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TUNINGS OF THE D&M MANAGEMENT PROCEDURE UNDER THE PANEL'S UPDATED OPERATING MODELS

パネルによって新しくされたオペレーティングモデルの下での **D&M** 管理方式のチューニング

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SUMMARY

A marginally modified version of the D&M_03 MP, which was selected for further consideration at the MP Workshop in Busan, is tuned to the Panel's updated Operating Models (OMs), PANEL_tag and PANEL_notag, for a range from 0.9 to 1.5 of the median B_{2022}/B_{2004} spawning biomass recovery level. Results for the PANEL_notag scenario are qualitatively similar to those for the Reference case OM from Christchurch, showing TAC trajectories which generally manifest steady declines over time. The poor recruitments generated by the new OMs for 2000 and the years immediately thereafter have a major negative impact on spawning biomass over the 2009-2014 period. TAC trajectories for the PANEL_tag OM are more optimistic, but the associated spawning biomass trajectories show a relatively wider spread than for the other OMs. This is a primarily consequence of the initial (2004) spawning biomass for PANEL_tag being only some 50% of that for PANEL_notag.

要約

釜山で開かれた MP に関するワークショップにおいてさらなる検討をすべきであると選ばれた D&M_03 MP にほんのわずかの修正を加え、パネルによって新しくされた二つのオペレーティングモデル (PANEL_tag と PANEL_notag)について、産卵資源量の B_{2022}/B_{2004} の回復レベルの中央値が 0.9 から 1.5 の間になるようチューニングを行った。PANEL_notag のチューニング結果は Christchurch で選ばれたオペレーティングモデルである Reference ケースをチューニングした結果と似たようなものになり、時間とともに少しずつ TAC が減少していくものとなった。新しいオペレーティングモデルによって生成された 2000 年とそのすぐ後の年の弱い加入率は 2009 年から 2014 年までの間の産卵資源量に負の影響を及ぼしている。PANEL_tag をチューニングした結果は PANEL_notag と比べて楽観的なものとなったが、産卵資源量の将来予測の幅は PANEL_notag と比べて広くなった。これは PANEL_tag の 2004 年の産卵資源量が PANEL_notag と比べて 50%も低いことによるものである。

INTRODUCTION

Previous tests results reported for candidate SBT Management Procedure (MPs) (e.g. Butterworth and Mori, 2004) were based upon operating models (OMs) developed at the CCSBT MP Workshop held in Christchurch in August 2003. The Panel of external scientists have subsequently updated these OMs to take more recent data into account, and provided two upon which to base further testing: "PANEL_tag" and "PANEL_no tag".

At the Third CCSBT Management Procedure Workshop held in Busan in April 2004, a version of the Butterworth and Mori MP termed "D&M_03" was selected for further consideration. This paper first describes some minor adjustments made to the parameter values of the component of the D&M TAC formula that depends on the proportion of lower ages in the longline catch, to allow for the fact that the data concerned have been updated. It then provides summary results of the application of this D&M_03 procedure to the PANEL_tag and PANEL_notag OMs for tunings to different levels for 20 year median spawning biomass recovery B_{2022}/B_{2004}, and for 3-yearly intervals for setting TACs.

METHODS

The D&M 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:

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

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:

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

with parameter values fixed at r_1=1.0, r_2=1.5 as is in Butterworth and Mori (2003).

The function $f(LL)$ which controls the TAC depending on the proportion of lower ages in longline catch is calculated as follows:

$$LL = \left(\frac{\sum_{a=4}^{6} LLC_{2003}}{\sum_{a=4}^{30} LLC_{2003}} + \frac{\sum_{a=5}^{7} LLC_{2004}}{\sum_{a=4}^{30} LLC_{2004}} + \frac{\sum_{a=6}^{8} LLC_{2005}}{\sum_{a=4}^{30} LLC_{2005}} \right) \Big/ 3 \qquad (3)$$

$$f(LL) = 1 \qquad \text{if} \quad LL \le 0.28$$

$$f(LL) = (1 + (LL - 0.28) * tune) \qquad \text{if} \quad 0.28 < LL < 0.33$$

$$f(LL) = (1 + 0.05 * tune) = \theta \qquad \text{if} \quad LL \ge 0.33$$

where LLC_y is the catch of age *a* of the Japanese longline fishery in year *y*.

Note that for the D&M_03 procedure, the control parameter *tune* was set to 4 (so that θ =1.2). The *f*(*LL*) factor applies only to the first year in which the TAC changes (2008 with changes every three years), being set to 1 thereafter. The idea of introducing this factor was to give flexibility to the MP to be able to vary the TAC depending on evidence for good or poor recent recruitment as reflected by the proportion of lower ages in the longline catch.

Figure 1 shows the distributions of *LL* for the Reference Case and No_AC trials corresponding to the Christchurch OMs for SBT. The values of 0.28 and 0.33 in equation (3) above were chosen to relate to the means of these distributions. Also shown in Figure 1 is the distribution of *LL* for the new PANEL_tag and PANEL_notag OMs. Given the updated data upon which these OMs are based, the distributions have shifted appreciably from those reflected by the Christchurch OMs, and it would accordingly be somewhat perverse not to make corresponding adjustments to the values in equation (3). Without a full exploration, and in particular without an updated trial analogous to the earlier No_AC scenario, it is not obvious how best to do this. For the purposes of this paper, the modifications adopted to equation (3) were as follows:

$$f(LL) = 1 \qquad \text{if} \quad LL \le 0.47$$

$$f(LL) = (1 + (LL - 0.47) * tune) \qquad \text{if} \quad 0.47 < LL < 0.52 \qquad (4)$$

$$f(LL) = (1 + 0.05 * tune) = \theta \qquad \text{if} \quad LL \ge 0.52$$

where the selection of 0.47 was based on the PANEL_tag mean of 0.47 in Figure 1 (the PANEL_notag mean hardly differs).

RESULTS

The D&M_03 MP has been tuned to B_{2022}/B_{2004} median recovery levels of 0.9, 1.1, 1.3 and 1.5 for both the PANEL_tag and PANEL_notag new OMs, by varying the tuning parameter α – see equation (1). The α values and some selected performance statistics are shown in Table 1. Table 1 also includes results for the PANEL_tag OM where the *f*(*LL*) factor in the MP is not implemented (i.e. *f*(*LL*) =1 for 2008). Furthermore, results are shown for each new OM for the MP that corresponds to tuning to a recovery level of 1.1 for the *other* OM. Finally the Table also includes results for the Christchurch Reference case OM to facilitate comparisons.

These results are also shown graphically. Figure 2 shows median spawning biomass and catch trajectories for various tunings for the PANEL_tag OM, together with corresponding worm plots. Figure 3 and 4 repeat these plots for the PANEL_notag and Christchurch Reference case OMs. Finally Figure 1 compares spawning biomass and catch trajectories for the MP tuned to 1.1 for the PANEL_tag OM, when applied to both the PANEL_tag and PANEL_notag OMs, while Figure 6 shows a similar comparison when the 1.1 tuning is for the PANEL_notag OM.

DISCUSSION

The *f*(*LL*) factor introduced to adjust for initial age-structure has virtually no effect on results (see Table 1 and Figure 2a). The new OMs do not, however, really provide an adequate test of the efficacy of introducing such a factor, for which one would desirably test MPs against a further OM which did not generate notably lower recruitments for 2000 and immediately following years as is the case for PANEL_tag and PANEL_no tag.

The plots in Figures 2 and 3 show the major negative impact that these low recruitments are projected to have on spawning biomass over the 2009 -2014 period. This feature was not present for the Reference case OM from Christchurch (see Figure 4).

Apart from this low recruitment effect, results for the D&M MP applied to the PANEL_notag OM are qualitatively similar to those for the Reference case OM: a generally steady decline in TACs for most catch trajectory realisations for tuning levels of 1.1 and above (compare Figures 3 and 4). Results for the PANEL_tag OM are quite different (Figure 2), reflecting relatively more optimistic TAC trajectories for the same tuning level, but also showing a relatively wider spread in the spawning biomass plots. The reason underlying this last qualitative difference is the large difference in the initial (2004) spawning biomass for these trajectories: some 100 000 tons for PANEL_notag compared to some 50 000 tons for PANEL_tag, so that the latter has much less “reserve” to compensate for TACs set higher than are in fact sustainable.

Results in Table 1 and Figures 5 and 6 show that tuning for a certain recovery level for the one new OM can result in appreciably different performance under the other. For example, a 1.1 tuning under PANEL_tag results in a 23% drop by 2022 in the median spawning biomass for the PANEL_notag scenario. This means that the matter of the relative weights to be given to these two new OMs is of importance. If both are considered reasonably plausible, it seems unlikely that the lower target tuning levels for the PANEL_tag OM would yield an acceptable MP overall, as large reductions in spawning biomass become possible for both the new OMs for such tunings.

ACKNOWLEDGEMENTS

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Table 1. Some statistics of applications of the D&M_03 procedure (modified as indicated in equation (4) given the new OMs). Statistics quoted are medians with 90% probability intervals given in parenthesis; catch levels are in tons.

OM	Tuning level	α	C_{2008}	C_{2021}	B_{2022}/B_{2004} (B_{2022}/B_{2002} for Reference)	AAV
PANEL_tag	0.9	1.5	17056 (16160-18027)	16369 (5210-23704)	0.895 (0.000-2.356)	0.027 (0.017-0.248)
	1.1	1.27	16044 (15286-16867)	14555 (8741-21047)	1.101 (0.108-2.604)	0.024 (0.015-0.213)
	1.3	1.05	15119 (14485-15810)	12685 (8278-18413)	1.305 (0.295-2.838)	0.024 (0.013-0.047)
	1.5	0.87	14281 (13752-14930)	10946 (7238-15828)	1.498 (0.484-3.057)	0.027 (0.013-0.049)
	1.1 [$f(LL)$=1]	1.27	16040 (15282-16820)	14555 (8745-21047)	1.101 (0.110-2.604)	0.024 (0.015-0.213)
	1.6 (PANEL_notag=1.1)	0.77	13841 (13376-14342)	10005 (6693-14435)	1.592 (0.585-3.171)	0.029 (0.015-0.051)
PANEL_notag	0.9	1.06	15281 (14560-16002)	11519 (7918-17760)	0.903 (0.269-1.962)	0.026 (0.012-0.062)
	1.1	0.77	13955 (13410-14481)	8878 (6487-13935)	1.095 (0.421-2.205)	0.033 (0.014-0.055)
	1.3	0.46	12541 (12216-12861)	6207 (4503-9545)	1.296 (0.575-2.475)	0.044 (0.022-0.066)
	1.5	0.14	11088 (10988-11188)	3611 (3024-4699)	1.507 (0.726-2.784)	0.067 (0.047-0.080)
	0.8 (PANEL_tag=1.1)	1.27	16241 (15389-17099)	13435 (8049-20253)	0.766 (0.162-1.790)	0.025 (0.014-0.208)
Reference case (Christchurch)	0.9	0.96	14515 (12277-17695)	13227 (8083-19054)	0.904 (0.357-1.811)	0.024 (0.013-0.043)
	1.1	0.47	12874 (11508-15263)	8023 (5309-11306)	1.101 (0.496-2.099)	0.031 (0.016-0.053)
	1.3	0.34 (w=0.5)	12047 (10386-12047)	5121 (2282-8361)	1.300 (0.663-2.328)	0.052 (0.029-0.089)

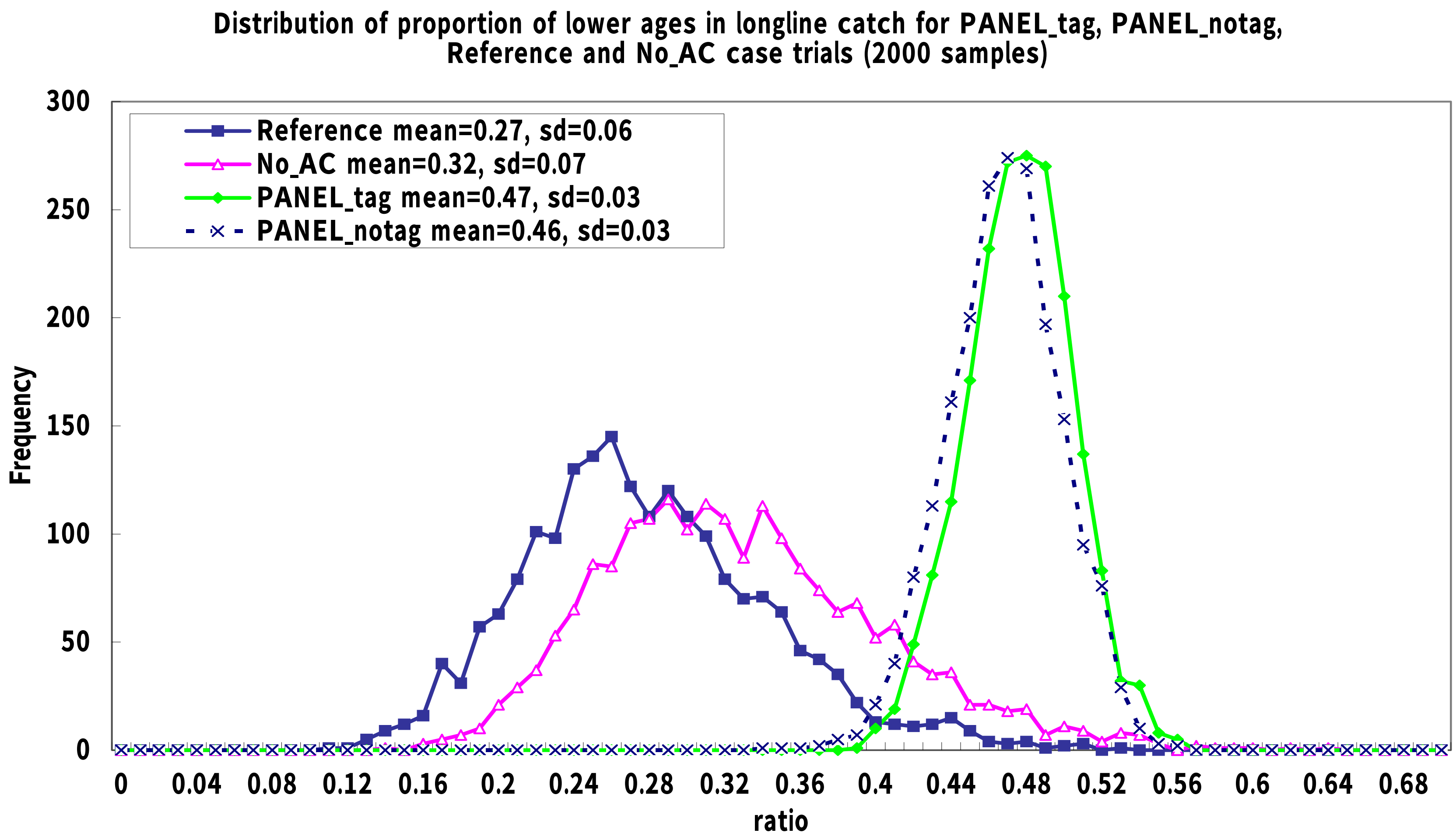


Figure 1 Distribution of proportion of lower ages (LL-see equation 3) in the longline catch for the PANEL_tag, PANEL_notag, Reference and No_AC cases (2000 samples).

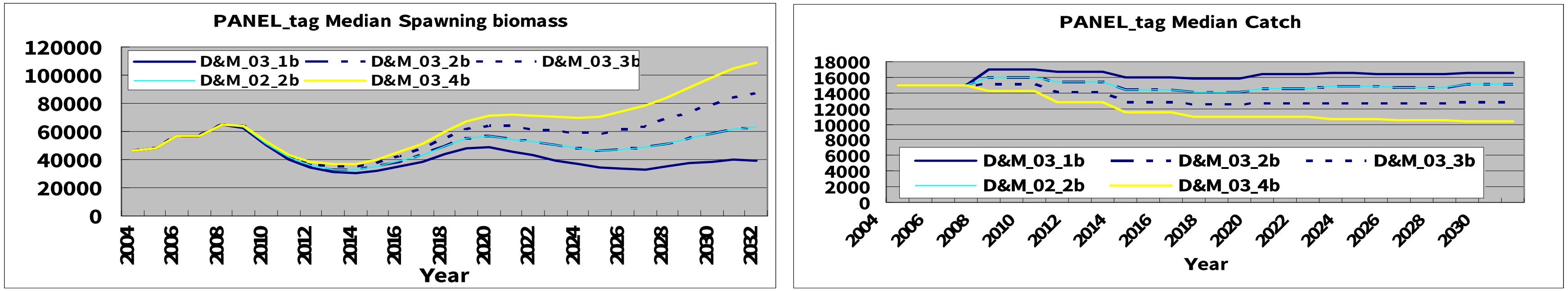


Figure 2a Median spawning biomass and catch trajectories for the candidate MP ("D&M_03") for B2022/B2004 tuning levels of a) 0.9; b) 1.1; c) 1.3; d) 1.5 for PANEL_tag OM. The MP named "D&M_02" is for *f*(LL)=1.

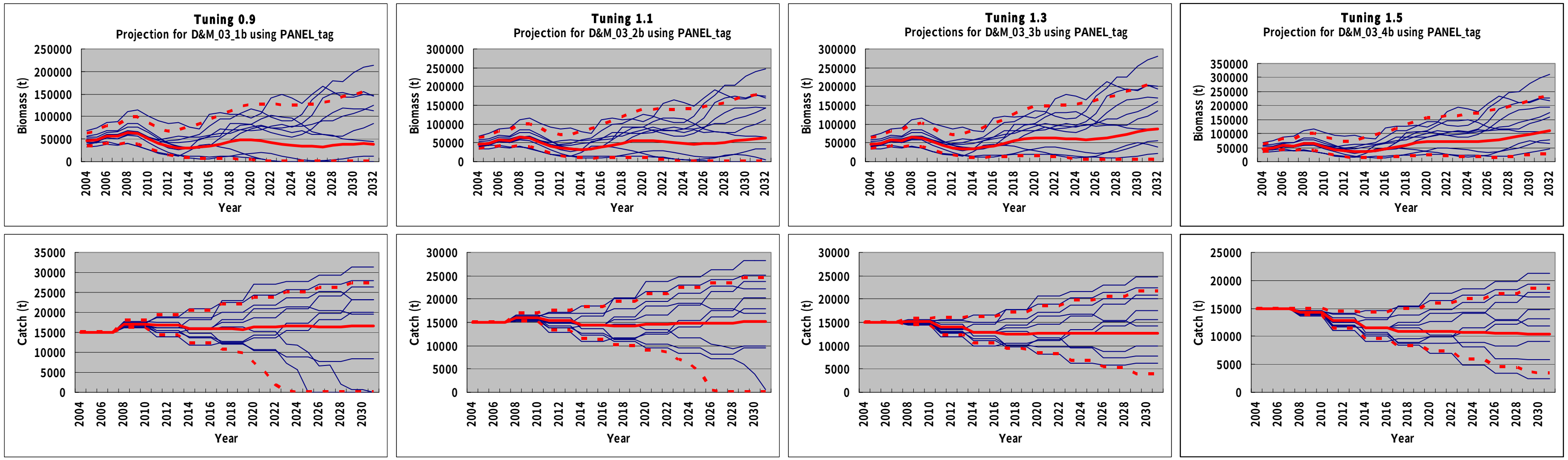


Figure 2b. Wormplots for the candidate MP ("D&M_03") for B2022/B2004 tuning levels of a) 0.9; b) 1.1; c) 1.3; d) 1.5 for PANEL_tag OM. The dashed lines show the 90% probability envelope.

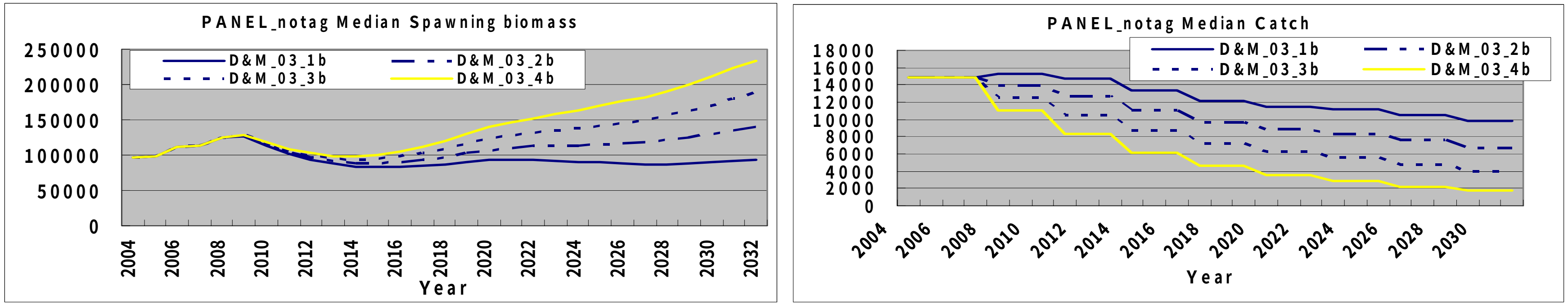


Figure 3a. Median spawning biomass and catch trajectories for the candidate MP ("D&M_03") for B2022/B2004 tuning levels of a) 0.9; b) 1.1; c) 1.3; d) 1.5 for PANEL_notag OM. The MP named "D&M_02" is for *f*(LL)=1.

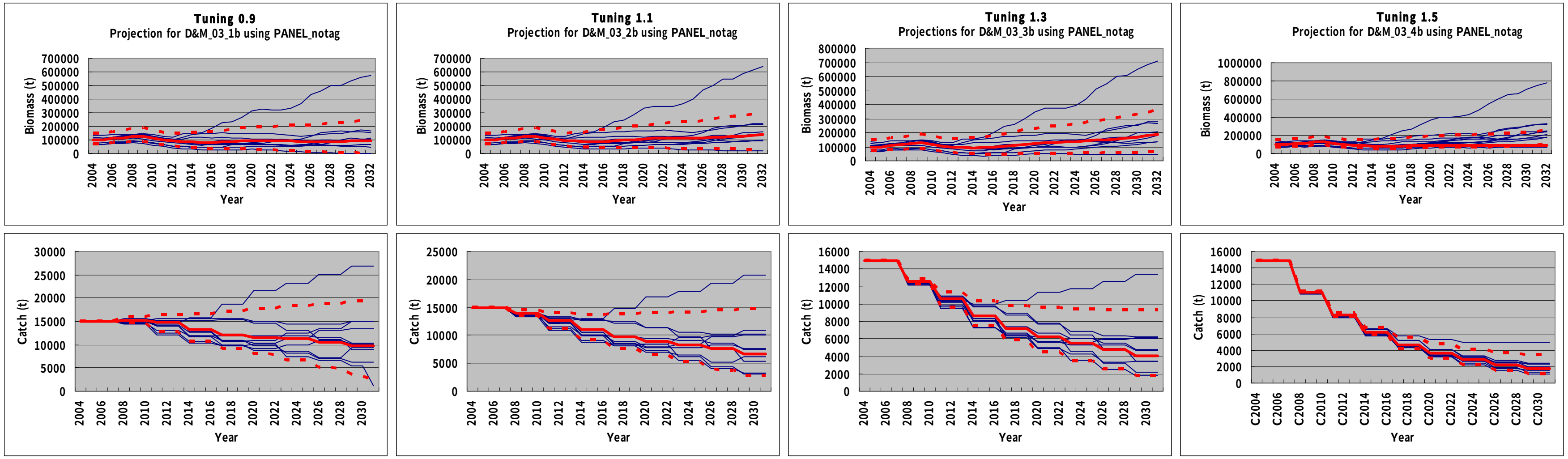


Figure 3b. Wormplots for the candidate MP ("D&M_03") for B2022/B2004 tuning levels of a) 0.9; b) 1.1; c) 1.3; d) 1.5 for PANEL_notag OM. The dashed lines show the 90% probability envelope.

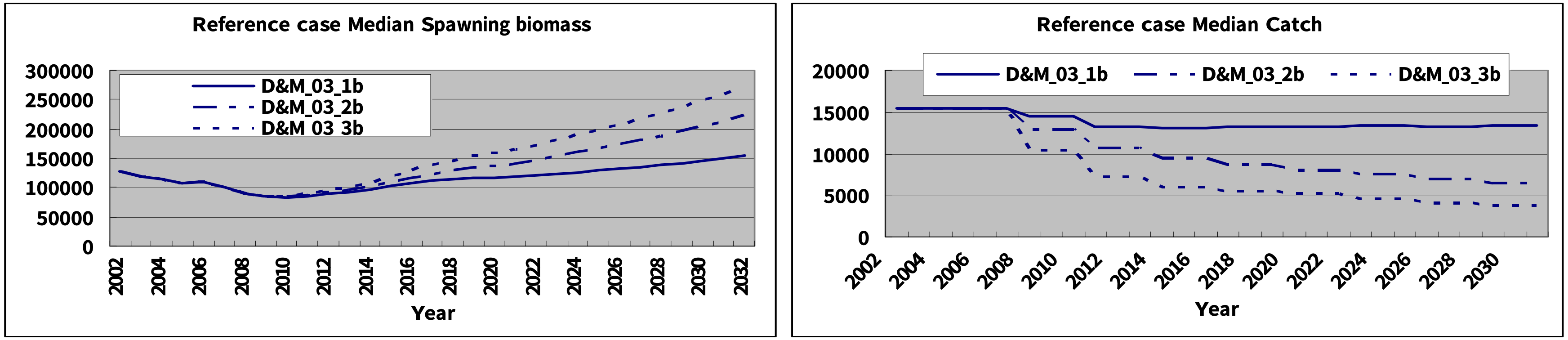


Figure 4a. Median spawning biomass and catch trajectories for the candidate MP ("D&M_03") for B2022/B2002 tuning levels of a) 0.9; b) 1.1; c) 1.3 for the Reference case (Christchurch) OM.

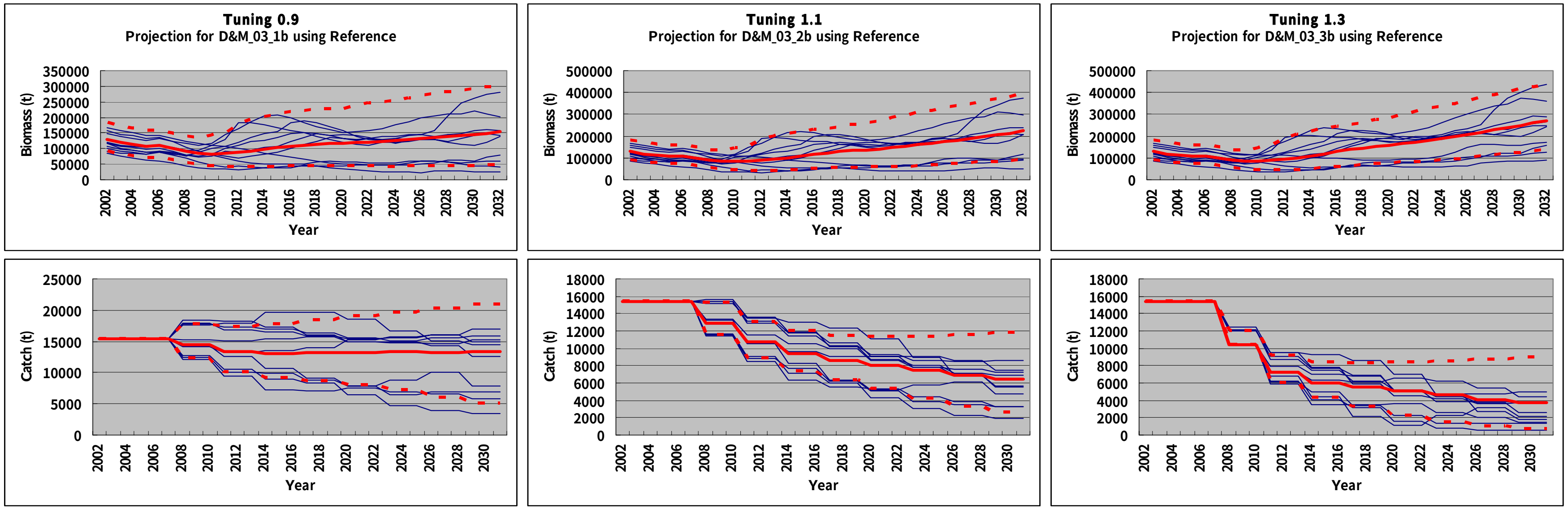
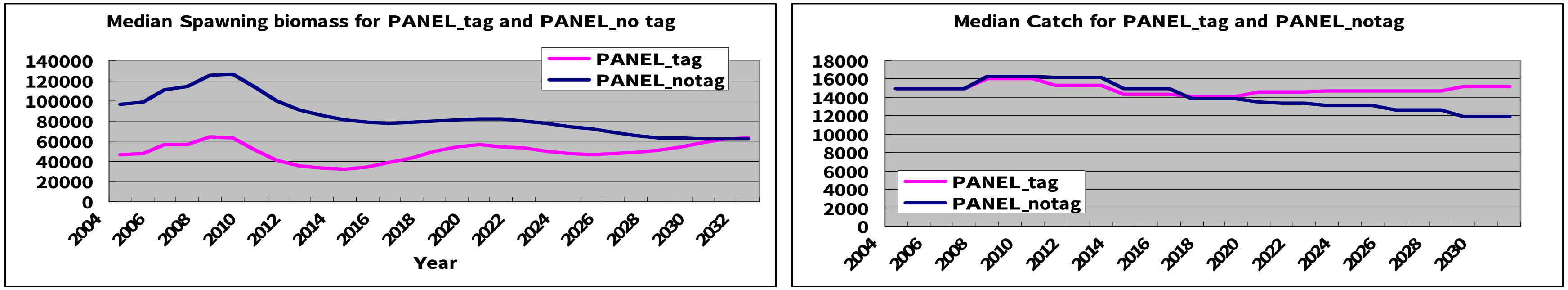
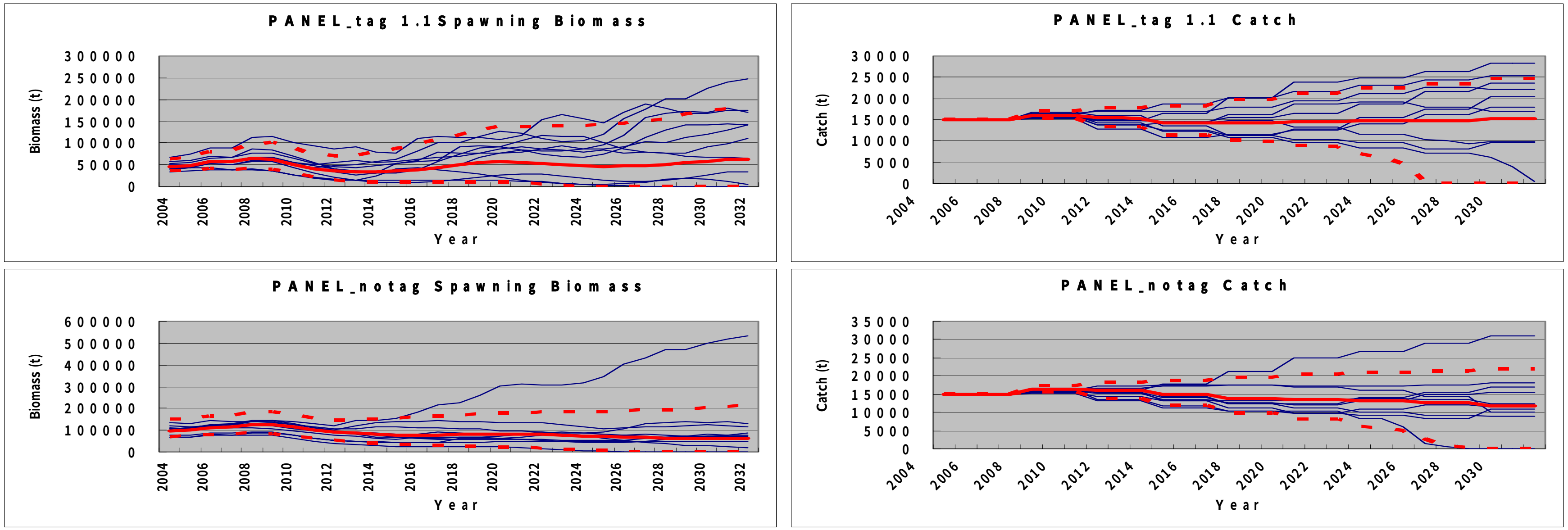


Figure 4b. Wormplots for the candidate MP ("D&M_03") for B2022/B2002 tuning levels of a) 0.9; b) 1.1; c) 1.3 on Reference case (Christchurch) OM. The dashed lines show the 90% probability envelope.

D&M_03 MP tuned to 1.1 recovery level for PANEL_tag OM (MP tuning parameter *a*=1.27)



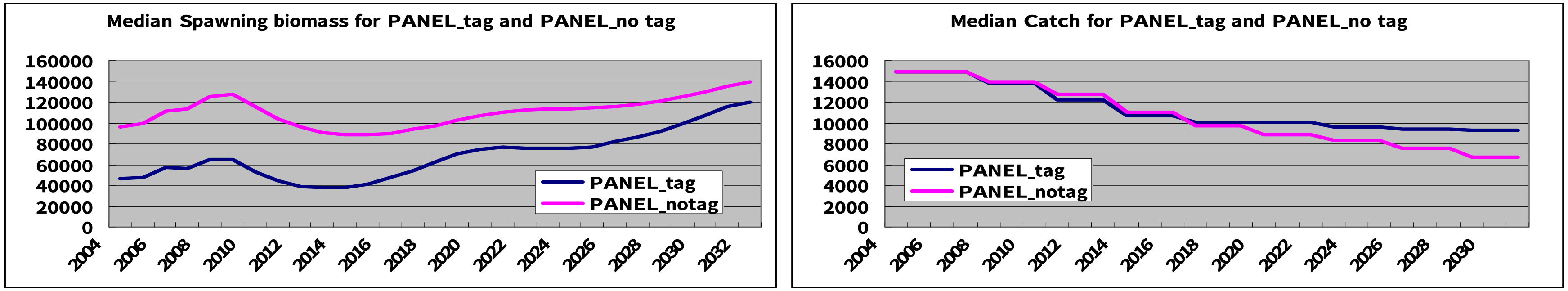
a) Median spawning biomass and catch trajectories



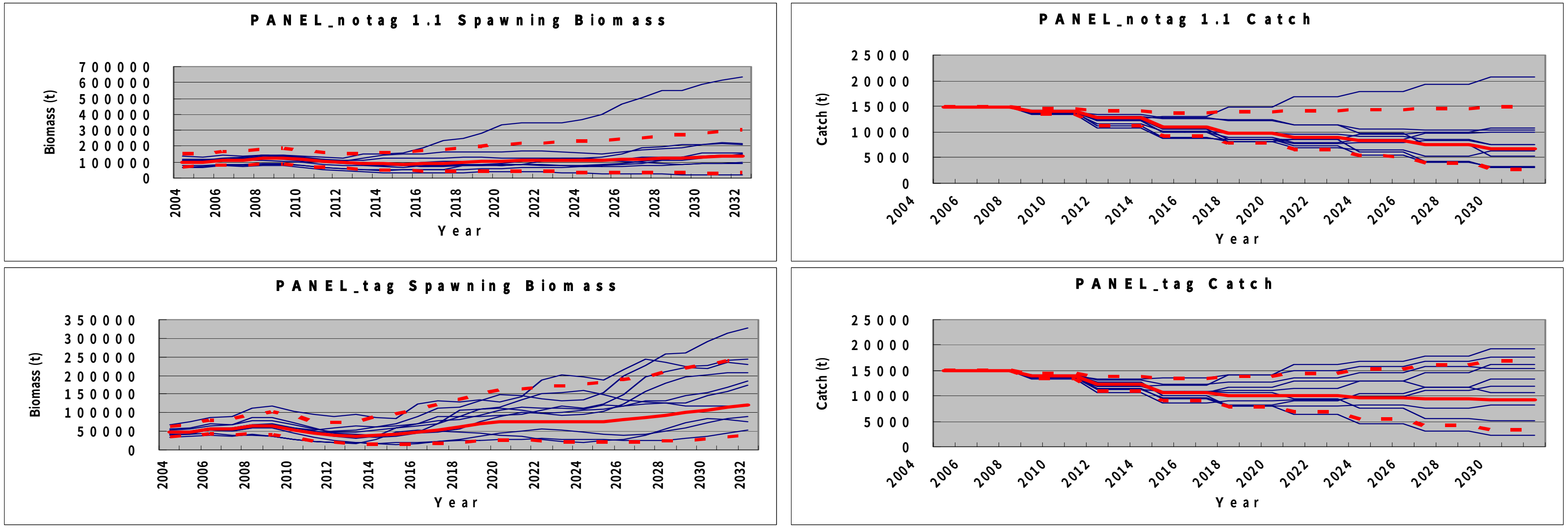
b) Wormplots

Figure 5. D&M_03 MP tuned to 1.1 recovery level for PANEL_tag OM (MP tuning parameter *a*=1.27). The dashed lines show the 90% probability envelope.

D&M_03 MP tuned to 1.1 recovery level for PANEL_notag OM (MP tuning parameter *a*=0.77)



a) Median spawning biomass and catch trajectories



b) Wormplots

Figure 6. D&M MP tuned to 1.1 recovery level for PANEL_notag OM (MP tuning parameter *a*=0.77). The dashed lines show the 90% probability envelope.