APPLICATION OF THE D&M MANAGEMENT PROCEDURE TO THE CORE AND SENSITIVITY TRIALS TO ASSIST IDENTIFY FACTORS TO WHICH MP PERFORMANCE IS LIKELY TO BE THE MOST SENSITIVE

管理方式（MP） のパフォーマンスに最も影響を与える要因を明らかにするための D&M 管理方式の Core と Sensitivity トライアルへの適用

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SUMMARY

The D&M MP is tuned to the Core set OM and then applied to constituent scenarios of the Core set and the Sensitivity trials. The presence or absence of appreciable changes in anticipated performance as factors are varied in these trials suggests that Indonesian selectivity might be included in the final Reference set, but the M0 factor excluded.

要約

D&M 管理方式で Core セット OM をチューニングし、さらにこの Core set を形成しているシナリオと感度テストのためのシナリオにこの管理方式を適用した。これらのシナリオに含まれている要因を含んだ場合と含まない場合とで管理方式のパフォーマンスがどれだけ変化するかを検討した結果、インドネシアの選択性に関するシナリオは最終段階の Reference セットに残す必要が示唆され、反対に、M0 に関するシナリオは除外してもよいことが示唆された。

INTRODUCTION

An important objective for the February 2005 CCSBT workshop in Seattle is to finalise a Reference set and Robustness trials (or Operating Models, OMs) for final Management Procedure (MP) testing. These are to be developed from the Core set and Sensitivity trials defined at present.

It is likely that a Sensitivity trial (factor) for which MP performance changes substantially from that for the corresponding baseline would be a candidate for inclusion in the Reference set. Similarly, if performance showed little difference for alternative levels of a factor in the Core set, this might be omitted from the Reference set.

This paper thus provides results for the application of an MP to the Core set and Sensitivity trials to assist the process of finalizing the Reference set and Robustness trials.

METHODS

The D&M management procedure (Butterworth and Mori 2003, 2004) has been used to assess comparative performance of an MP across different OMs in this paper. The D&M management procedure is based on fitting a discrete age-aggregated Fox dynamic production model to past catch and CPUE data. The details of how the model is fit are set out in Butterworth and Mori (2004), and will not be repeated here. Estimates of the parameter values from this model fit are used to compute future TACs as follows:

$$TAC_{y+1} = \left(w_y TAC_y + \alpha(1 - w_y) \cdot M\hat{S}YR_y \cdot \hat{B}_{MSY} \cdot \left(\frac{\hat{B}_y}{\hat{B}_{MSY}} \right)^{\gamma} \cdot g(\hat{r}_y) \right) \cdot f(LL) \tag{1}$$

where $\hat{B}_{MSY}$ is the estimated maximum sustainable yield level (MSYL),

γ is a control parameter (here fixed to be 0.6),

w_y is a control parameter (which can change from year to year, though is kept year-invariant and equal to 0.7 in all the applications considered here),

$M\hat{S}YR_y$ is the estimated maximum sustainable yield rate, calculated as $M\hat{S}Y_y / MSYL$ ($\hat{r}_y / \ln \hat{K}_y$ for the Fox model – note that these estimated values change with year y as more data become available),

$\hat{B}_y$ is the estimated biomass for year y, which (together with $\hat{r}_y$ and $\hat{K}_y$) is re-estimated for each projection year,

$g(\hat{r}_y)$ is a function which reduces the TAC further if $\hat{r}_y$ is low,

$f(LL)$ is a function which adjusts the TAC depending on the proportion of lower ages in longline catch, and

α is a control parameter which is varied to obtain the desired median B_{2022}/B_{2004} tuning level.

The TAC reduction factor $g(\hat{r}_y)$ is set to:

$$g(\hat{r}_y) = \begin{cases} 0 & \text{for } 0 \le \hat{r}_y \le r_1 \\ \dfrac{1}{r_2 - r_1}(\hat{r}_y - r_1) & \text{for } r_1 < \hat{r}_y < r_2 \\ 1 & \text{for } r_2 \le \hat{r}_y \end{cases} . \tag{2}$$

with parameter values fixed at r_1=0.4, r_2=1.0 as is in Butterworth and Mori (2003).

Here we assumed $f(LL)$=1 for simplicity and since the aim at this stage is to compare performance across different OMs rather than to optimize the MP. Parameter values for a $f(LL)$ function will be better chosen once a Reference set is finalised.

Sample sizes for applications to the core and sensitivity OMs were 500 and 200 respectively; this was in the interests of speed of computation, given that the purpose of this exercise was to make qualitative rather than exact quantitative comparisons.

RESULTS

Both the Core set (Cfullnotag) and the sensitivity test which incorporates tagging data in conditioning the OM (Cfulltag) have been used to tune the D&M procedure to achieve median recovery levels of 0.9 and 1.1 (see Table 1).

Corresponding catch and spawning biomass trajectories are shown in Figs 1 and 2 for Cfullnotag and in Figs 3 and 4 for Cfulltag.

Figs 5 and 6 compare a Cfullnotag tuning to recovery level 1.1 across the Cfullnotag and Cfulltag OMs, while Figs 7 and 8 do the same for the corresponding Cfulltag tuning.

Figs 9 and 10 respectively compare recovery (B_{2022}/B_{2004}) and catch (C_{2031}) statistics for the Core set (or a factor thereof) and corresponding Sensitivity trials. Figs 11 and 12 do likewise for constituent factors within the Core set, where the value of the factor itself is fixed and the trial integrated over the other factors. Generation of the associated OMs was achieved by replacing the Core set weights across levels of the factor of interest by 1 for the value in question and 0 for the other values.

The trial names shown in Figs 9-12 are as in the standard trials documentation, and the scenarios they reflect are generally self-evident therefrom. Amongst the Sensitivity trials of Figs 9-10, note that low R-4 and low R-6 refer to scenarios where recent low recruitment occurs for 4 and 6 years, rather than for 2 only as in the Core set.

DISCUSSION

From Figs 1-8 it is evident that the addition of tag data in re-conditioning the Core set OM (Cfullnotag) to provide the Cfulltag OM, results in appreciably more optimistic prognoses for the SBT resource. Much of this difference reflects the different weightings, which arise from different likelihoods for the various levels of Core set factors M0, M10 and Omega. Table 2 shows these differing likelihoods in the form of differences in –lnL, so that higher values reflect lower weights accorded. (Note that steepness *h* and CPUE are included in this Table in the interests only of completeness, as these factors are weighted by priors alone in developing the Core set.)

Table 2 suggests that the key reason for the differences in prognoses when tagging data are taken into account is that these data are appreciably less consistent with the lowest M0 and M10 levels, which consequently receive relatively less weight for the Cfulltag OM compared to the Cfullnotag Core set.

In the Sensitivity test results of Figs 9 and 10, two features stand out. The first is the notable deterioration in performance as the period of low recruitment is extended for the immediate future. The second is the large negative impact on recovery when the maximum age for which Indonessian selectivity is estimated is reduced from 30 to 18.

Amongst the Core set factors (Figs 11 and 12), there is little variation in performance for different values for M0. Of interest is that while performance in terms of median recovery is worse for the lowest value of M10 in terms of the median, such performance nevertheless reflects much less variability for the lowest M10 than for the central value (presumably a reflection of higher biomasses in absolute terms for low M10 value). Identifying the reason for the appreciably worse recovery performance for CPUE series CPUE_04 merits attention.

In summary, in relation to moving from the current Core set to a Reference set, these results suggest a case for dropping the M0 but including the Indonesian selectivity factor in the Reference set.

ACKNOWLEDGEMENTS

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REFERENCES

Butterworth, D. S. and Mori, M. 2003. Further investigations of a Fox-model based management procedure for southern bluefin tuna. Document CCSBT-ESC/0309/37. 24pp

Butterworth, D. S. and Mori, M. 2004. Application of variants of a Fox-model based MP to the "Christchurch" SBT trials. Document CCSBT-MP/0404/06. 26pp

Table 1. Values of the α tuning parameter of the D&M management procedure to obtain particular median recovery levels for the Cfullnotag and Cfulltag operating models, based on a sample size of 500.

OM	Tuning level	α	B_{2022}/B_{2004}
Cfullnotag	0.9	0.78	0.90
	1.1	0.50	1.10
	[Cfulltag=1.1]	0.94	0.79
Cfulltag	0.9	1.23	0.90
	1.1	0.94	1.10
	[Cfullnotag=1.1]	0.50	1.39

Table 2. The values shown are the differences in the average -lnL compared to the lowest -lnL in each row.

Factor	OM					
Steepness		0.385	0.55	0.73		
	notag	0.0	1.0	3.6		
	tag	0.0	1.7	4.2		
M0		0.3	0.4	0.5		
	notag	0.0	0.1	0.7		
	tag	3.8	0.9	0.0		
M10		0.07	0.1	0.14		
	notag	1.5	0.0	1.4		
	tag	5.2	0.8	0.0		
Omega		0.75	1			
	notag	0.0	0.9			
	tag	1.5	0.0			
CPUE		1	2	3	4	5
	notag	8.65	12.76	17.05	0.00	3.01
	tag	7.36	9.77	13.35	0.00	0.73

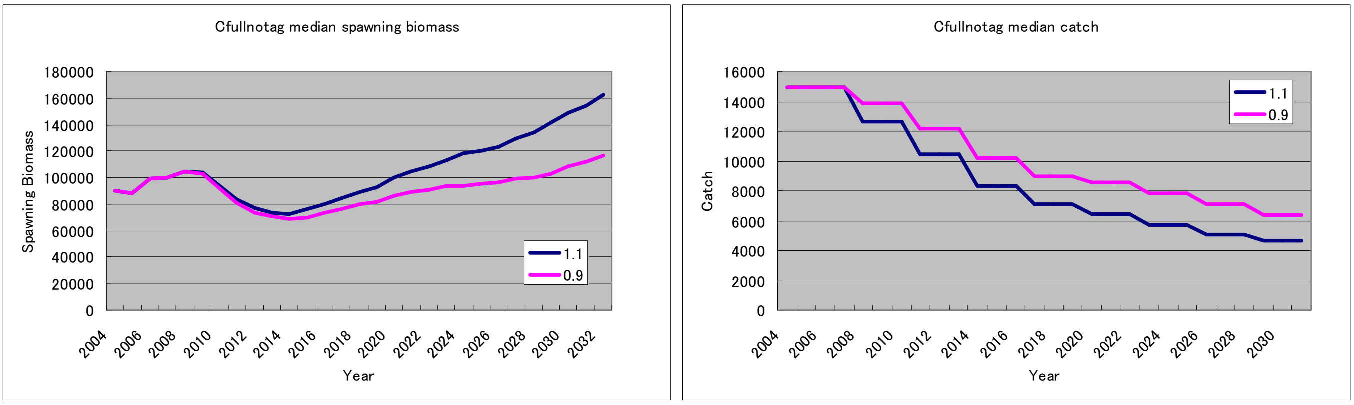

Figure 1. Median spawning biomass and catch trajectories for the D&M MP (*f*(*LL*)=1) for B2022/B2004 tuning levels of a) 0.9 and b) 1.1 for the **Cfullnotag** OM.

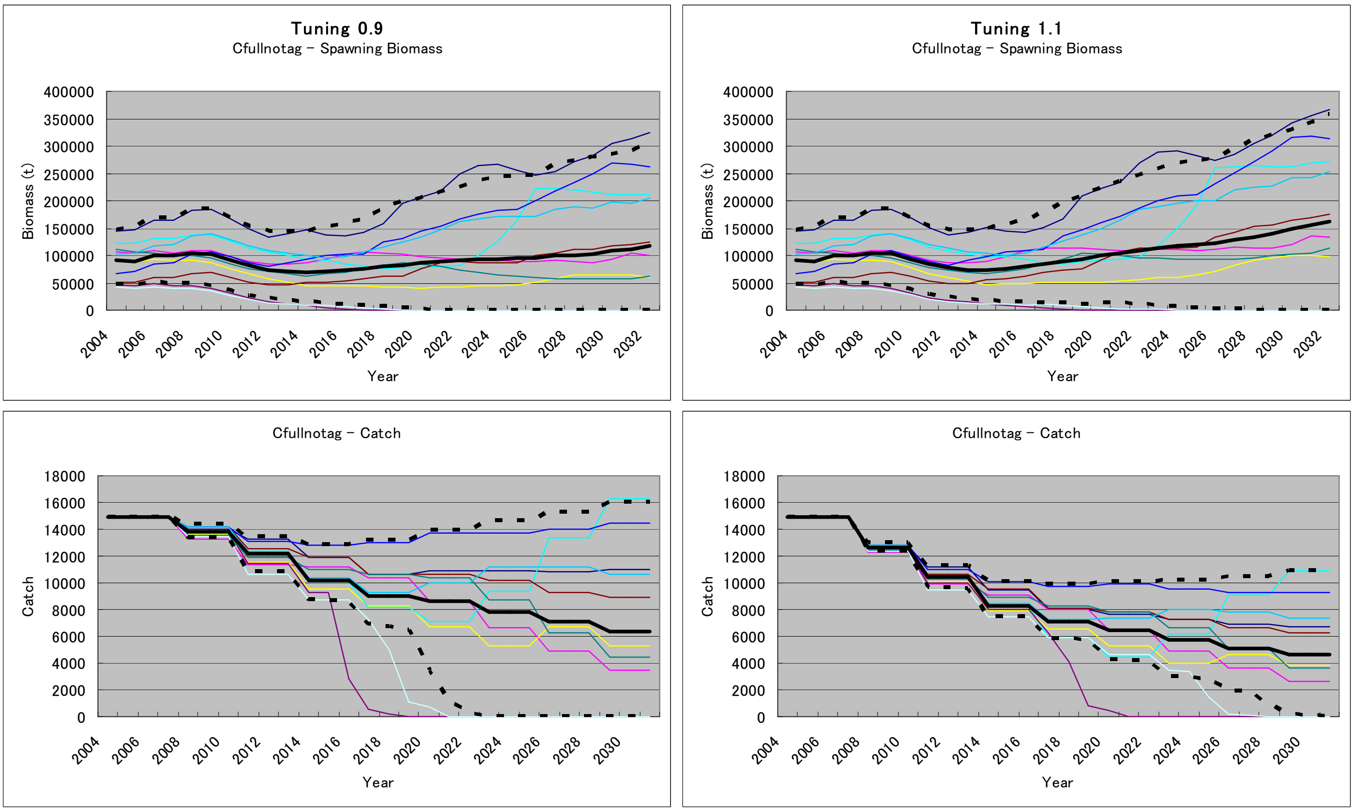

Figure 2. Wormplots for the D&M MP (*f*(*LL*)=1) for B2022/B2004 tuning levels of a) 0.9 and b) 1.1 for the **Cfullnotag** OM. The dashed lines show the 90% probability envelopes and the black dark lines show the median trajectories.

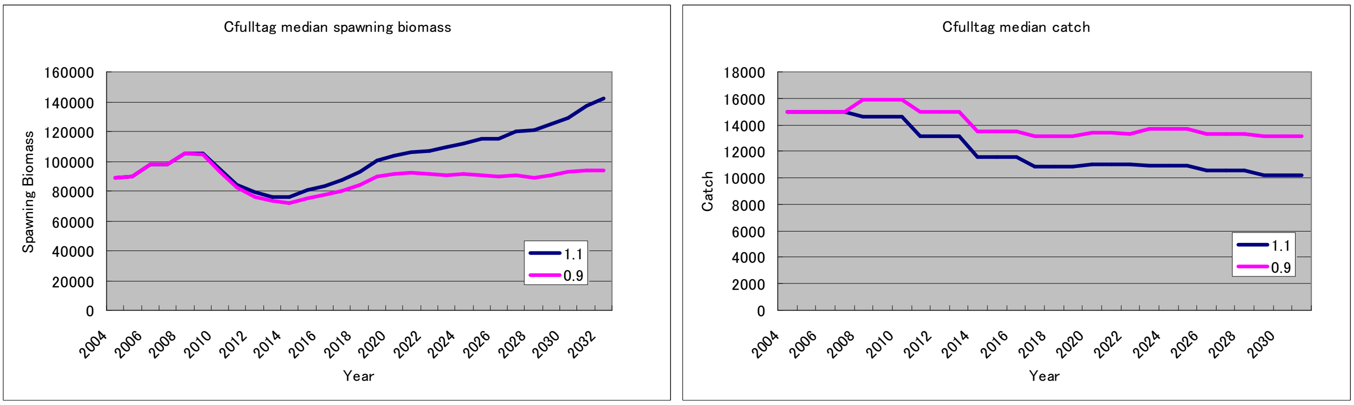

Figure 3. Median spawning biomass and catch trajectories for the D&M MP (*f*(*LL*)=1) for B2022/B2004 tuning levels of a) 0.9 and b) 1.1 for the **Cfulltag** OM.

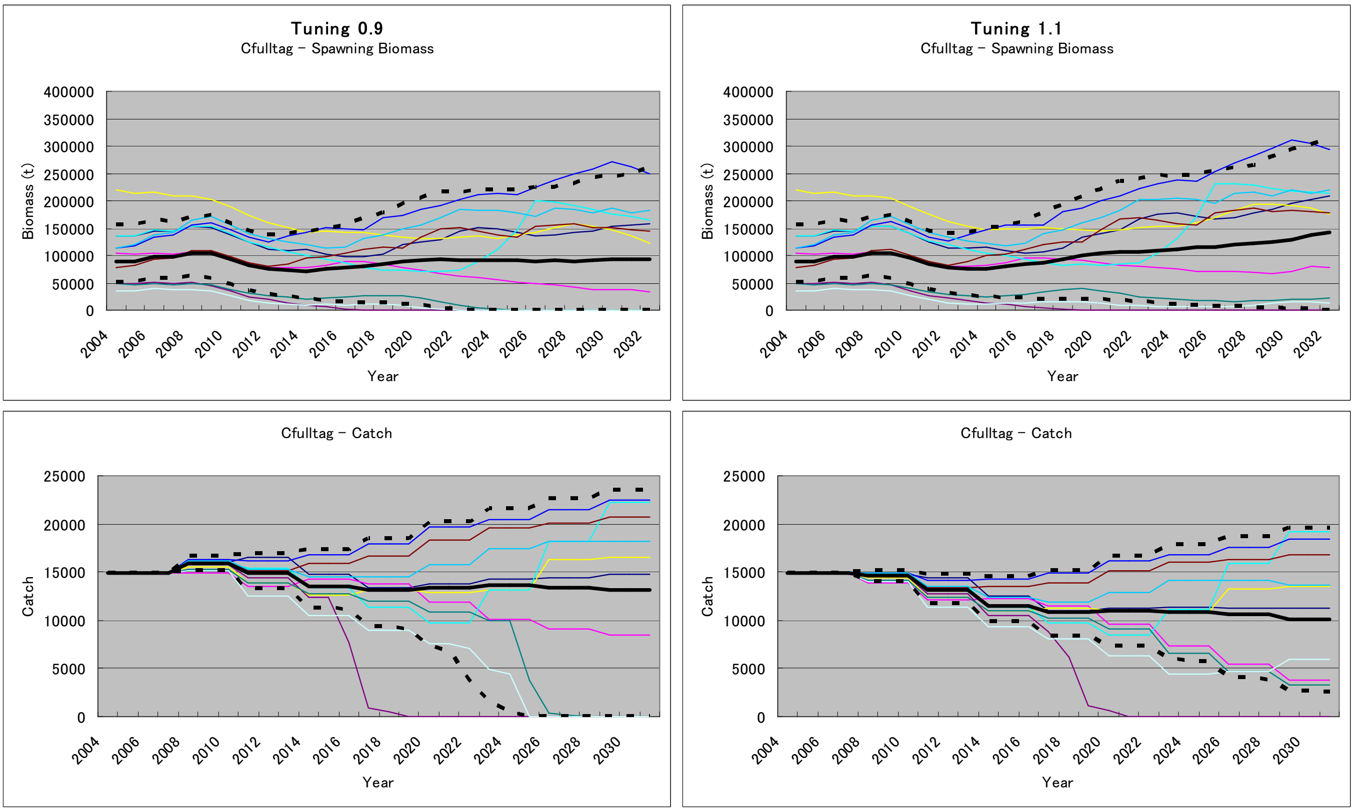

Figure 4. Wormplots for the D&M MP (*f*(*LL*)=1) for B2022/B2004 tuning levels of a) 0.9 and b) 1.1 for the **Cfulltag** OM. The dashed lines show the 90% probability envelopes and the black dark lines show the median trajectories.

D&M MP (*f*(*LL*)=1) tuned to 1.1 recovery level for Cfullnotag OM (MP tuning parameter α=0.50)

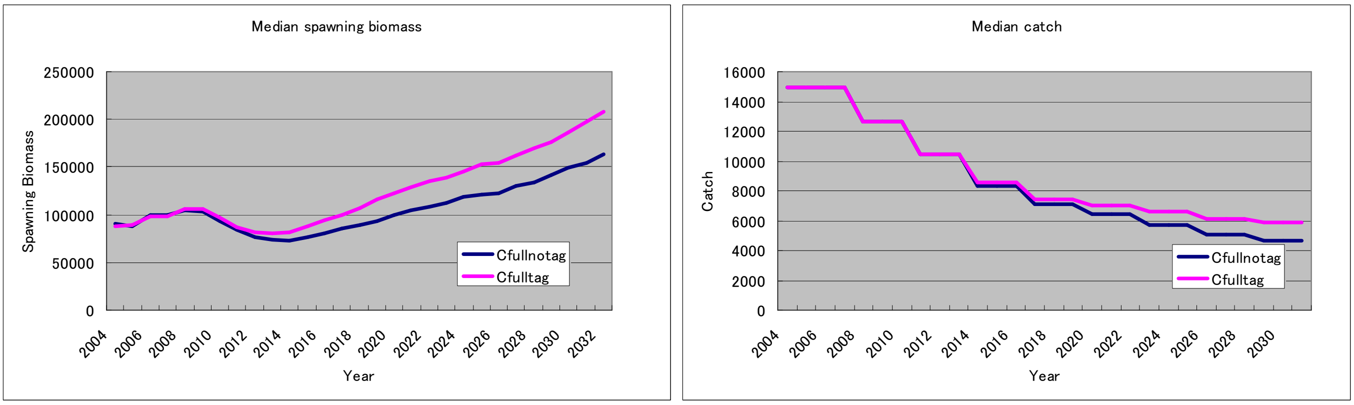

Figure 5. Median spawning biomass and catch trajectories for the D&M MP (*f*(*LL*)=1) for a B2022/B2004 tuning level of 1.1 for the **Cfullnotag** OM (MP tuning parameter α=0.50) for the Cfulltag and Cfullnotag OMs.

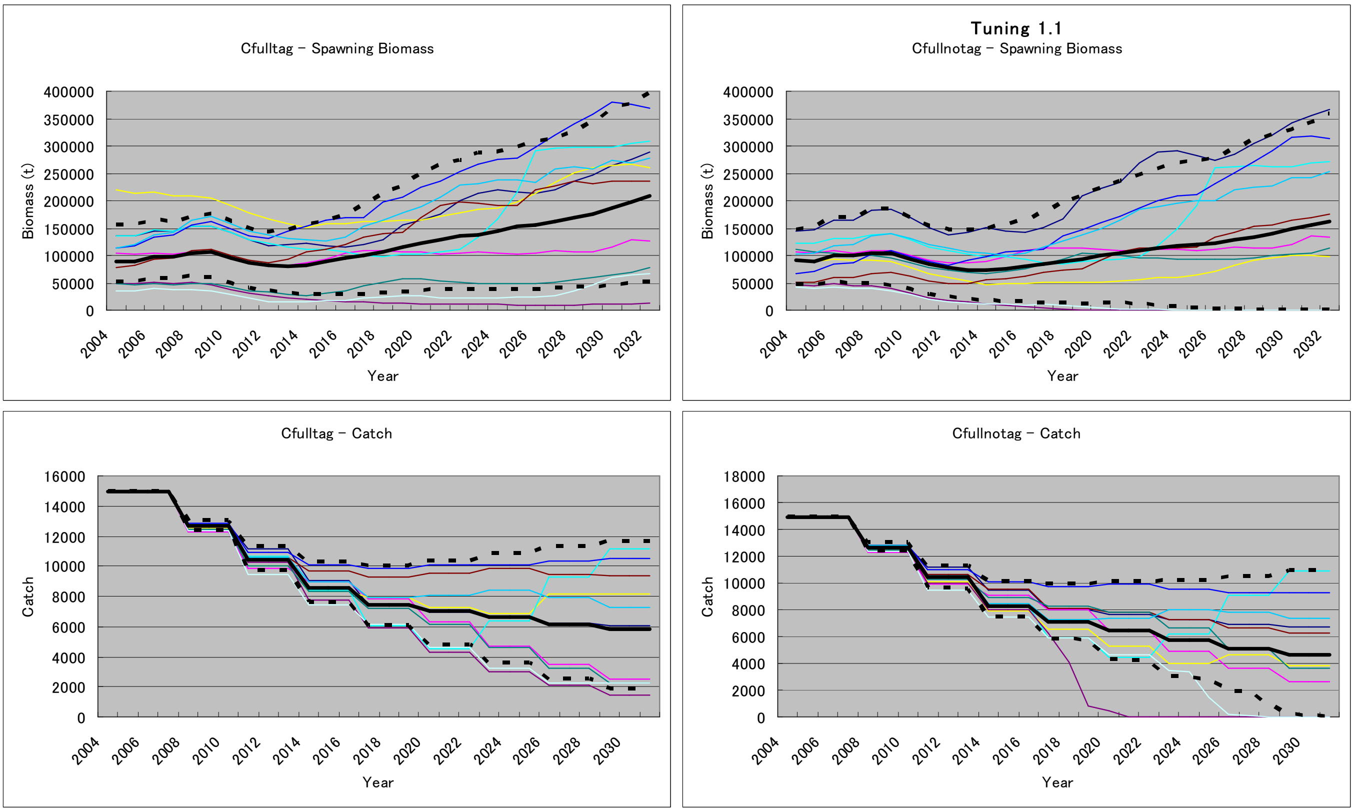

Figure 6. Wormplots for the D&M MP (*f*(*LL*)=1) for B2022/B2004 tuning level of 1.1 for the **Cfullnotag** OM (MP tuning parameter α=0.50) for the Cfulltag and Cfullnotag OMs. The dashed lines show the 90% probability envelopes and the black dark lines show the median trajectories.

D&M MP (f(LL)=1) tuned to 1.1 recovery level for Cfulltag OM (MP tuning parameter α=0.94)

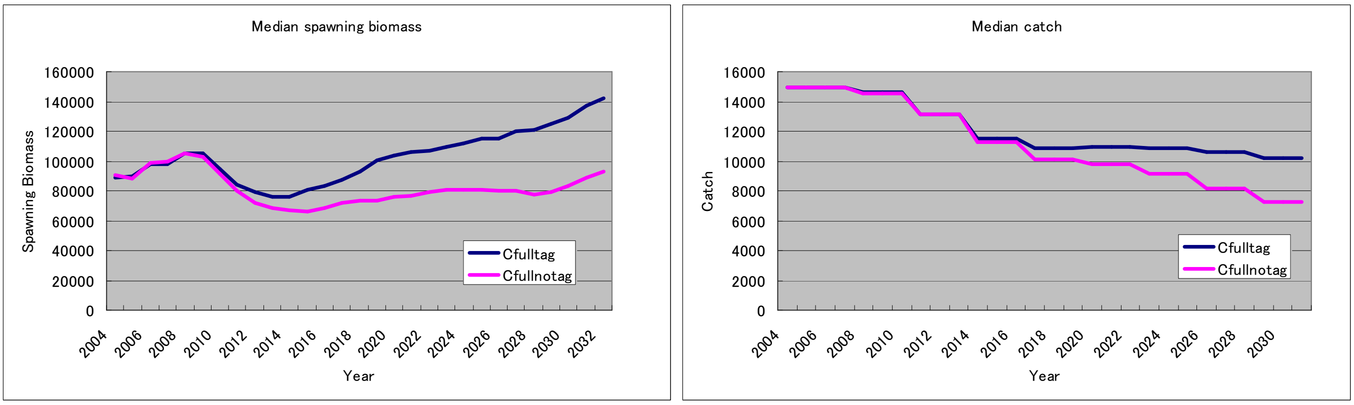

Figure 7. Median spawning biomass and catch trajectories for the D&M MP (f(LL)=1) for a B2022/B2004 tuning level of 1.1 for the **Cfulltag** OM (MP tuning parameter α=0.94) for the Cfulltag and Cfullnotag OMs.

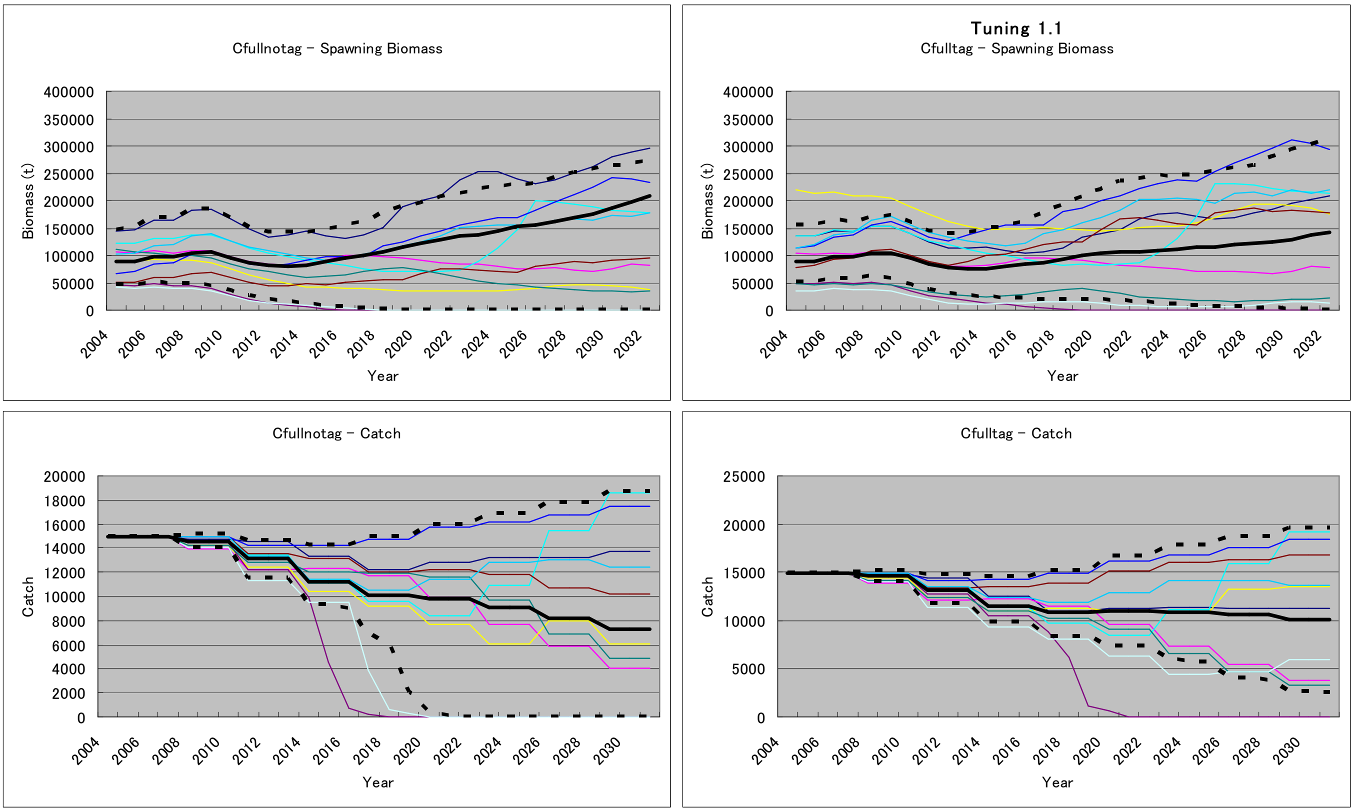

Figure 8. Wormplots for the D&M MP (f(LL)=1) for B2022/B2004 tuning level of 1.1 for the **Cfulltag** OM (MP tuning parameter α=0.94) for the Cfulltag and Cfullnotag OMs. The dashed lines show the 90% probability envelopes and the black dark lines show the median trajectories

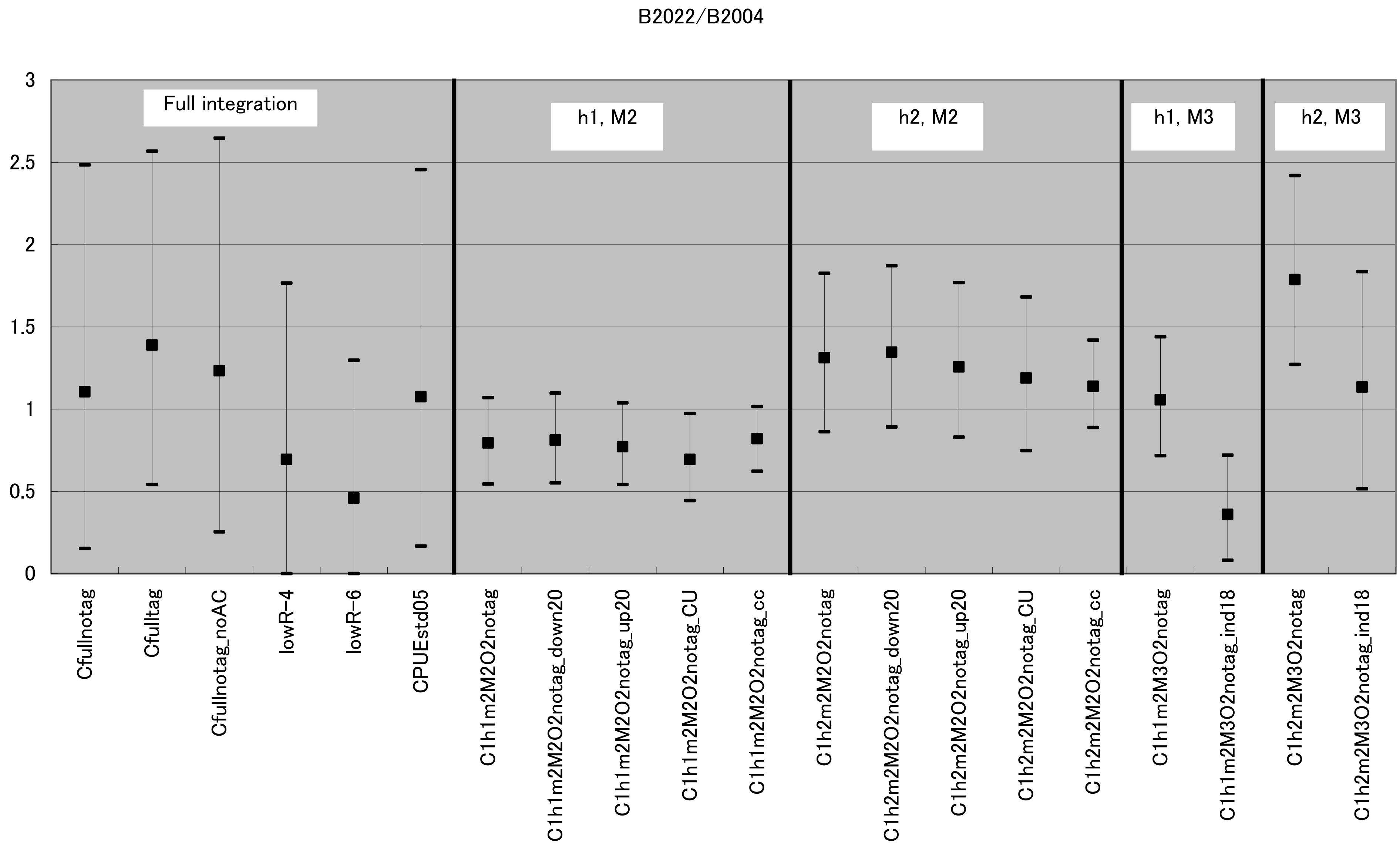

Figure 9. Comparison of performance for the Core set against the Sensitivity trials in terms of recovery (B_{2022}/B_{2004}). The result for the Core set or its constituent scenario is shown as the leftmost entry in each box. For the constituent scenarios, Omega=1, M0 is central and CPUE is the median; h1 and h2 are the low and central values of steepness *h*, and M2 and M3 the central and high values of natural mortality M10. The central square reflects the median, and the error bars the 90% probability interval.

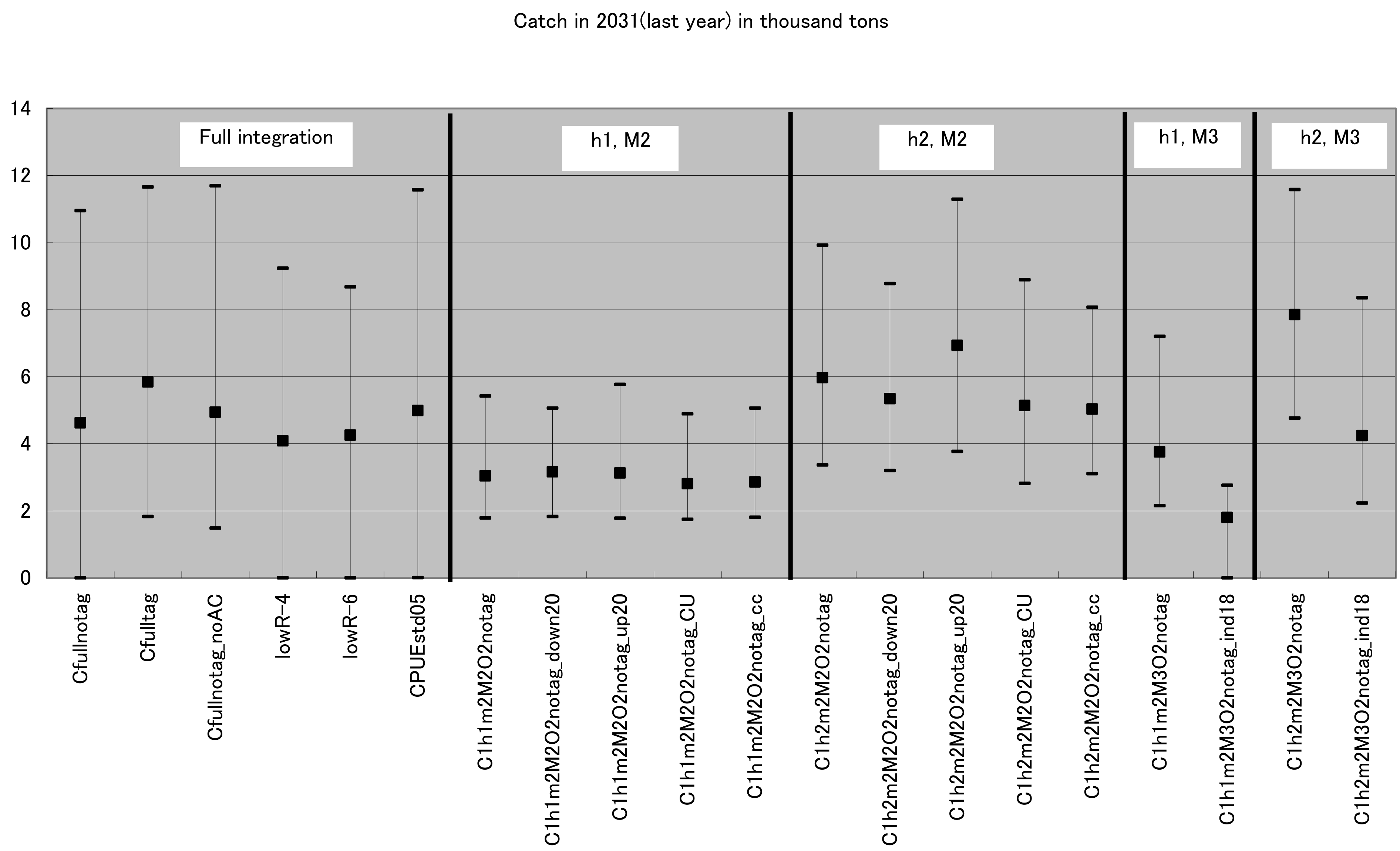

Figure 10. Comparison of performance for the Core set against the Sensitivity trials in terms of the catch in 2031. The notation is as for Figure 9.

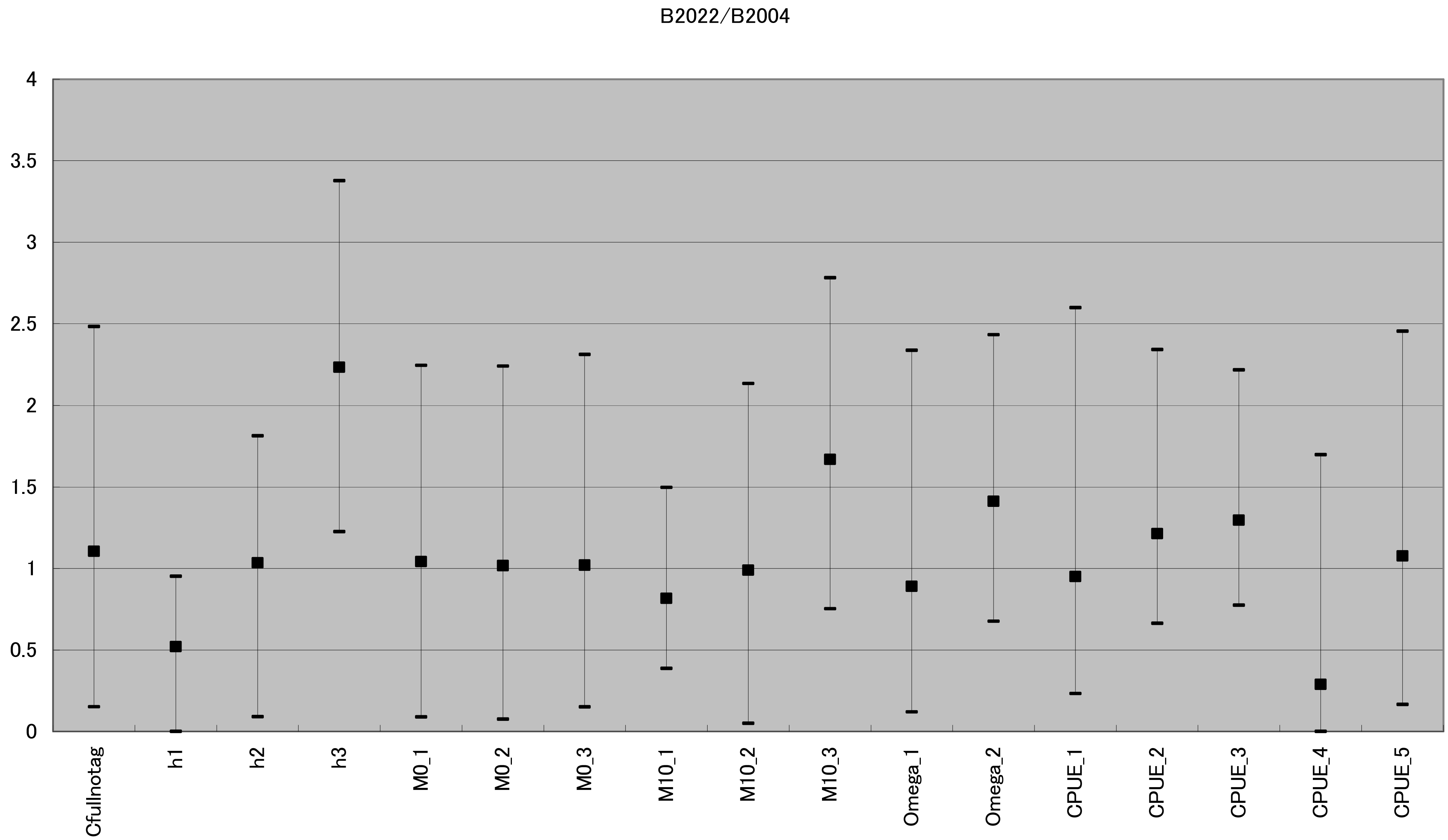

Figure 11. Comparison of performance for specific values of the Core set factors integrated over the other factors of the Core set in terms of recovery (B_{2022}/B_{2004}). Notation is as for Figure 9.

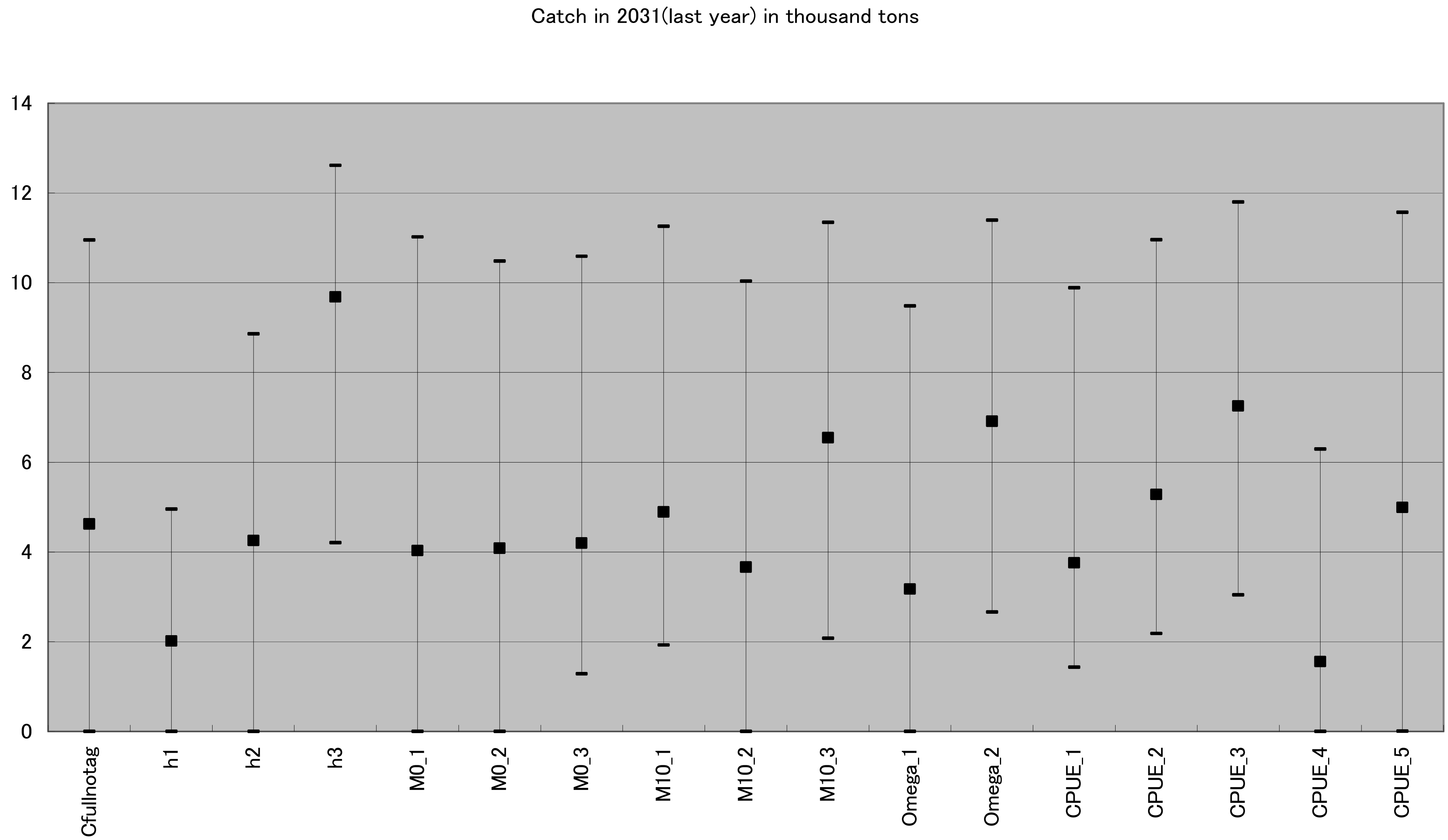

Figure 12. Comparison of performance for specific values of the Core set factors integrated over the other factors of the Core set in terms of catch in the year 2031. Notation is as for Figure 11.