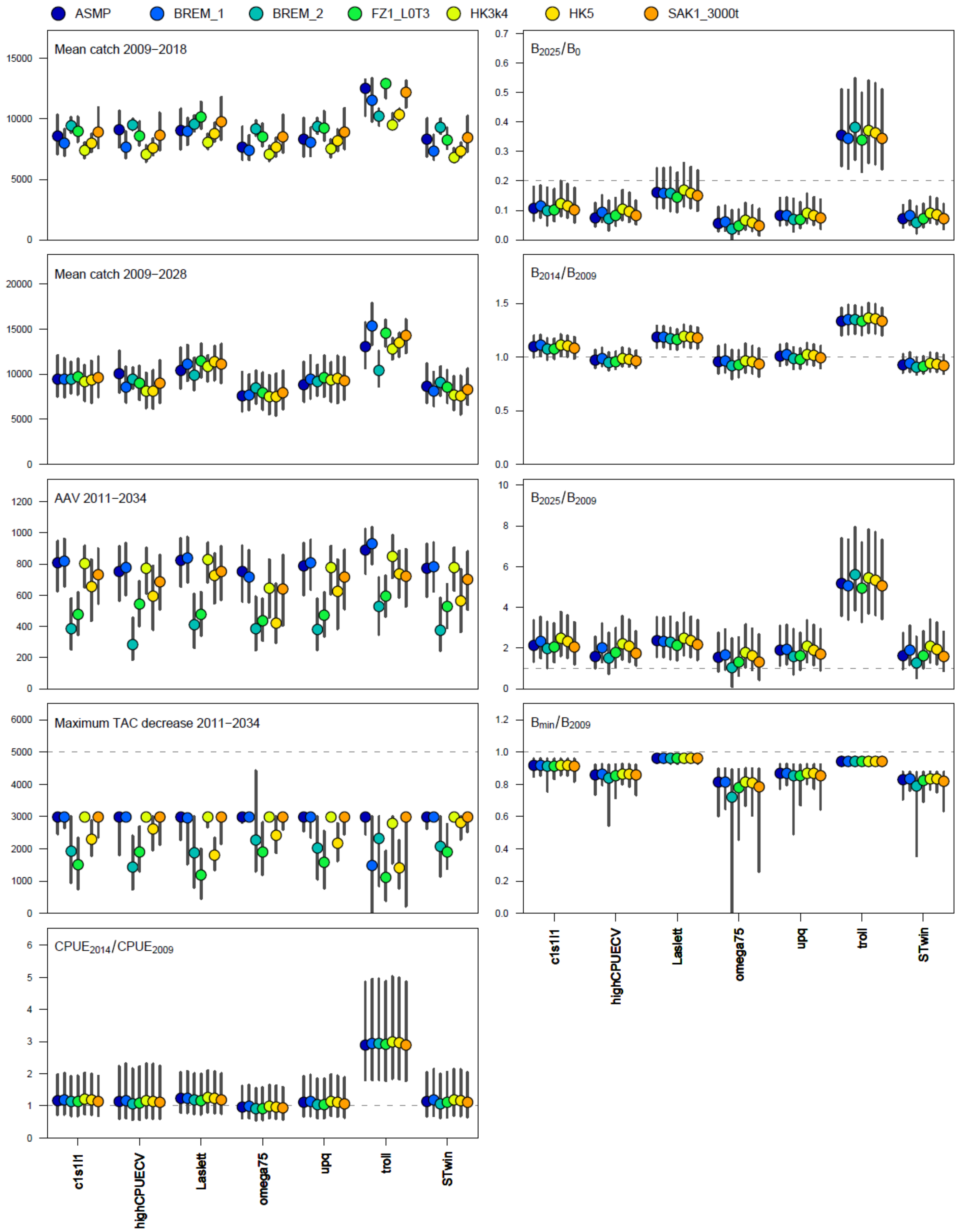


Fig.4. Same as figure 1, except **grouped by robustness trials**, for tuning 5, schedule c, maximum TAC change 3000 mt.

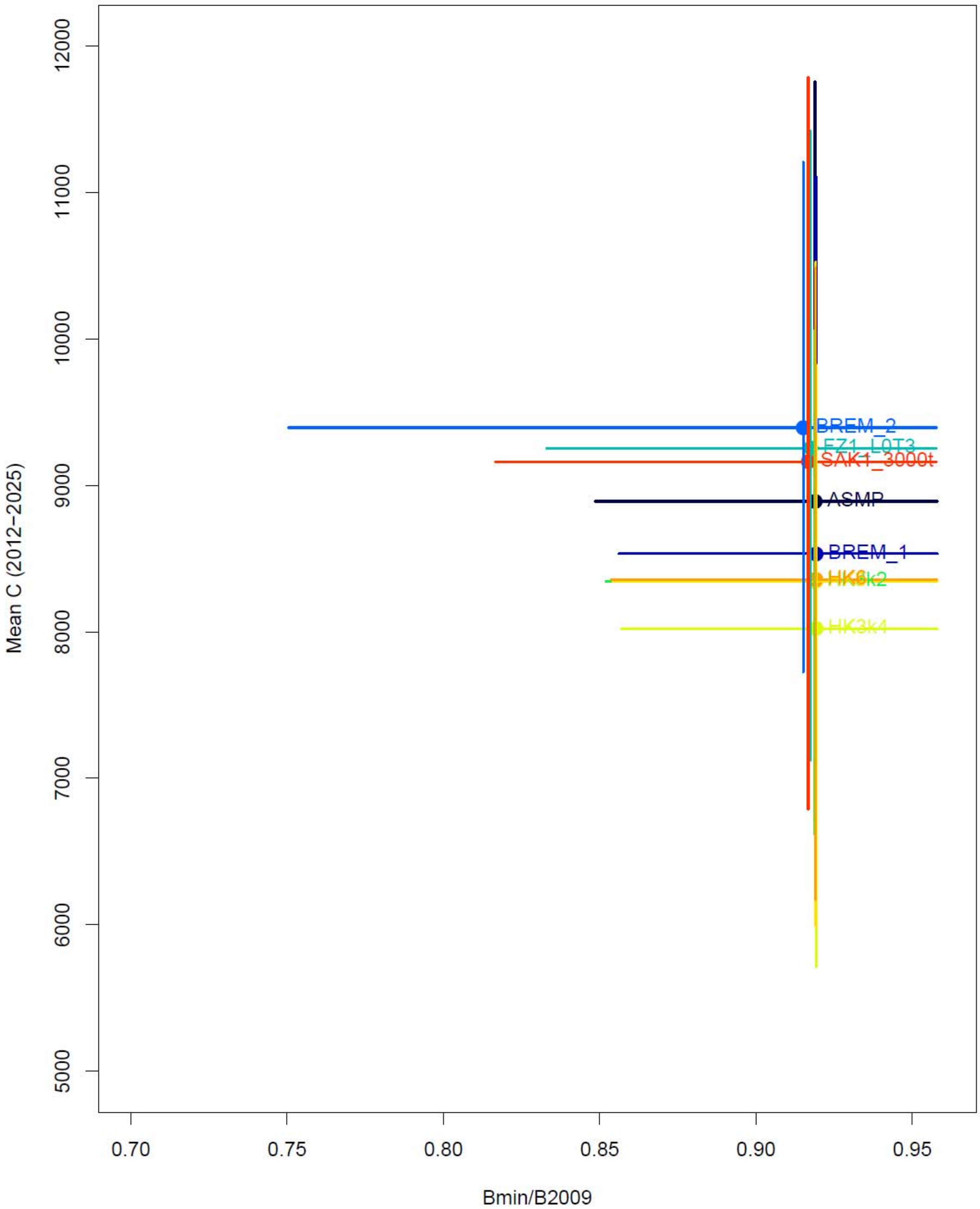


Fig.5. Tradeoff between mean catch over 2012-2024, and the ratio of **minimum spawning biomass**Bmin to that in 2009. Minimum biomass is calculated over the full projection period (2009-2040). The circles are the median and the lines are the 10th and 90th intervals, for the base case c1s1l1, tuning 5, schedule c, maximum TAC change 3000 mt.

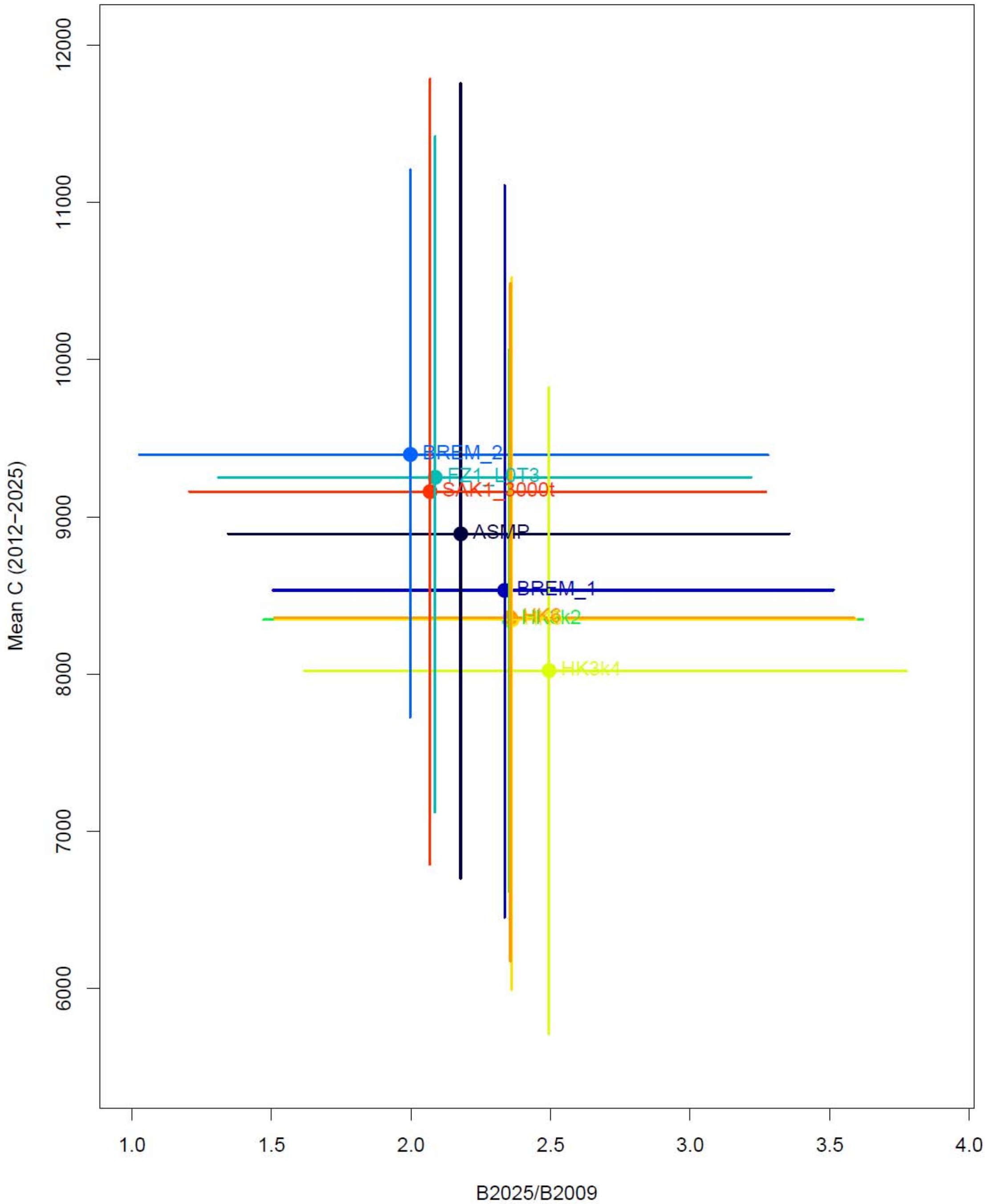


Fig.6. Tradeoff plot between mean catch over 2012-2025 and the **spawning biomass** in 2025 relative to 2009, for the base case c1s1l1, tuning 5, schedule c, maximum TAC change 3000 mt.

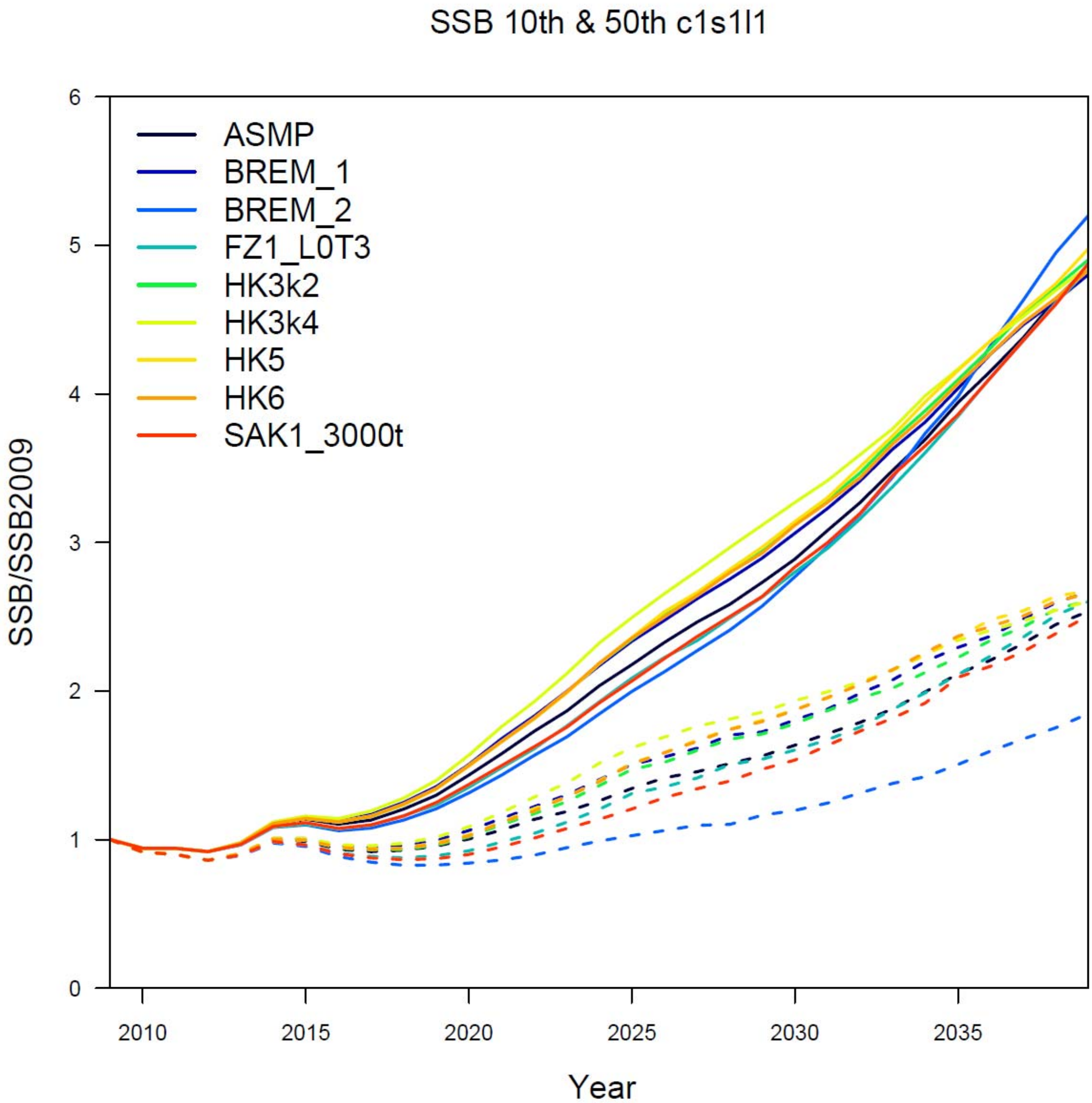


Fig.7. Time trajectory plot for spawning biomass relative to that in 2009, showing the median (solid line) and lower 10th percentile (dashed line) for the different MPs, for the **base case c1s1l1**, tuning 5, schedule c, maximum TAC change 3000 mt.

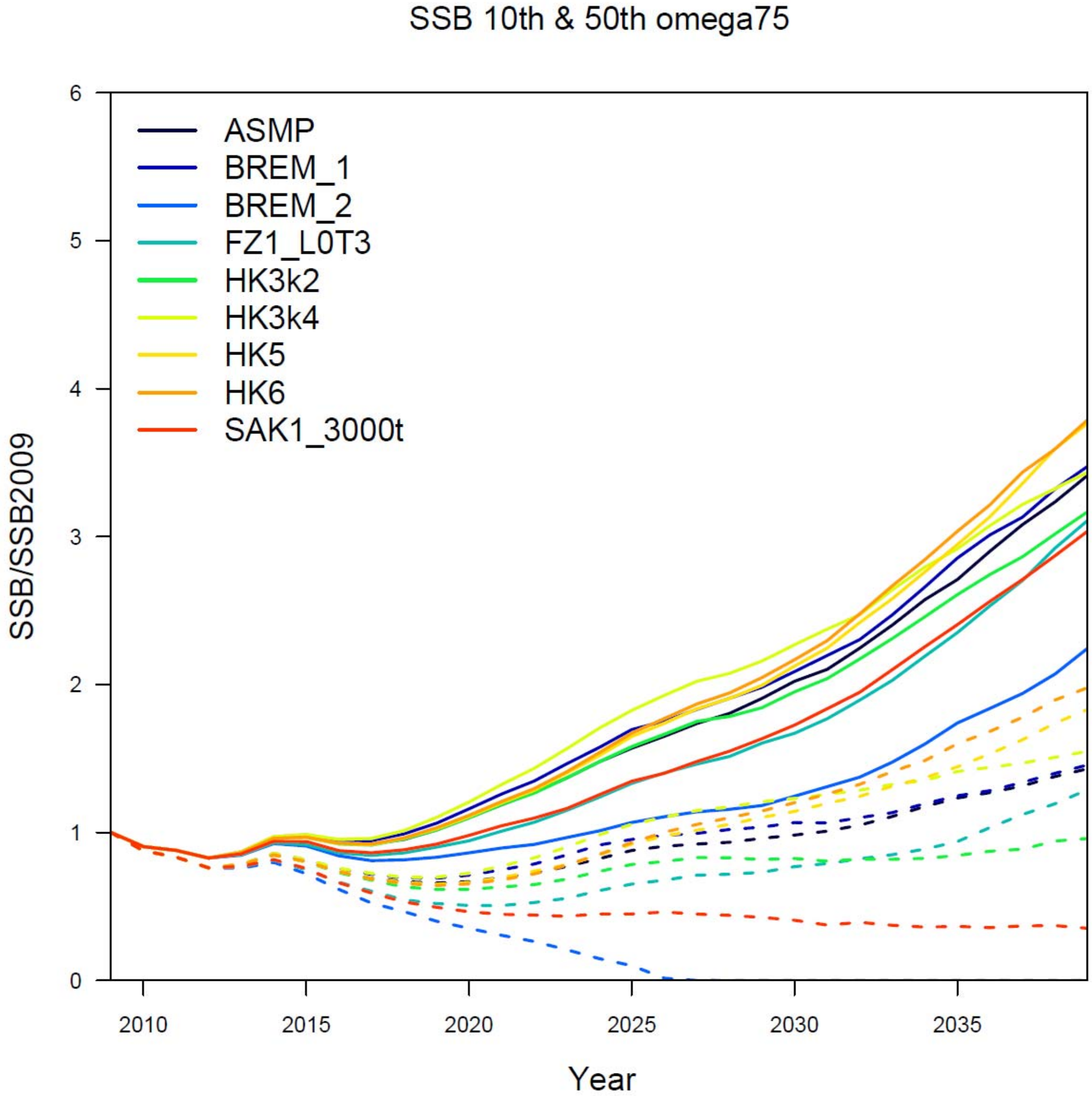


Fig.8. Time trajectory plot for spawning biomass relative to that in 2009, showing the median (solid line) and lower 10th percentile (dashed line) for the different MPs, for the **omega75 case**, tuning 5, schedule c, maximum TAC change 3000 mt.

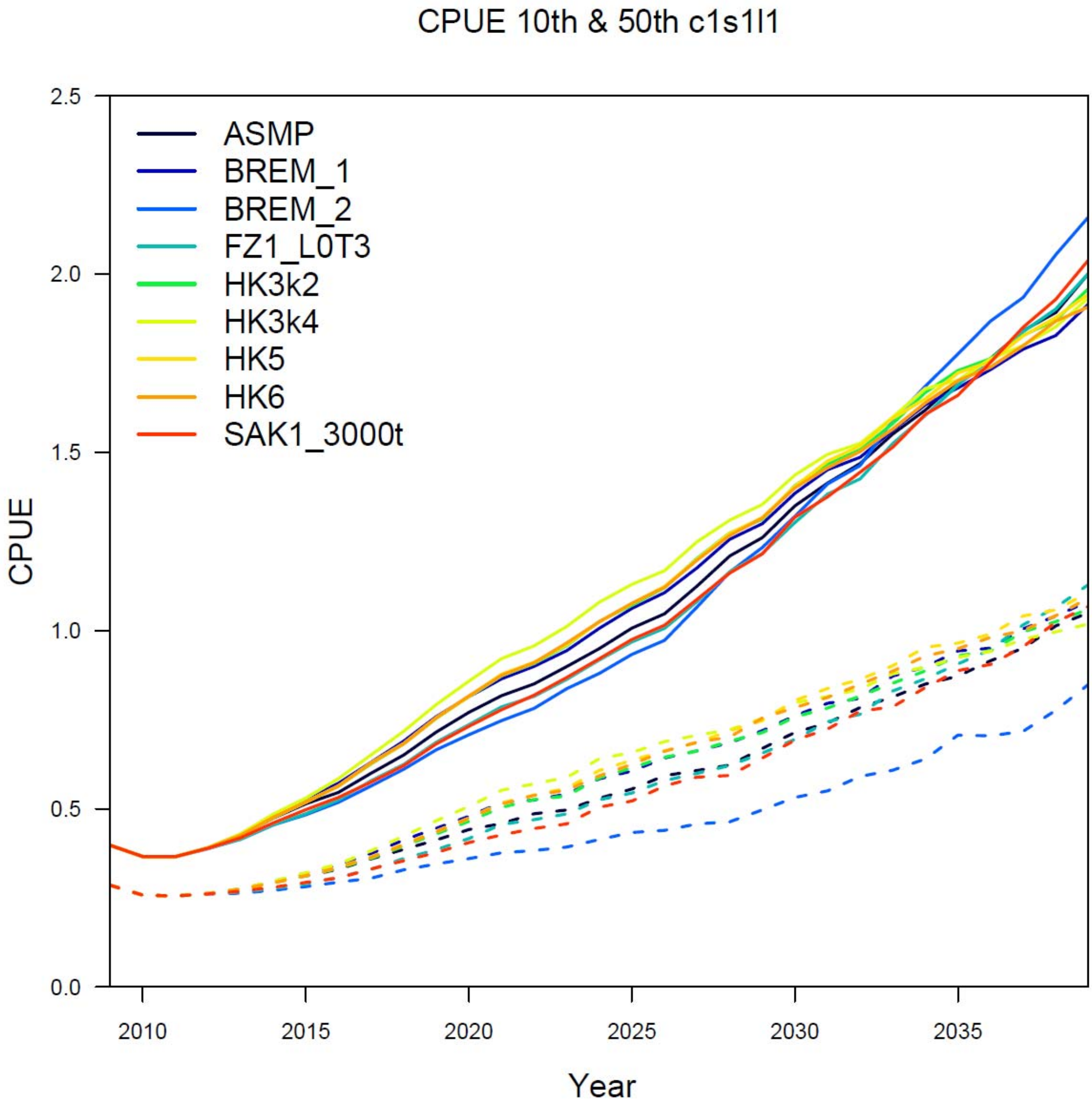


Fig.9. Time trajectory plot **for CPUE**, showing the median (solid line) and lower 10th percentile (dashed line) for the different MPs, for the **base case c1s1l1**, tuning 5, schedule c, maximum TAC change 3000 mt.

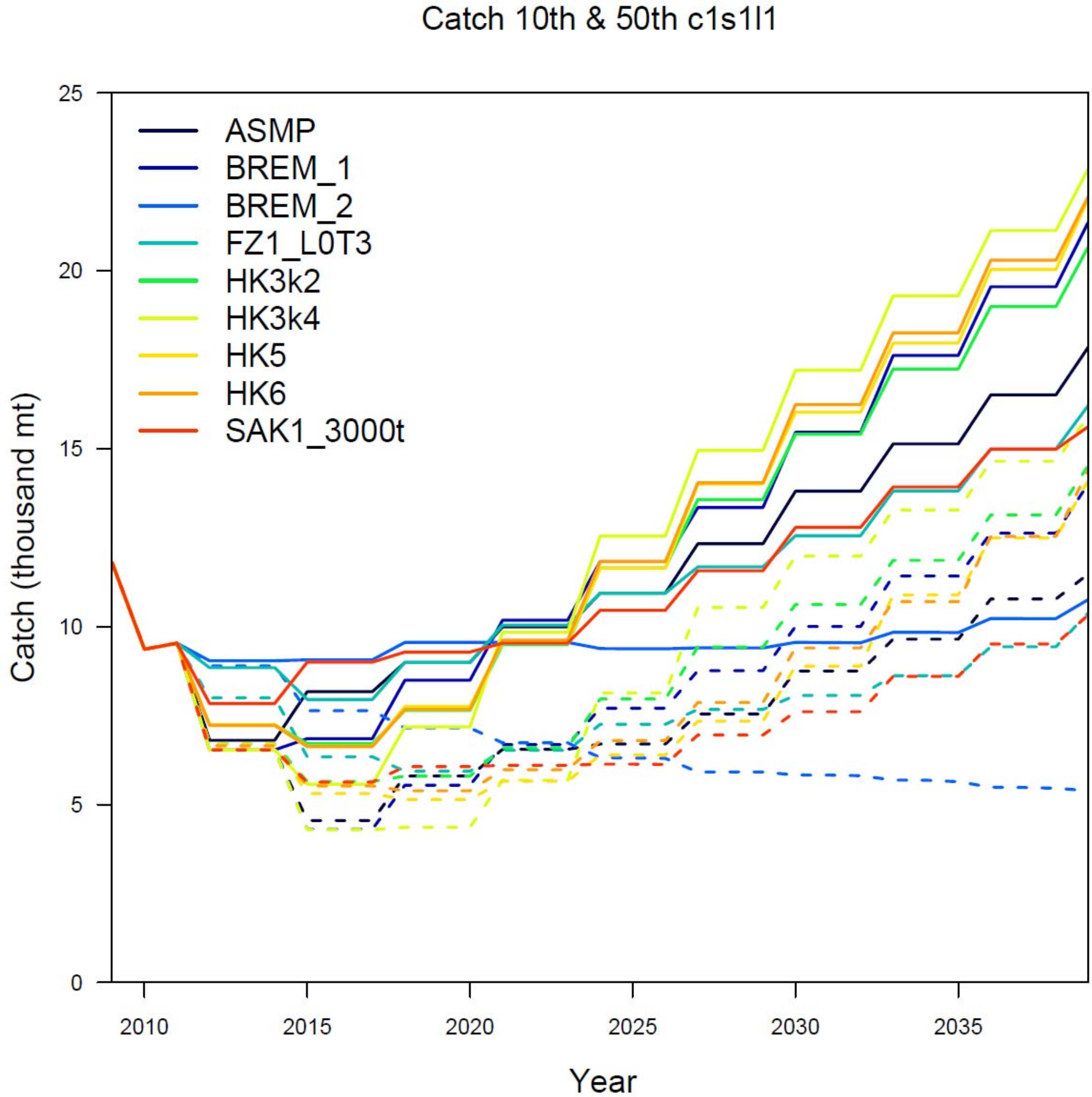


Fig.10. Time trajectory plot **for catches**, showing the median (solid line) and lower 10th percentile (dashed line) for the different MPs, for the **base case c1s1l1**, tuning 5, schedule c, maximum TAC change 3000 mt.

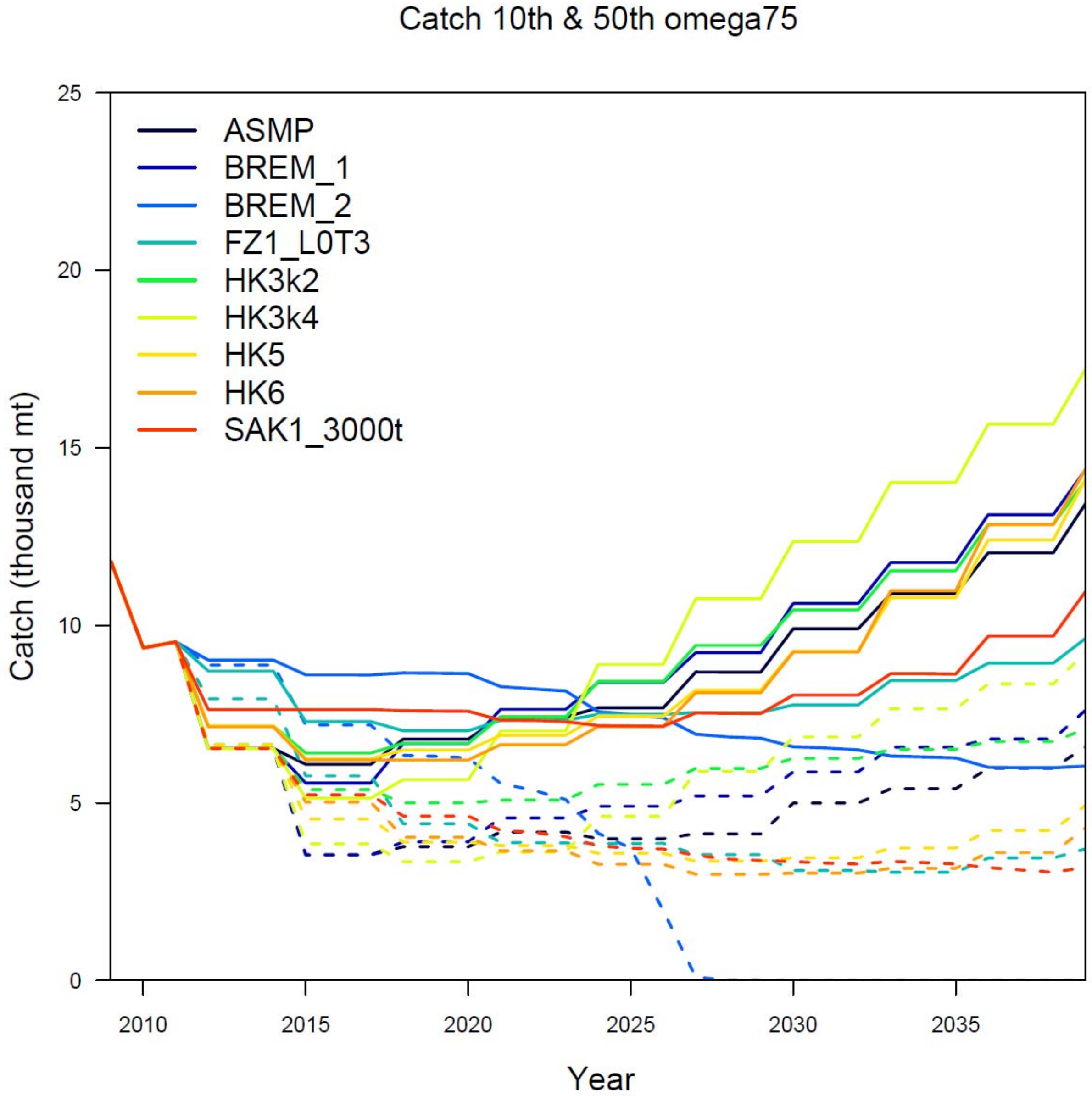


Fig.11. Time trajectory plot **for catches**, showing the median (solid line) and lower 10th percentile (dashed line) for the different MPs, for the **omega75 robustness trial**, tuning 5, schedule c, maximum TAC change 3000 mt.

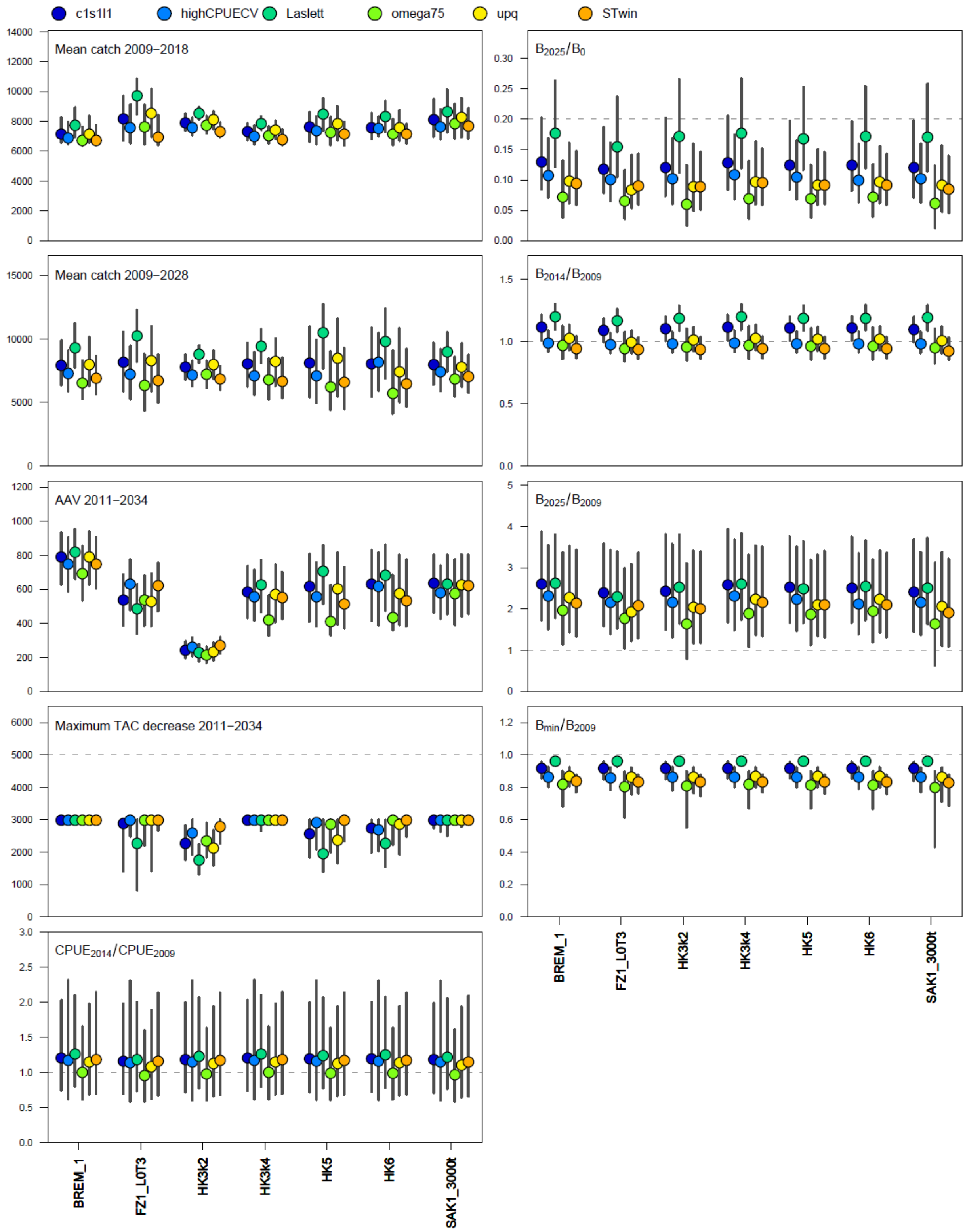


Fig.12. Comparison of MP performance, **grouped by MPs**, with all MPs subject to a constraint of changing the TAC by no more than 3000 mt (up or down), under **tuning 2**, catch schedule c. The base case is c1s1l1, and different robustness trials are represented by different colors.

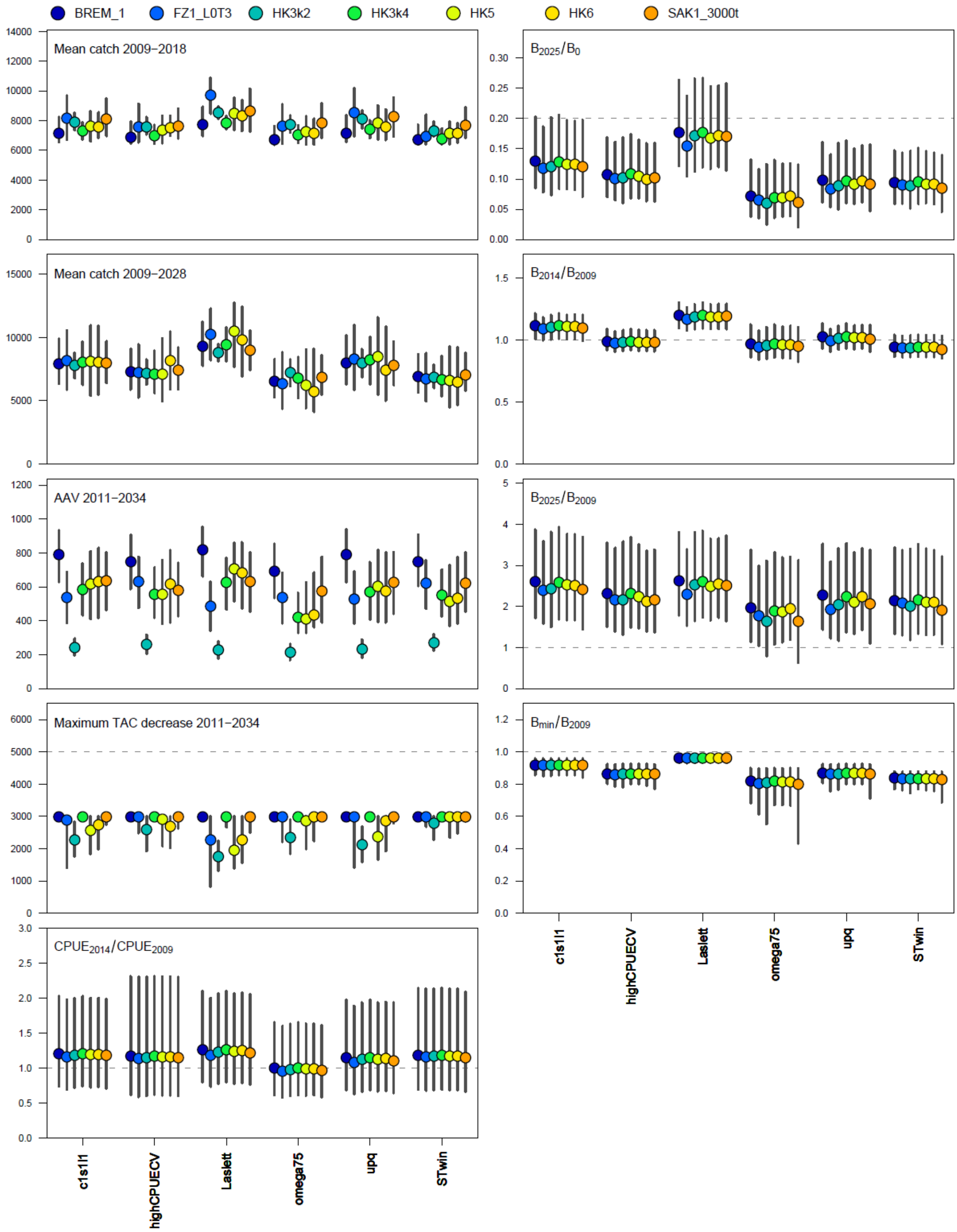


Fig.13. Comparison of MP performance, **grouped by robustness trials**, with all MPs subject to a constraint of changing the TAC by no more than 3000 mt (up or down), under **tuning 2**, catch schedule c. The base case is c1s1l1, and different robustness trials are represented by different colors.

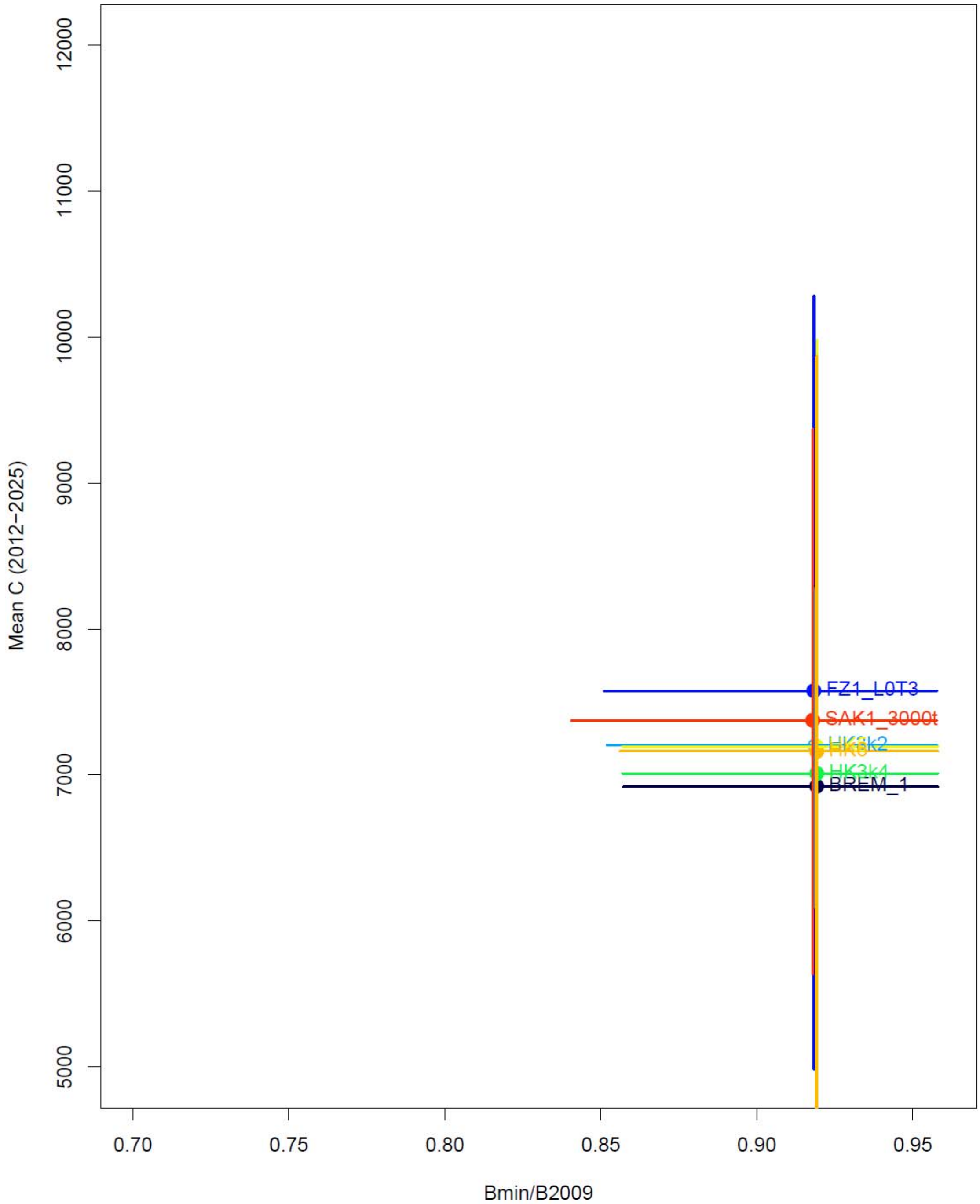


Fig.14. Tradeoff between mean catch over 2012-2024, and the ratio of **minimum spawning biomass**Bmin to that in 2009. Minimum biomass is calculated over the full projection period (2009-2040). The circles are the median and the lines are the 10th and 90th intervals, for the base case c1s1l1, **tuning 2**, schedule c, maximum TAC change 3000 mt.

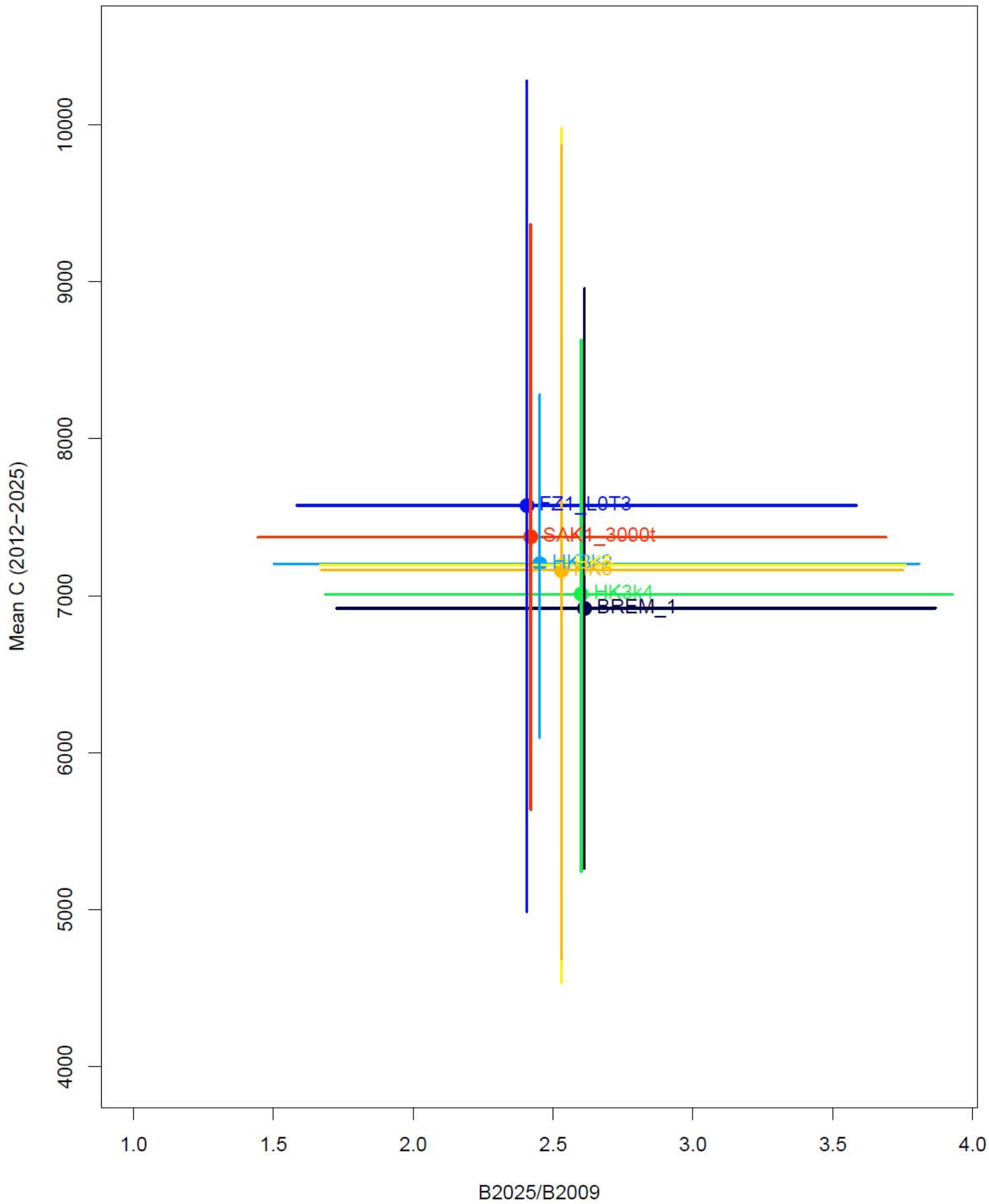


Fig.15. Tradeoff plot between mean catch over 2012-2025 and the **spawning biomass in 2025** relative to 2009, for the base case c1s1l1, **tuning 2**, schedule c, maximum TAC change 3000 mt.

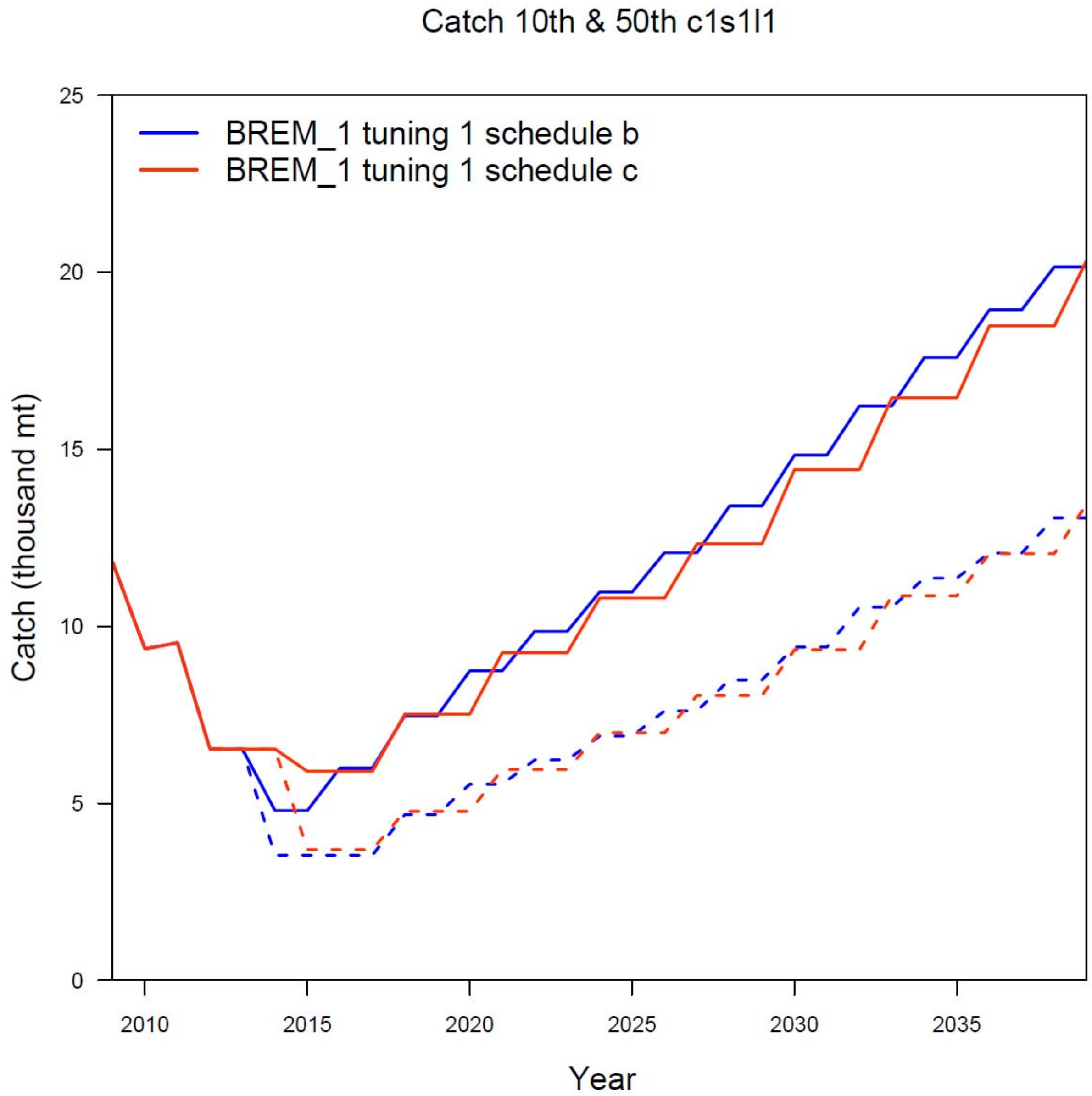


Fig.16. Comparison of **catch schedule b** (every 2 years) **and c** (every 3 years), showing the catch trajectories for BREM_1 MP, base case c1s1l1, maximum TAC change of 3000 mt, and **tuning option 1**.

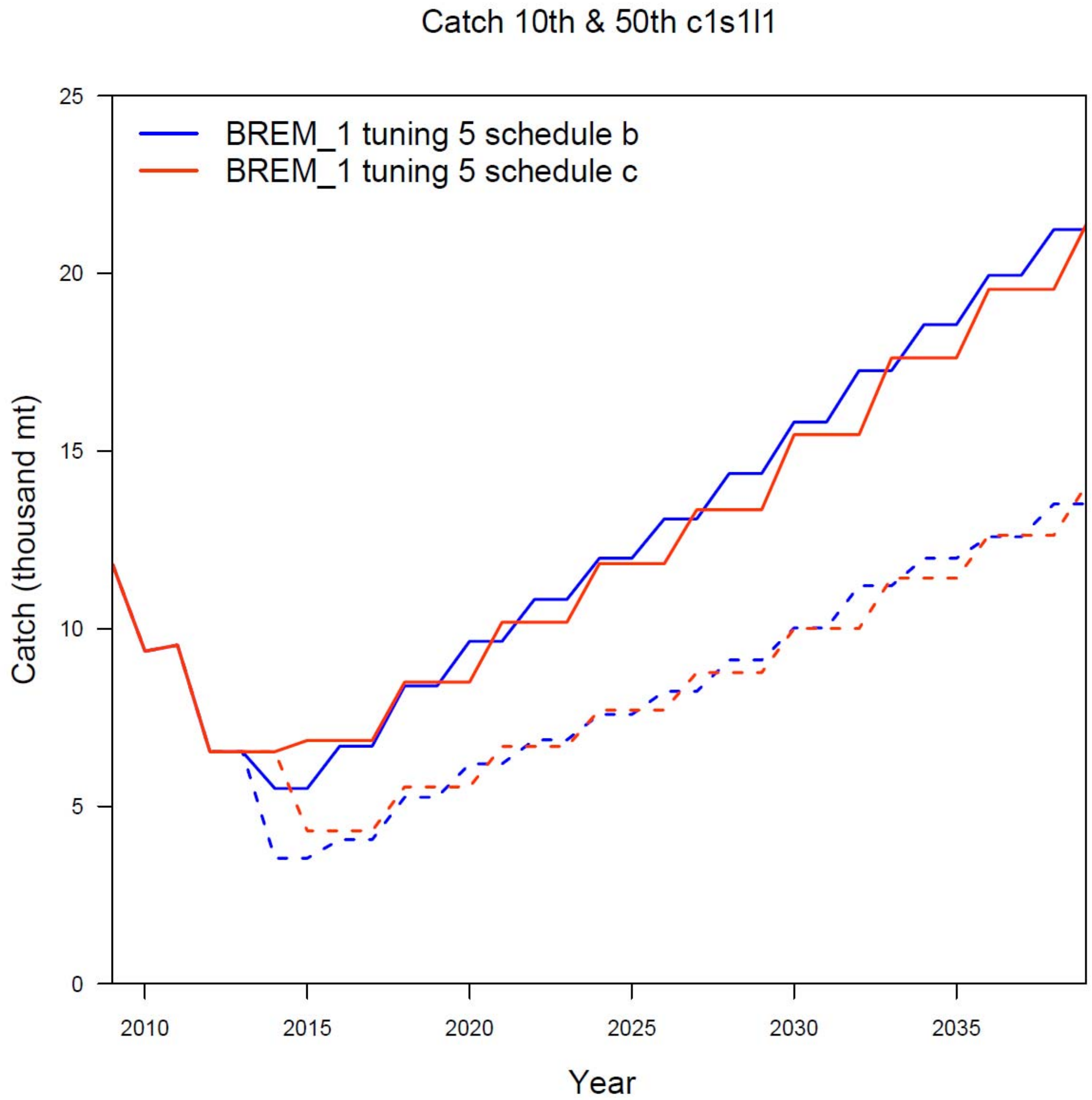


Fig.17. Comparison of **catch schedule b** (every 2 years) **and c** (every 3 years), showing the catch trajectories for BREM_1 MP, base case c1s1l1, maximum TAC change of 3000 mt, and **tuning option 5**.

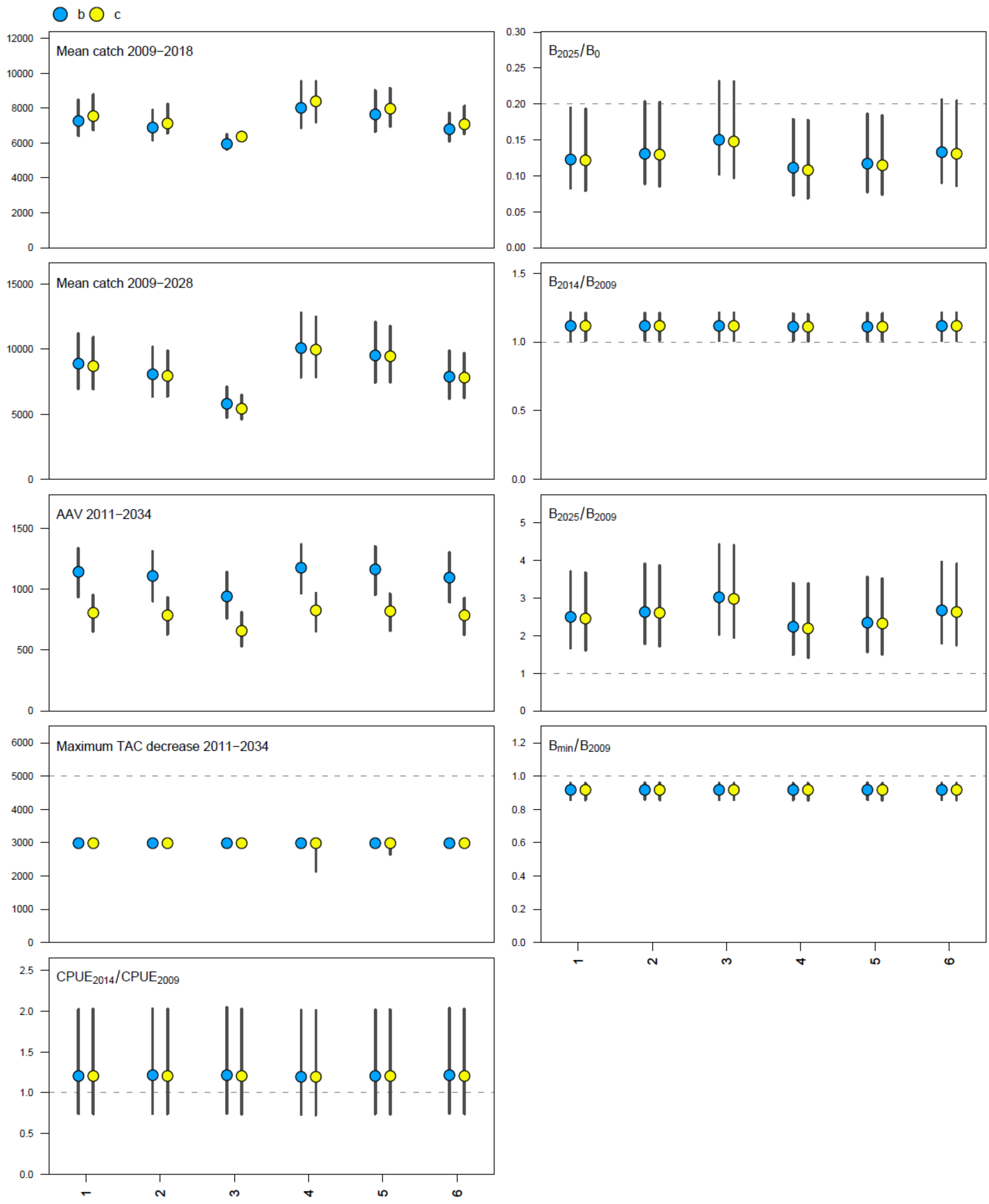


Fig.18. Comparison of **catch schedule b** (every 2 years) **and c** (every 3 years) for each of the six tuning options (1-6), for the BREM_1 MP, base case c1s1l1, maximum TAC change of 3000 mt.