

**Performance of the empirical management procedure (MP2)  
under the updated operating models**

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We evaluated the performance of the empirical management procedure (MP2) using the updated operating model (reference set and robustness trials). In order to meet management targets, TACs need to be increased steadily and substantially under the updated reference set, and the MP behavior is different from that under the previous reference set used at the 2010 ESC meeting. This is because the updated operating model estimates a very productive stock at present due to higher steepness and recent good recruitments. Tuning options, particularly regarding the maximum allowable change of TAC, would need to be reconsidered when using this optimistic operating model for performance evaluation of MPs.

**更新されたオペレーティングモデルのもとでの経験的な管理方式の性能評価**

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更新されたオペレーティングモデルを用いて、経験的な管理方式 MP2 の性能を評価した。この新しいオペレーティングモデルを使う限り、管理目標を達成させるには、TAC をかなり急に増加させなければならず、これまでの挙動と大きく異なった。これは更新されたオペレーティングモデルが高いステープネスと近年のよい加入により、生産性の高い資源状態を予測するためである。もしこのような楽観的なオペレーティングモデルを管理方式の性能評価に使うのなら、チューニングの条件、特に TAC の変更幅については再考が必要であろう。

## Introduction

The first meeting of the CCSBT Strategy and Fisheries Management Working Group (SFMWG) held in 2009 confirmed that development of a Management Procedure (MP) would be finalized in 2010 for the implementation in 2012. However, the Extended Commission (EC) meeting held in 2010 did not reach an agreement of a final MP, and in addition requested the Extended Scientific Committee (ESC) to conduct a new stock assessment and to re-evaluate candidate MPs in 2011.

In this document, we evaluate the performance of a candidate MP (MP2; HK7) under the updated operating model. MP2 calculates a TAC based on the trend of a longline CPUE index along with the current ratio of the aerial survey index to a target.

## Projection conditions and robustness trials

For this exercise, we have used the projection program “sbtprojv119.exe” (distributed on 13 June 2011) and conditioning results obtained using a conditioning program “sbtmod24.exe” (distributed on 31 May 2011). A set of conditioning results (basehupsqrt.grid) distributed by the responsible Panel member was tentatively used as the updated reference set for this analysis. Default options for testing MPs were determined in inter-session discussions regarding tuning options (70% in 2035 or 2040; the so-called tuning options 2 or 5), a maximum allowable change of the TAC (3000t or 5000t), an implementation time lag (1 year), a TAC change frequency (every three years) and an initial TAC reduction (**Table 1**). Consequently, four runs with different options were conducted to evaluate MP performance. The catch allocation for each fleet was based on nominal allocations except for Japan=3000t (i.e., option 2). MPs were tuned to within  $\pm 1\%$  of the tuning level (i.e.,  $70 \pm 1\%$ ).

A set of 24 robustness trials was established tentatively based on inter-session discussion. We conducted calculations for all these trials, but in this document we show results for the following five robustness trials only, as these had greater impacts on results, particularly for the more pessimistic scenarios: *lowR*, *STwin*, *omega75*, *upq*, *updownq*.

## Specification of HK7 (MP2)

HK7 (“Hiroyuki Kurota ver. 7”) determines a TAC from the two candidate TACs: one calculated using the CPUE trend (slope) for age 4+ over the most recent years ( $\delta TAC^{cpue}$ ), and the other using the AS (aerial survey) index over the most recent years ( $\delta TAC^{aerial}$ ) (Kurota et al., 2010).

The change of TAC is specified as:

$$\delta TAC_{y+1}^{cpue} = \begin{cases} 1 - k_1 |\lambda|^{\gamma_{cpue}} & \lambda < 0 \\ 1 + k_2 \lambda & \lambda \geq 0 \end{cases}$$

$$\delta TAC_{y+1}^{aerial} = \begin{cases} 1 + \beta_{as} \left( \frac{AS_{cur}}{AS_{tar}} - 1 \right) & AS_{cur} \geq AS_{tar} \\ 1 + \beta_{as} \left( \left( \frac{AS_{cur}}{AS_{tar}} \right)^{\gamma_{as}} - 1 \right) & AS_{cur} < AS_{tar} \end{cases}$$

where

$$AS_{cur} = \exp \left( \frac{1}{\tau_{as}} \sum_{i=y-\tau_{as}}^{y-1} \ln(I_i^{AS}) \right)$$

$$AS_{tar} = \alpha_{as} \exp \left( \frac{1}{15} \left( \sum_{i=1993}^{2000} \ln(I_i^{AS}) + \sum_{i=2005}^{2011} \ln(I_i^{AS}) \right) \right)$$

$$m_{min} \leq \delta TAC_{y+1}^{cpue}, \delta TAC_{y+1}^{aerial} \leq m_{max}$$

where

$\lambda$  is the slope of the regression of  $\ln(I_i^{CPUE})$  against year (from  $y - \tau_{cpue} - 1$  to  $y - 2$ ),

$k_1, k_2$ , and  $\gamma_{cpue}$  are control parameters governing the TAC derived from the CPUE trend,

$I_i^{AS}$  is the aerial survey index in year  $y$ ,

$\tau_{as}$  is the time-period over which the mean of the AS index is calculated,

$m_{max}, m_{min}$  are the upper and lower limit for  $\delta TAC^{cpue}$  and  $\delta TAC^{aerial}$ , and

$\alpha_{as}, \beta_{as}, \gamma_{as}$  are control parameters governing the TAC derived from the AS index.

These candidates for the TAC change for each year are combined as follows:

$$TAC_{y+1} = TAC_y \times \min \left( \delta TAC_{y+1}^{cpue}, \delta TAC_{y+1}^{aerial} \right)$$

When the TAC change computed from the above equation ( $|TAC_{y+1} - TAC_y|$ ) is less than 100t and  $TAC_y$  is more than 1000t, the TAC is not changed to prevent very small TAC changes (i.e.,  $TAC_{y+1} = TAC_y$ ).

In this analysis, two minor aspects that do not influence final results were changed from the previous formulation: (1) setting the upper and lower limit for  $\delta TAC^{cpue}$  to the same extent as  $\delta TAC^{aerial}$  and

(2) including data from 2011 in defining  $AS_{tar}$ .

$\alpha_{as}$  is the main tuning parameter. Default parameter values (except for  $k_2$ ) used for the MP (originally called as HK7\_29b at 2010 ESC) are  $\tau_{cpue} = 7$ ,  $k_1 = 1.5$ ,  $\gamma_{cpue} = 1.0$ ,  $\tau_{as} = 3$ ,  $\beta_{as} = 1.5$ ,  $\gamma_{as} = 1.0$ ,  $m_{max} = 1.5$ , and  $m_{min} = 0.5$ . For the run 4 incorporating an initial TAC reduction in 2012-4 (Table 1), the TAC for 2015-7 which is the first set was determined based on the TAC in 2011 (9449t), rather than the TAC in 2012-4 (3000t), to allow as quick a TAC increase as possible.

Responsiveness to the upward CPUE slope (the  $k_2$  parameter) was set at 2.0 for the original MP2 (HK7\_29b). However, when this low value was used for the updated operating model results (basehupsqrt.grid), projection results were very optimistic, i.e., the stock biomass would increase substantially and quickly to exceed the management objective in 2035, even if TAC was increased at the maximum rate under the default parameter values. Therefore, in this study, values of  $k_2$  were set at 5.0 and 10.0 so that the MP can be more reactive when increasing the TAC when the CPUE trend is upward.

At the 2010 ESC meeting, this MP was constrained by a “cap” to prevent a TAC increase in 2013-5, so as to provide steady stock recovery with a higher probability (CCSBT 2010). However, preliminary analyses showed that this cap often would make it difficult to achieve the management target because it prevents an early TAC increase, and consequently the stock recovers beyond the target. Accordingly we have examined performance of MP both with and without the TAC cap in this analysis.

## Results and Discussion

### *Tuning success relating to the maximum TAC change*

Tuning for the runs 1, 2 and 4 (**Table 1**) was very difficult within the realistic range of parameter values used for this analysis. This is because the stock biomass recovers too far beyond the management target and any TAC increase is not fast enough to slow this biomass increase sufficiently. The maximum allowable change in the TAC heavily restricts the behaviors of the MPs, and in the case of a 3000t limit, TACs are not allowed to increase sufficiently, particularly in the early years, to be able to achieve the management target. For the updated reference set, a cap of at least 5000t might be necessary on the maximum TAC change to allow MPs having different behaviors to be better compared.

The initial TAC reduction (run 4) contributed to earlier and steadier stock recovery, but allowed the stock to recover too quickly in terms of the tuning target (**Table 1**).

### ***General pattern of TAC change***

When the MP can be tuned to the management target as indicated by blue shading in **Table 1**, TACs increase steadily and substantially under the updated reference set in most realisations (**Figure 1**). This pattern of TAC change is quite different from that under the previous reference set, where the TACs were expected to decline in the near future, and then following the stock recovery to increase later. This reflects the fact that the updated operating model is more optimistic because of its higher steepness values and good recent recruitments (Sakai et al., 2011). In particular, this MP increases TACs substantially in the late 2010s, because longline CPUEs, followed by the spawning biomass, recover more dramatically due to the higher recruitments occurring over 2005-2010. After that, the increase rate of TAC becomes lower because the magnitude of the CPUE trends reduces. Finally TACs would reach around 30000t in 2040.

### ***Tuning year***

Comparison between the results for run 3 (**Figures 1 and 2**) and run 3b (which was formulated tentatively by the authors to allow further consideration of the tuning year; **Table 1, Figures 3 and 4**) indicates that the tuning year (2035 vs 2040) does not appreciably influence MP behaviors. This feature is different from results under the previous reference set, where the future TAC trajectories did depend on the tuning year. Under the updated reference set, MP2 leads to a lower limit for the spawning stock biomass (e.g., 10 percentile of SSB) which is flat after the 2030s.

### ***Variation in MP behaviors***

In run 3 with a 5000t limit on TAC changes, MPs were able to be tuned by setting different values for the responsiveness to CPUE slope (i.e.  $k_2$  values) with and without the TAC cap (**Figure 1**; except the leftmost panel). These four results show that (1) the higher  $k_2$  led to TACs which are rather too variable, and (2) MPs with the TAC cap increase TACs more steadily initially, and with little probability of a TAC reduction afterwards.

### ***Robustness trials***

The following five scenarios amongst the robustness trials showed rather characteristic (pessimistic in most cases) results compared to the reference set: lowR, STwin, Omega75, upq, and updownq (**Figures 2 and 4**). In particular, STwin (using alternative CPUE series) and Omega75 led to the most pessimistic future projections, though results for even these two scenarios are much more optimistic than for previous OMs (**Figures 5 and 6**). In general, however, MP 2 deals well with these five scenarios; it increases the stock biomass steadily, even for the two most pessimistic

scenarios, by changing TACs in an appropriate direction. In this sense, MP 2 would be quite robust to different model assumptions and input data under the updated operating model.

### ***Exploration of different forms of MP2***

There was some concern about using the CPUE slope rather than a target in MP2, because MP2 sometimes takes catch to a very low level in the later years and keeps it there, even in the case of an increasing SSB (CCSBT, 2010). However, this behavior was hardly evident in this analysis using the updated operating model, because TACs do not have to be reduced to very low levels. Nonetheless, we preliminarily modified MP2 by incorporating concept of a CPUE target with several methods (e.g., simply setting a target by the same way as for the aerial survey index). In general, however, setting an appropriate target was difficult for the updated operating model, because TACs should be increased by setting a very low target (even lower than the current CPUE level) despite the current low stock level (i.e., 5% of  $SSB_0$ ). This low target also increases TACs too much in later years (i.e., it overshoots), because this type of MP does not have a chance to reduce TACs until CPUEs become lower than the very low target. In this context, the CPUE slope is likely to provide rather better information to control TACs robustly than the target under the updated operating model, though this feature might be situation-dependent.

### **Acknowledgements**

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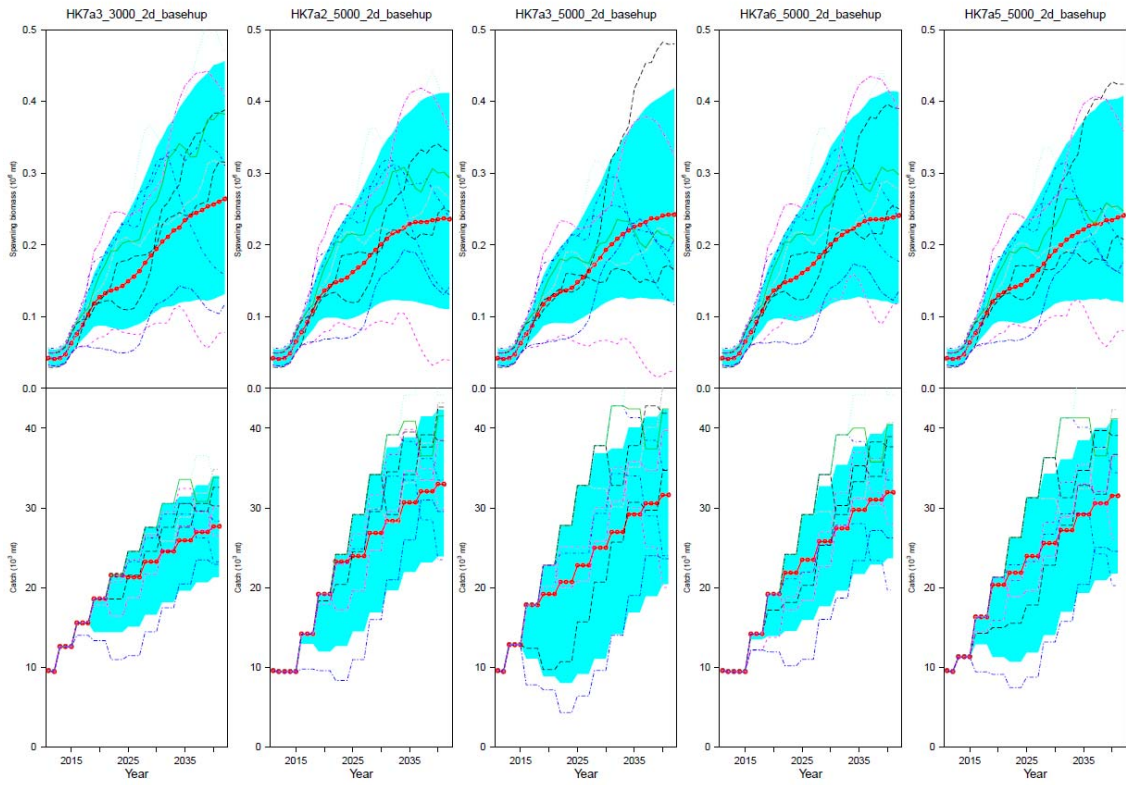
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**Table 1.** Summary table of options for MP testing and control parameter values used for MP2 variants examined in this document. The blue-shaded variants reflect that tuning was successful in meeting the associated criteria (also see **Figures 1 and 3**), whereas “x” indicates a tuning failure, and the probability in the parenthesis afterwards is the minimum probability of achievement of management goal under the conditions (where  $\alpha_{as}=0.01$  is virtually equivalent to no TAC reduction due to a low aerial survey index).

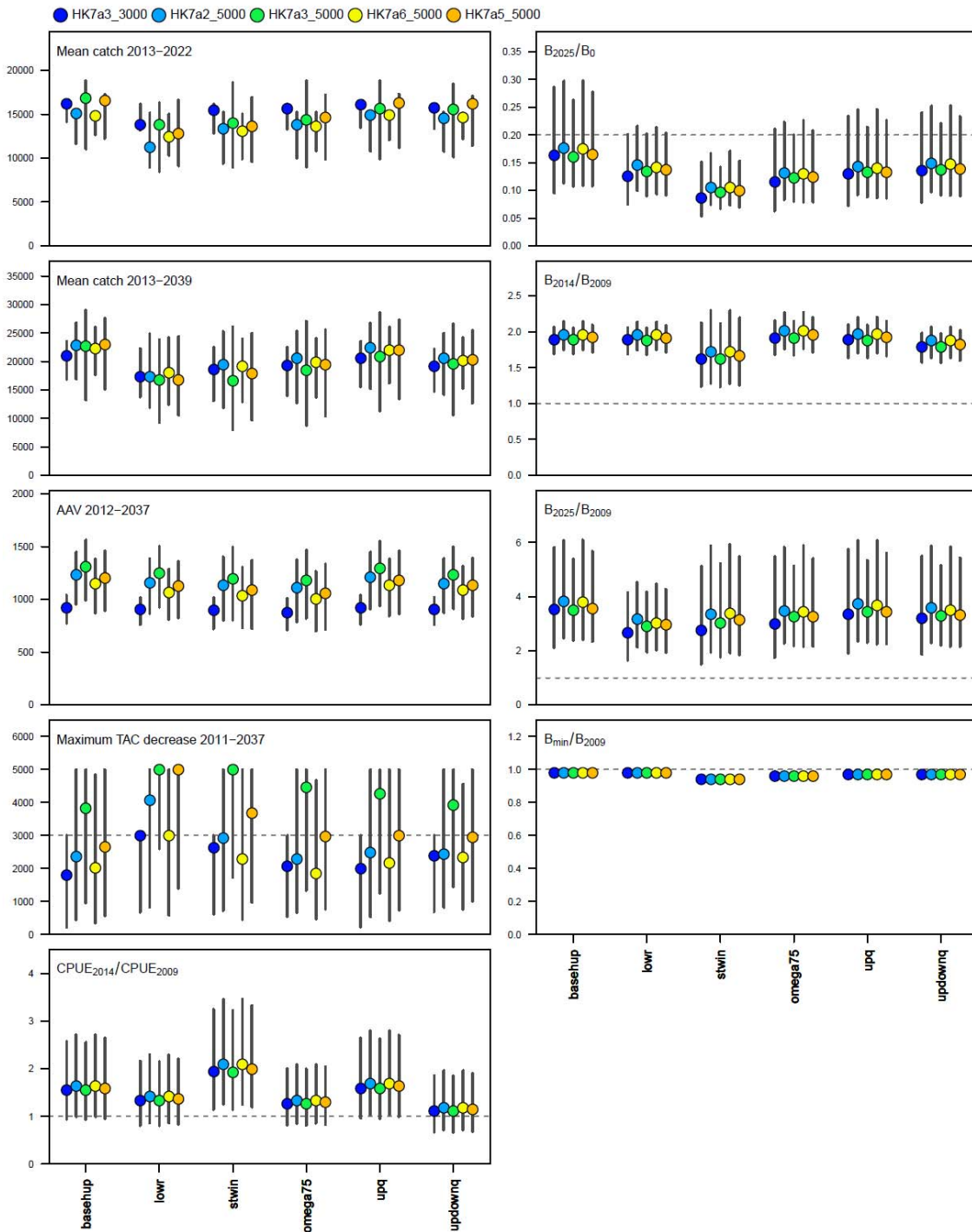
MP	Figure	max TAC change	tuning year	initial TAC reduction	tuning level	response to upward CPUE trend $k_2$	TAC cap in 2013-5	tuning parameter (AS target $\alpha_{as}$ )	note
HK7_29b (original at 2010 ESC)		3000		NO		2	ON		
<b>RUN 1</b>		<b>3000</b>	<b>2035</b>	<b>NO</b>	<b>70%</b>				
HK7a2 3000		3000	2035	NO	x (83%)	10	ON	0.01	
HK7a3 3000	1, 2	3000	2035	NO	70%	10	OFF	0.66	
HK7a6 3000		3000	2035	NO	x (85%)	5	ON	0.01	
HK7a5 3000		3000	2035	NO	x (75%)	5	OFF	0.01	
<b>RUN 2</b>		<b>3000</b>	<b>2040</b>	<b>NO</b>	<b>70%</b>				
HK7a2 3000		3000	2040	NO	x (87%)	10	ON	0.01	
HK7a3 3000		3000	2040	NO	x (72%)	10	OFF	0.01	
HK7a6 3000		3000	2040	NO	x (89%)	5	ON	0.01	
HK7a5 3000		3000	2040	NO	x (81%)	5	OFF	0.01	
<b>RUN3</b>		<b>5000</b>	<b>2035</b>	<b>NO</b>	<b>70%</b>				
HK7a2 5000	1, 2	5000	2035	NO	70%	10	ON	0.7	
HK7a3 5000	1, 2	5000	2035	NO	70%	10	OFF	0.96	
HK7a6 5000	1, 2, 5	5000	2035	NO	70%	5	ON	0.6	
HK7a5 5000	1, 2, 6	5000	2035	NO	70%	5	OFF	0.8	
<b>RUN3b</b>		<b>5000</b>	<b>2040</b>	<b>NO</b>	<b>70%</b>				
HK7a2 5000	3, 4	5000	2040	NO	70%	10	ON	0.68	
HK7a3 5000	3, 4	5000	2040	NO	70%	10	OFF	0.93	
HK7a6 5000	3, 4	5000	2040	NO	70%	5	ON	0.5	
HK7a5 5000	3, 4	5000	2040	NO	70%	5	OFF	0.76	
<b>RUN4</b>		<b>3000</b>	<b>2035</b>	<b>YES</b>	<b>70%</b>				
HK7a3 3000		3000	2035	YES	x (98%)	10	OFF	0.01	
HK7a3_5000		5000	2035	YES	x (88%)	10	OFF	0.01	$m_{max}=2.0$

**Figure 1.** Time trajectory plot for catch and stock biomass for the reference set. The shaded regions represent range between the 10 percentile and 90 percentile of the 2000 simulations for five MPs under **runs 1 and 3**, where the tuning year is 2035. The thick bulleted line represents the median and the individual lines represent a sample of the different realizations.

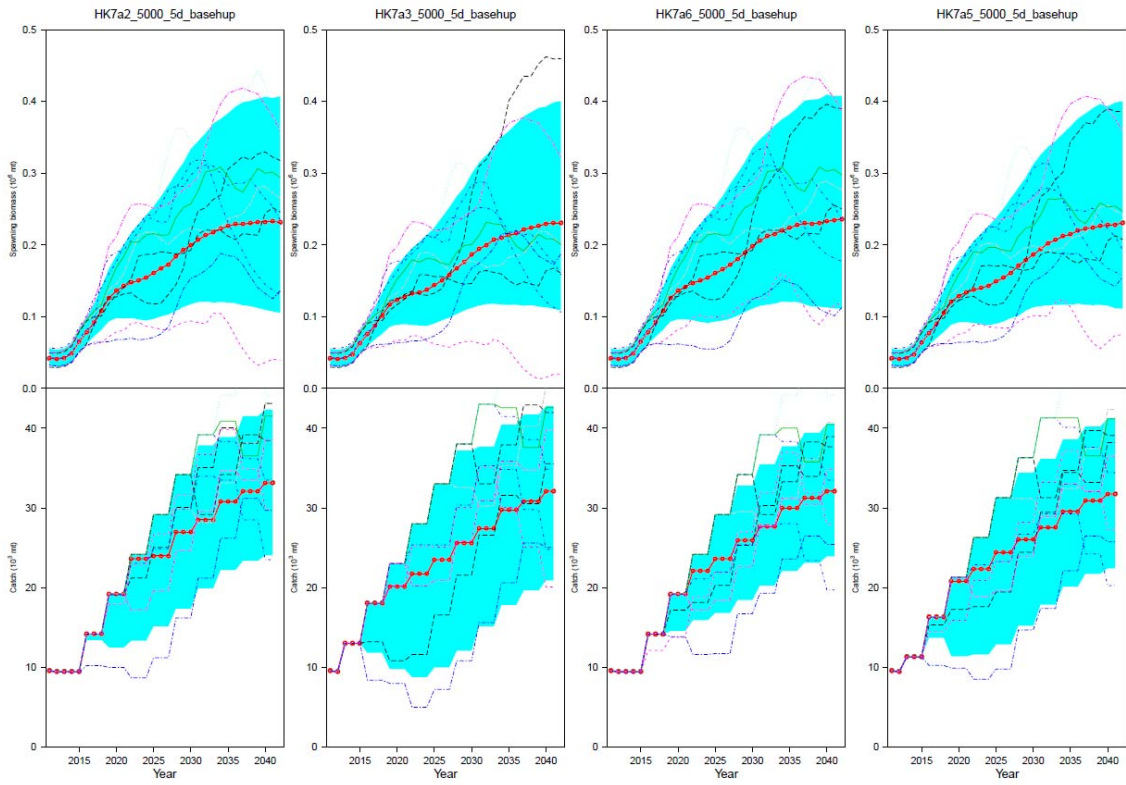




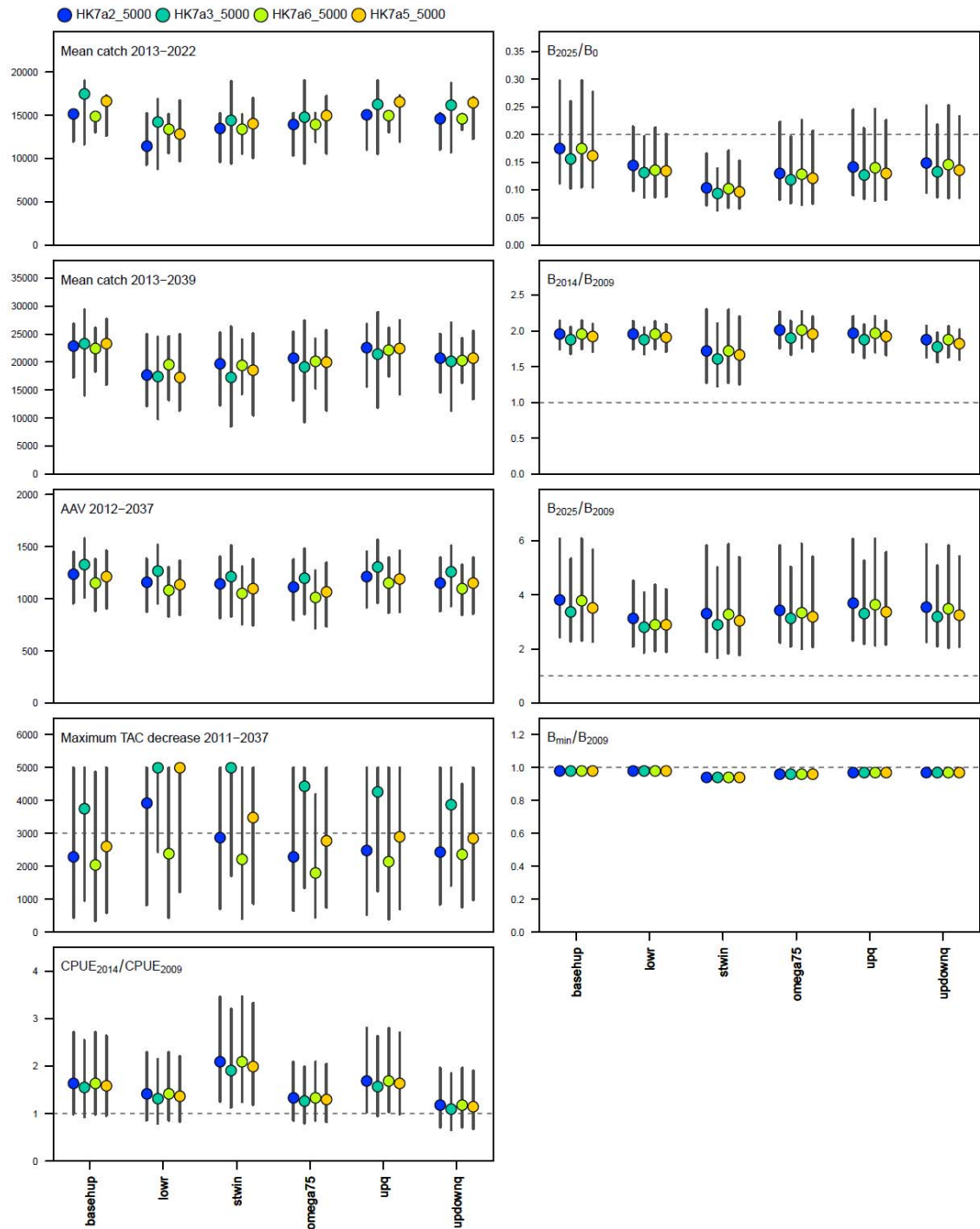
**Figure 2.** Comparison of MP performance for the reference set and the robustness trials, showing the median and 10 percentiles for selected MPs under runs 1 and 3.



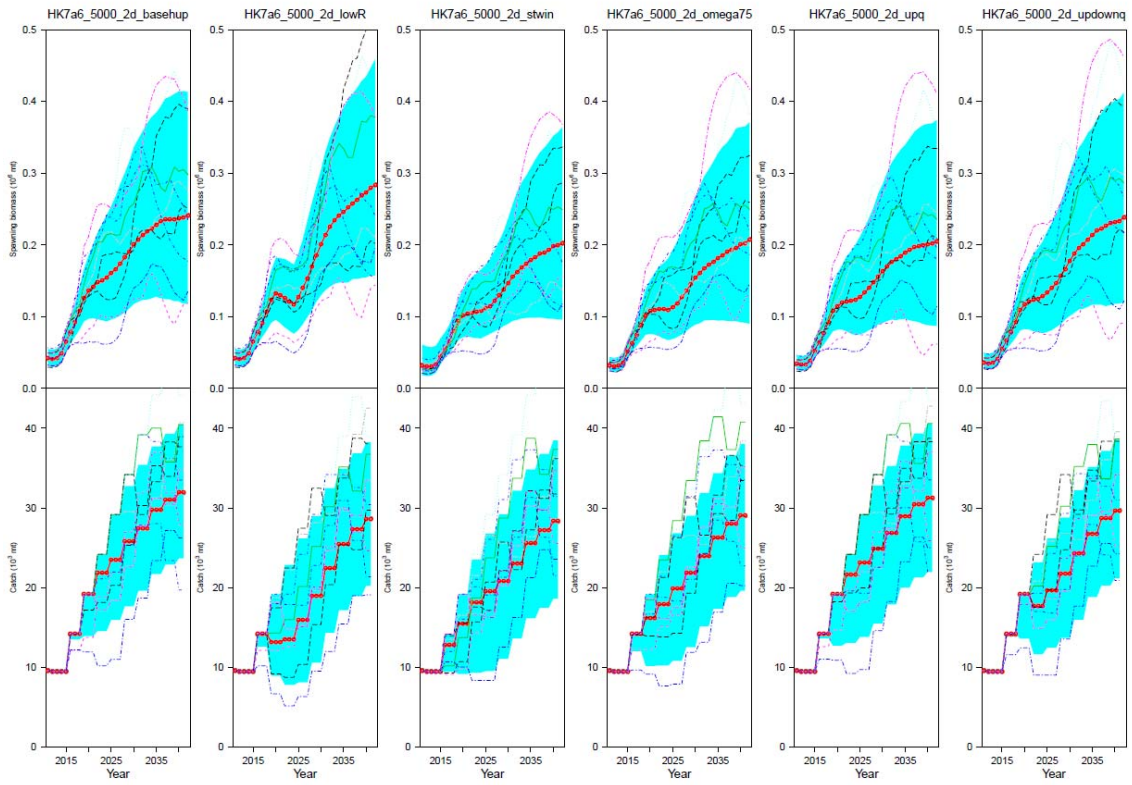
**Figure 3.** Time trajectory plot for catch and stock biomass for the reference set. The shaded regions represent range between the 10 percentile and 90 percentile of the 2000 simulations for four MPs under **run 3b**, where the tuning year is 2040. The thick bulleted line represents the median and the individual lines represent a sample of the different realizations.



**Figure 4.** Comparison of MP performance for the reference set and the robustness trials, showing the median and 10 percentiles for selected MPs under **run 3b**.



**Figure 5.** Time trajectory plot for catch and stock biomass of *HK7a6\_5000* (run 3) for the reference set and five robustness trials. The shaded regions represent range between the 10 percentile and 90 percentile of the 2000 simulations. The thick bulleted line represents the median and the individual lines represent a sample of the different realizations.



**Figure 6.** Time trajectory plot for catch and stock biomass of *HK7a5\_5000* (run 3) for the reference set and five robustness trials. The shaded regions represent range between the 10 percentile and 90 percentile of the 2000 simulations. The thick bulleted line represents the median and the individual lines represent a sample of the different realizations.

