Results of the initial exploration of potential Management Procedures based on the CPUE index.

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(alphabetic order)

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Summary: Results of initial exploitation of potential Management Procedures were presented. Efforts were concentrated in developing Management Procedures with simple decision rule to control TAC based on age-aggregated longline CPUE. Five concepts with one respective specification judged as reasonably performing were presented. Results showed that all five concepts, even the simplest concept, improved stock management capability comparing with a constant catch scheme. All concepts also showed similar level of performance satisfaction

要約：管理方策案の第 1 段階の模索結果を示した。ここでは年齢分解していないはえ縄 CPUE に基づいて TAC を変更するという単純な決定ルールによる管理方策案の開発に集中した。５つの考え方について、それぞれ妥当に機能していると判断された 1 事例の結果を示した。これらの結果から、もっとも単純な考え方を含め、5 つの考え方のいずれも、一定漁獲の場合よりも資源管理能力が高まることが明らかになった。またどの考え方でも同じ程度うまく機能していた。

Processes taken since the previous SAG/SC:

Our initial effort to explore possible Management Procedures started after the conclusion of the 2002 Scientific Committee mainly using the Excel-version of operating model originally developed by R. Hilborn during the 2002 SAG/SC and slightly modified by K. Hiramatsu afterward. This process was aimed to develop our understandings on how to utilize operating model as well as on general behaviors of model corresponding to various decision rules. During this process, each individual examined and developed his or her own idea of possible procedures independently and results from all procedures were compared and discussed regularly for further modification or alternative ideas. This exercise continued until December 2002.

The standards to judge a performance of possible Management procedures were settled as follows about this time: i) the rate of decline in biomass of two scenarios with low productivity will be slowed at least and biomass trend possibly turn into an increase before the end of projection period, i.e. 2022, and ii) the stability of catch trajectory especially for scenarios with high productivity (in the other words, those scenario with high productivity will not show overshoot in catch increase, then into wild oscillation). The potential impacts to the industries were also kept in mind.

Several procedures reasonably satisfied with the above mentioned standards were then examined with the operating model developed by V. Haist and distributed to the national scientists through the CCSBT Secretariat on November 2002 (v1.03). All of results shown here were the results with this version. Generally speaking, the Excel-version and Vivian's v1.03 shows similar catch and biomass behaviors and we considered the Excel-version as quite useful tool for initial examination of various ideas.

Individual working scheme was maintained at the second stage of testing with the Vivian's v1.03 operating models. This allowed us to maintain a certain level of variety in concepts of candidate procedures. At the same time, it was noted that the similar level of satisfaction in performance could be attained through many different ways. However, there were several procedures we completely dropped at the initial examination stage with Excel-version model. One example of this was the decision rule putting constrain to a quantity in TAC decline but no constrain for amount in TAC increase, which could not stop a biomass decline in two scenario with low productivity and catch behavior of high productivity scenarios became less stable.

Here, all of our exercises concentrated on the procedures with simple decision rules to adjust TAC based on an overall age-aggregated longline CPUE. No adjustment in relative assignment of TAC among fisheries through Management Procedures was made at this stage. We also have not tried any model-based Management Procedures.

Overall description of Management Procedues examined:

Here we presented the results of five ideas of simple decision rule based on overall longline CPUE. The result of one specification with the most reasonable performance found during the testing was selected for each concept for presentation. However, the choice of example was made arbitrarily based on the developer's judgment along the common standard. Also, there was no systematic searching of the most appropriate parameters. Then, these examples should be taken as those with reasonable performance but not as representations of the best cases.

Table 1 shows the summary of five ideas examined here. The names of procedures correspond to the developer's initial. Key component of each idea is as follows:

TI: This procedure will adjust TAC with a pre-fixed quantity when an observed regression of ln(CPUE) is above or below a pre-fixed threshold.

HK: Upper and lower limit for a quantity of TAC change is introduced to the reference procedures developed during the 2002 SAG/SC.

KH: This procedure assigns asymmetric response to TAC according to an observed value of slope, introducing rapid decline of TAC corresponding to CPUE decline but slower increase of TAC even under the upward CPUE trend. This specific procedure also sets an upper and lower limit to a quantity of TAC changes.

NT: This procedure explores a possible impact to delay in TAC adjustment especially when reducing TAC. Asymmetric response to TAC adjustment is also applied but in a different format from that used in KH.

HS: TAC is adjusted based on a slope of ln(CPUE) as well as a difference between target level and current CPUE. The concept follows the procedure developed by S.Tanaka for IWC. The developer has struggled to select an appropriate target level.

More detailed explanation and specification each procedure are shown in Appendix 1-5 with the result of catch and biomass trajectories in hierarchy3 as well as worm plot of ten runs each for the scenario with the highest (h9M10) and lowest (h3M10) productivity. The catch and biomass trajectories under three levels of constant catch (i.e. zero catch, catch at the current level of 16,000 t and catch at the doubled level of current as 32,000t) are shown in Figure 1 for a reference purpose.

Table 1. Summary table for five candidate MPs

Candidate MP	Stepwise TAC response to changing λ*	Upper and lower limits for change in TAC	Rapid TAC reduction when λ<0	Target CPUE	Management time-lag
TI	Yes ±1000ton	Yes ±1000ton	No	No	No
HK	No	Yes ±2000ton	No	No	No
KH	No	Yes ×0.1～1.06	Yes	No	No
NT	No	No	Yes	No	Yes 2 years
HS	No	No	Yes	Yes	No

*λ is the slope of the regression of ln(CPUE)

Summary results and conclusion:

The summarized results using the presentation format developed by Australia and distributed for three constant catch and five procedures mentioned above for hierarchy 3 is shown in Figure 2. The comparison among different procedures for hierarchy 3 and 4 is shown in Figure 3.

The points noted during this whole exercise and impression from these initial results are as follows:

- All of procedures examined here showed an improvement in stabilizing future level biomass comparing with constant catch scheme.

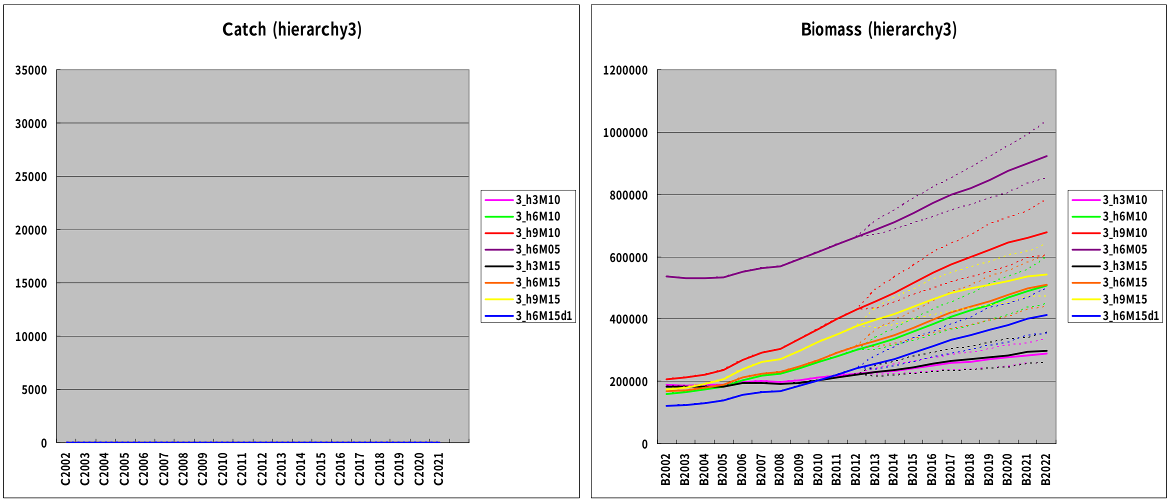
- At the same time, all procedures examined showed similar performance as long as using our standard way of qualitative judgment. In the other words, the similar level of performance can be obtained with various procedures and complexity in Management Procedures does not necessarily indicate an improvement of performance.

- Although independent working scheme has maintained throughout the current development of possible Management Procedures, some of us reached to the same procedures to resolve certain problems. Those include asymmetric response and constrain on maximum quantity to TAC change in one year.

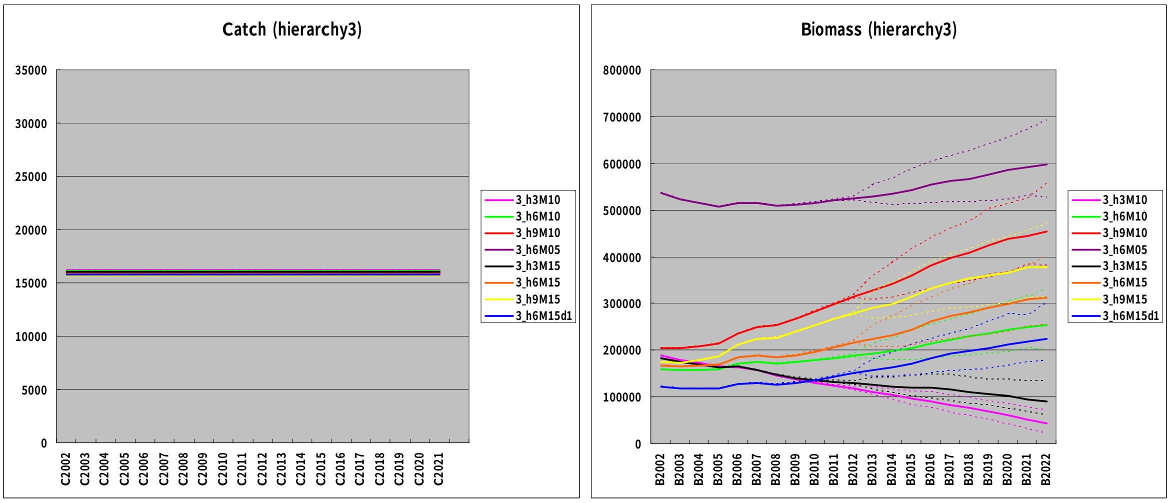
- Also, all procedures adopted slope of ln(CPUE) across 10 year period. Several members found that catch and biomass behaviors became less stable when using the slope less than 5 year period. However, nobody has a chance to examine with which year period overall behavior would be stabilized.

- Further exploration will be needed to examine an impact of time delay to realize TAC change, which allows a certain time for both administrators and industries to prepare for the forthcoming changes in TAC.

zero catch (decision rule "0t")



current catch level (decision rule "16000t")



current catch level × 2 (decision rule "32000t")

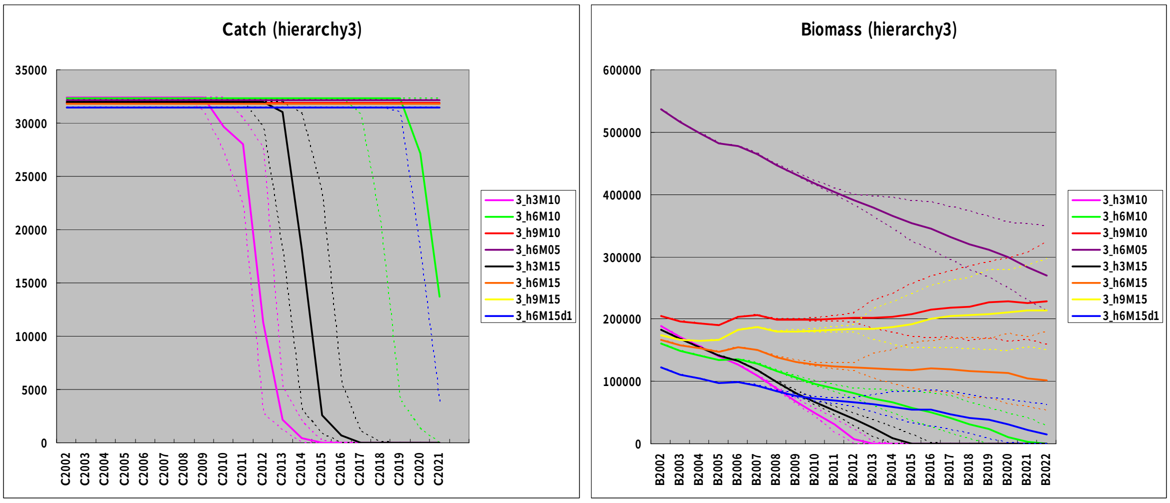


Figure 1. Catch and biomass trajectory under three levels of constant catch scheme for hierarchy 3.

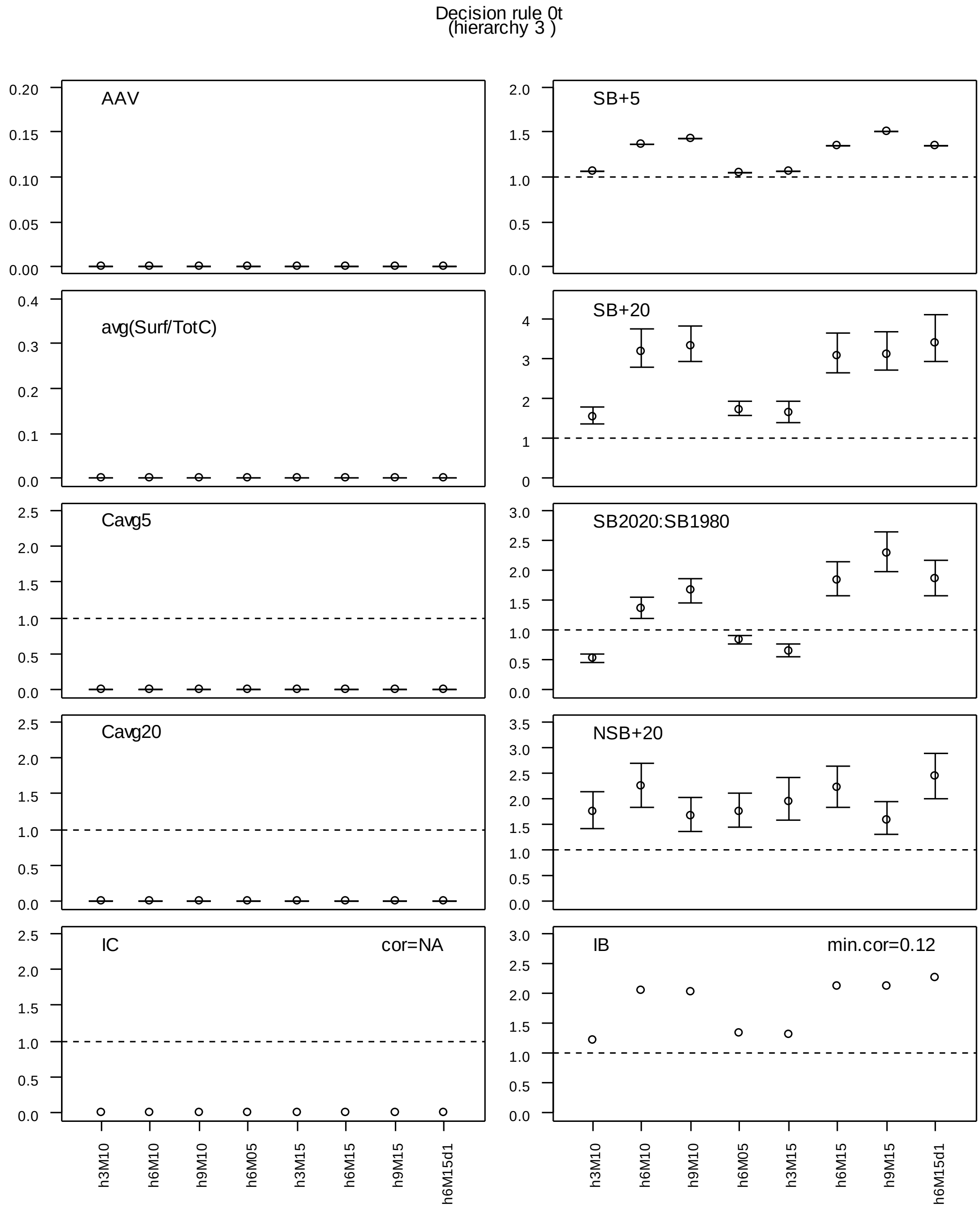


Figure 2-1. Comparison among scenarios for zero-catch scheme.

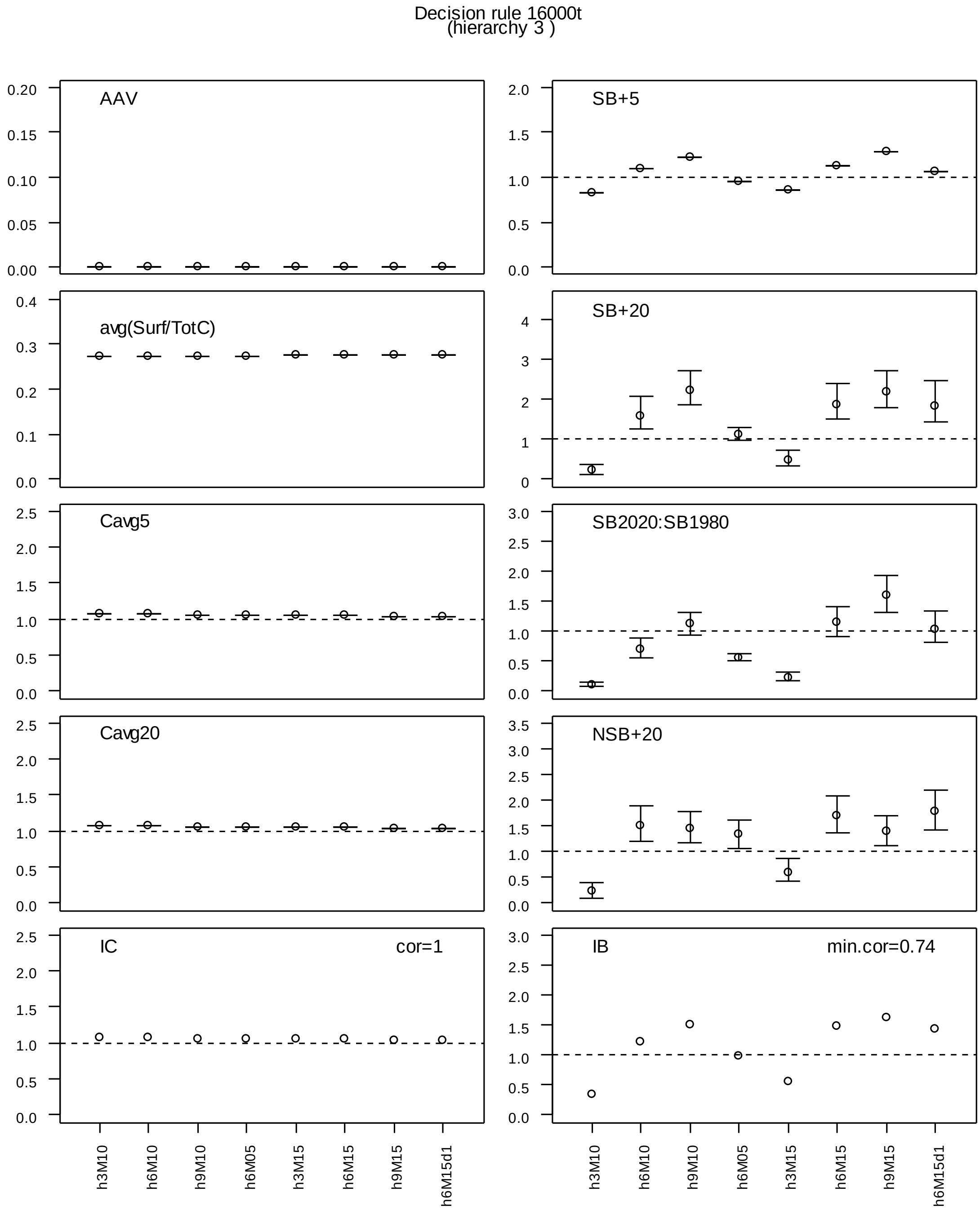


Figure 2-2. Comparison among scenarios for constant-catch scheme at the current level.

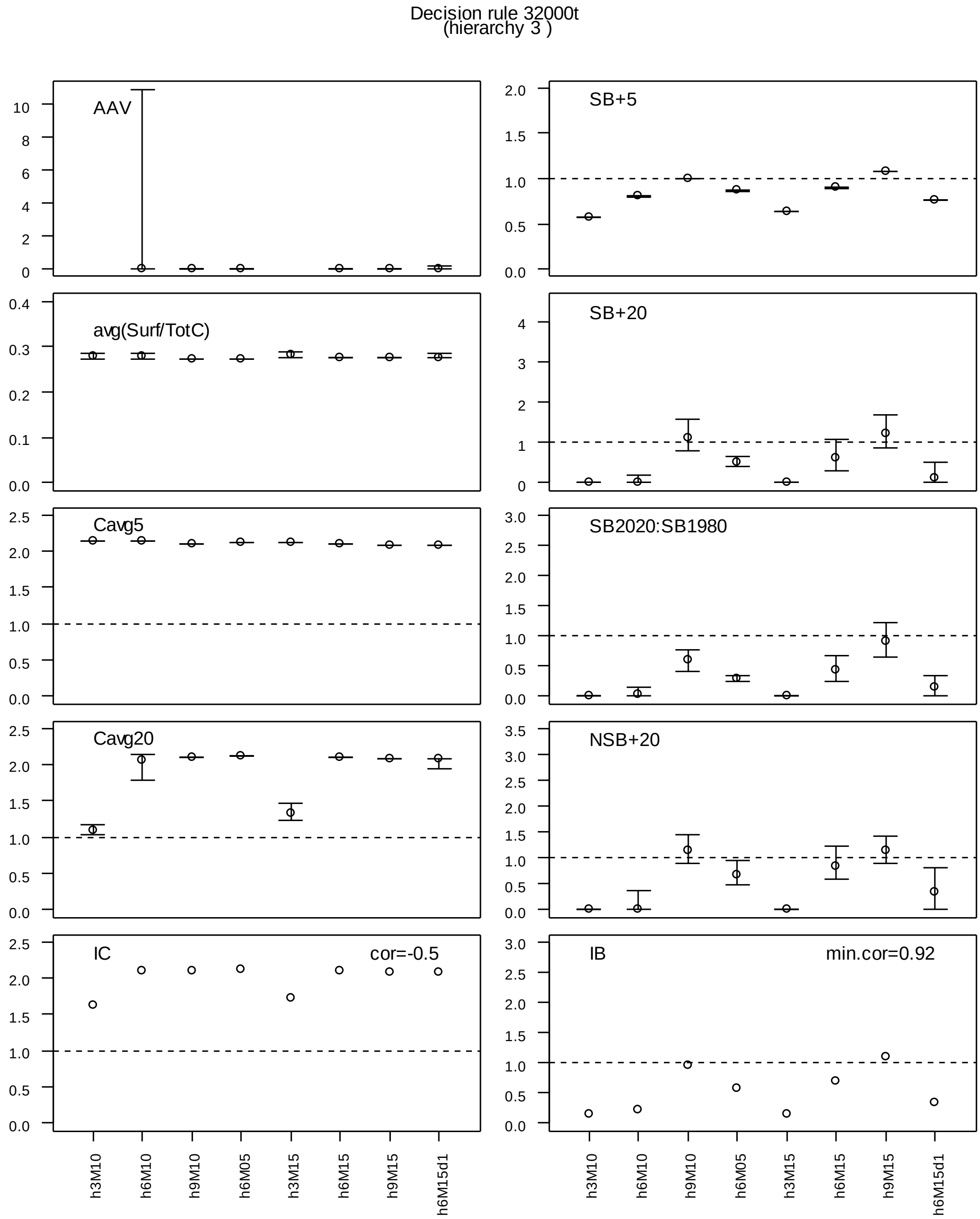


Figure 2-3. Comparison among scenarios for constant-catch scheme at the doubled catch of current level. AAV (10th quantile, median, 90th quantile) are 1423, 1549, 1688 for h3M10 and 1181, 1420, 1622 for h3M15.

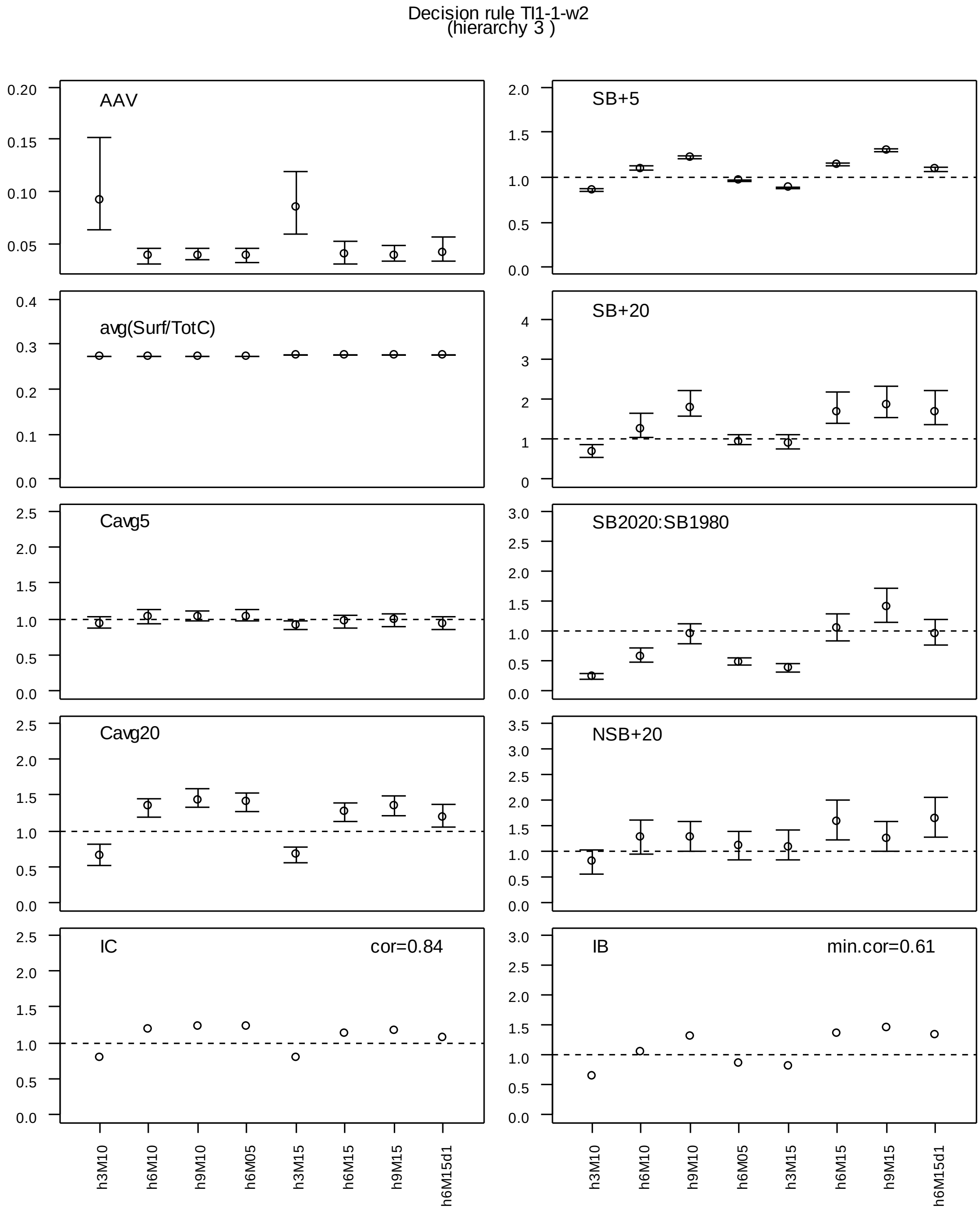


Figure 2-4. Comparison among scenarios for Management Procedure 'TI1-1-w2'. See Appedix 1 for detailed description of procedure and catch and biomass trajectories.

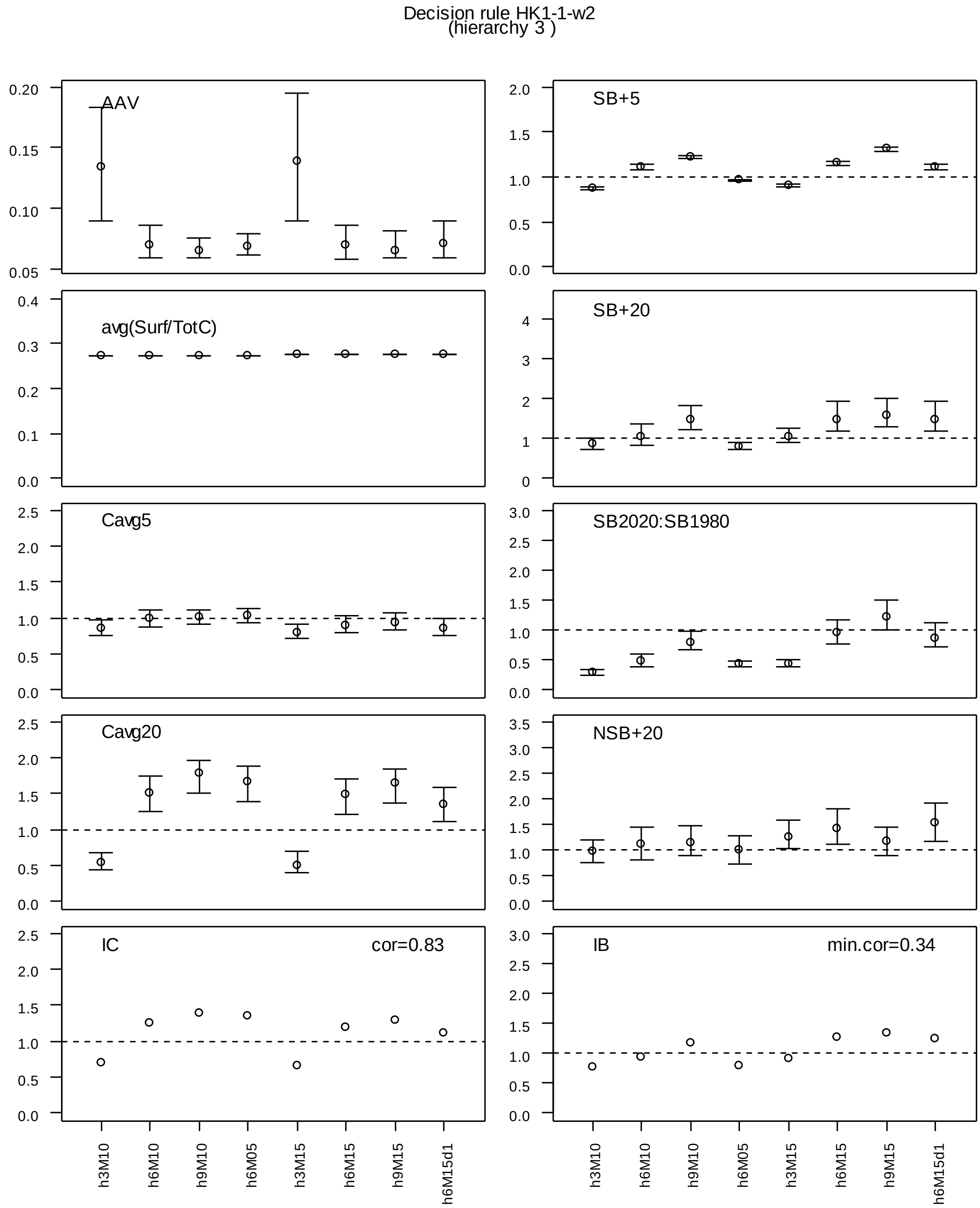


Figure 2-5. Comparison among scenarios for Management Procedure ‘HK1-1-w2’. See Appedix 2 for detailed description of procedure and catch and biomass trajectories.

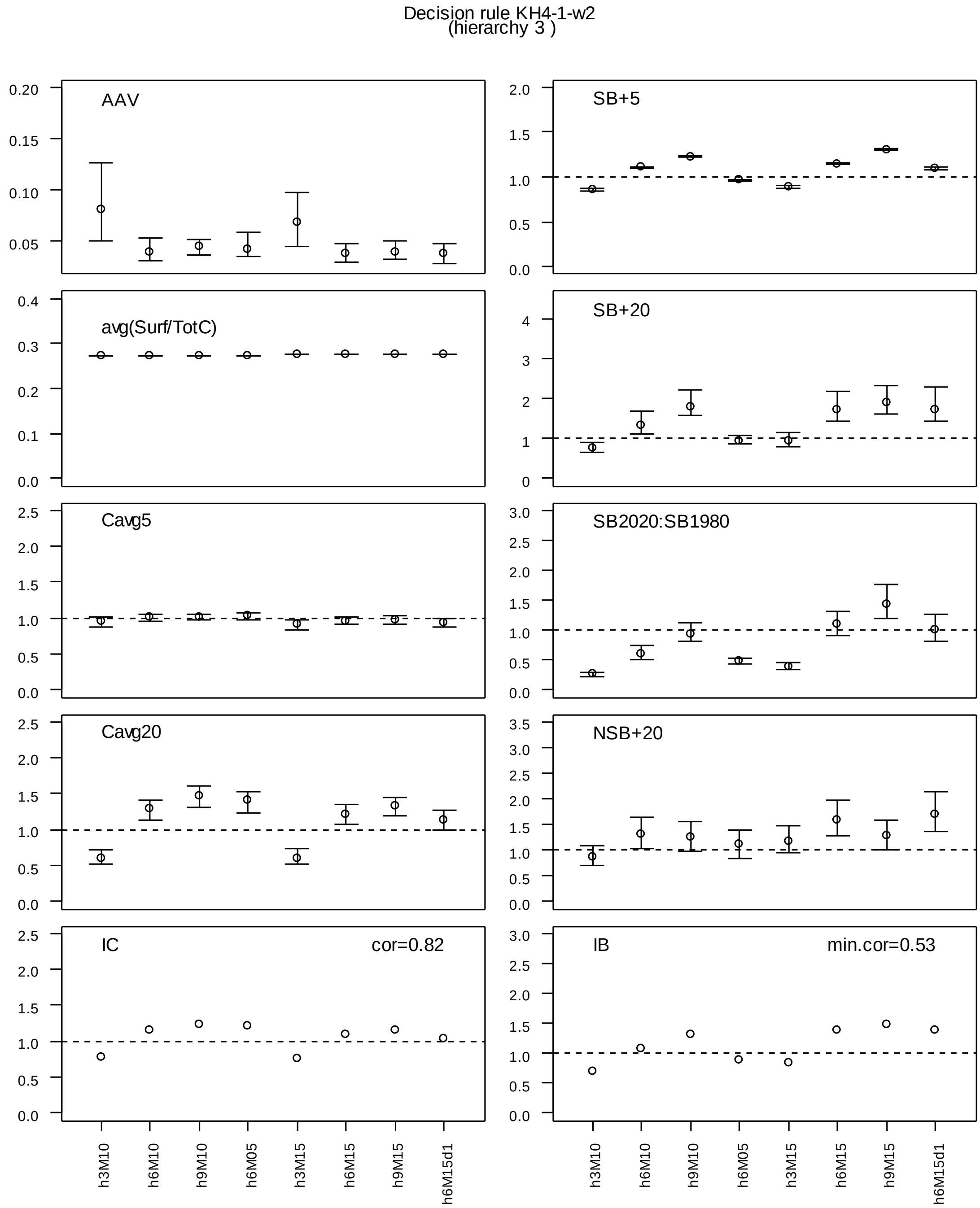


Figure 2-6. Comparison among scenarios for Management Procedure 'KH4-1-w2'. See Appedix 3 for detailed description of procedure and catch and biomass trajectories.

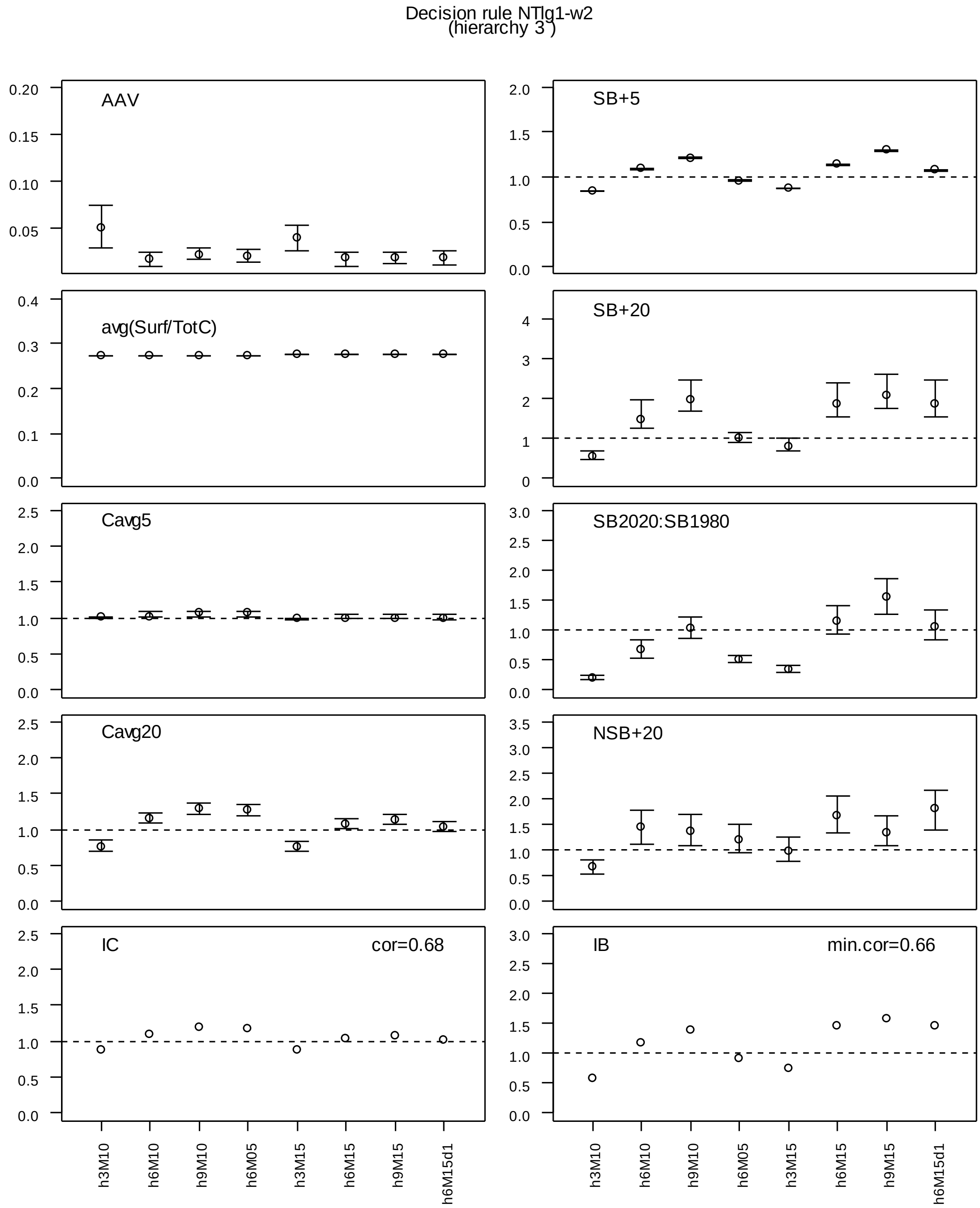


Figure 2-7. Comparison among scenarios for Management Procedure ‘NTlg1-w2’. See Appedix 4 for detailed description of procedure and catch and biomass trajectories.

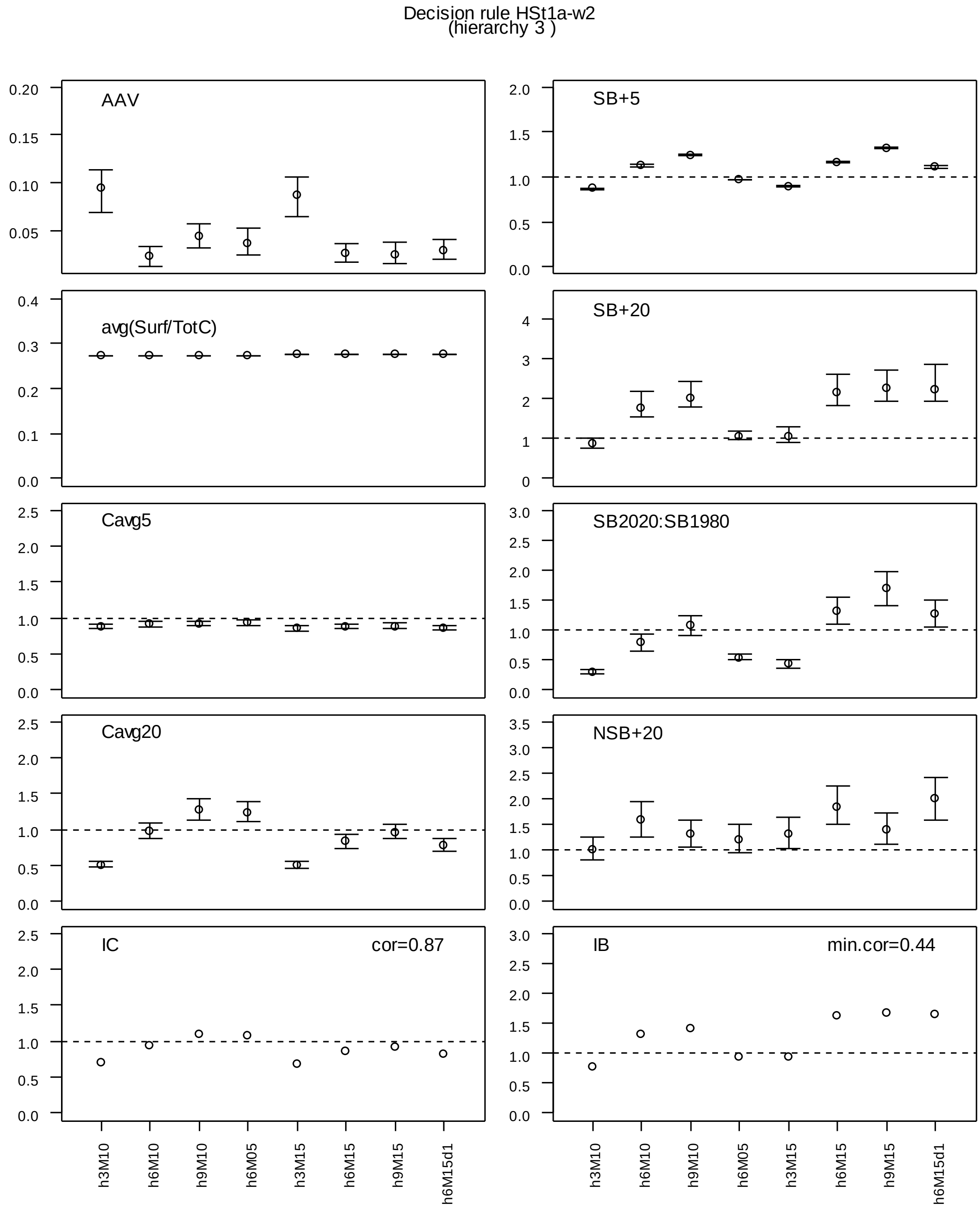


Figure 2-8. Comparison among scenarios for Management Procedure 'HSt1a-w2'. See Appedix 5 for detailed description of procedure and catch and biomass trajectories.

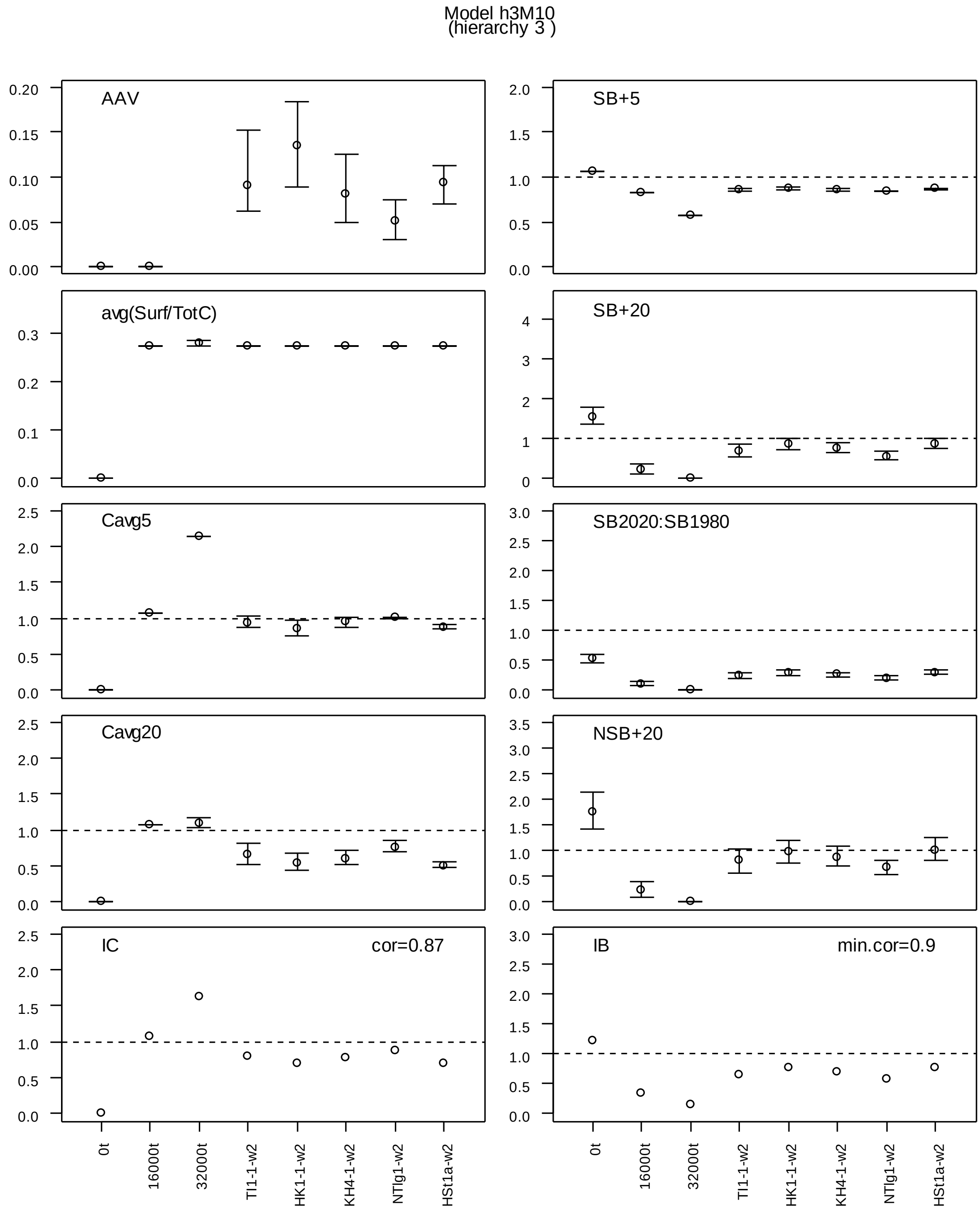


Figure 3-1. Comparison among potential Management Procedures with scenario 'h3M10'.

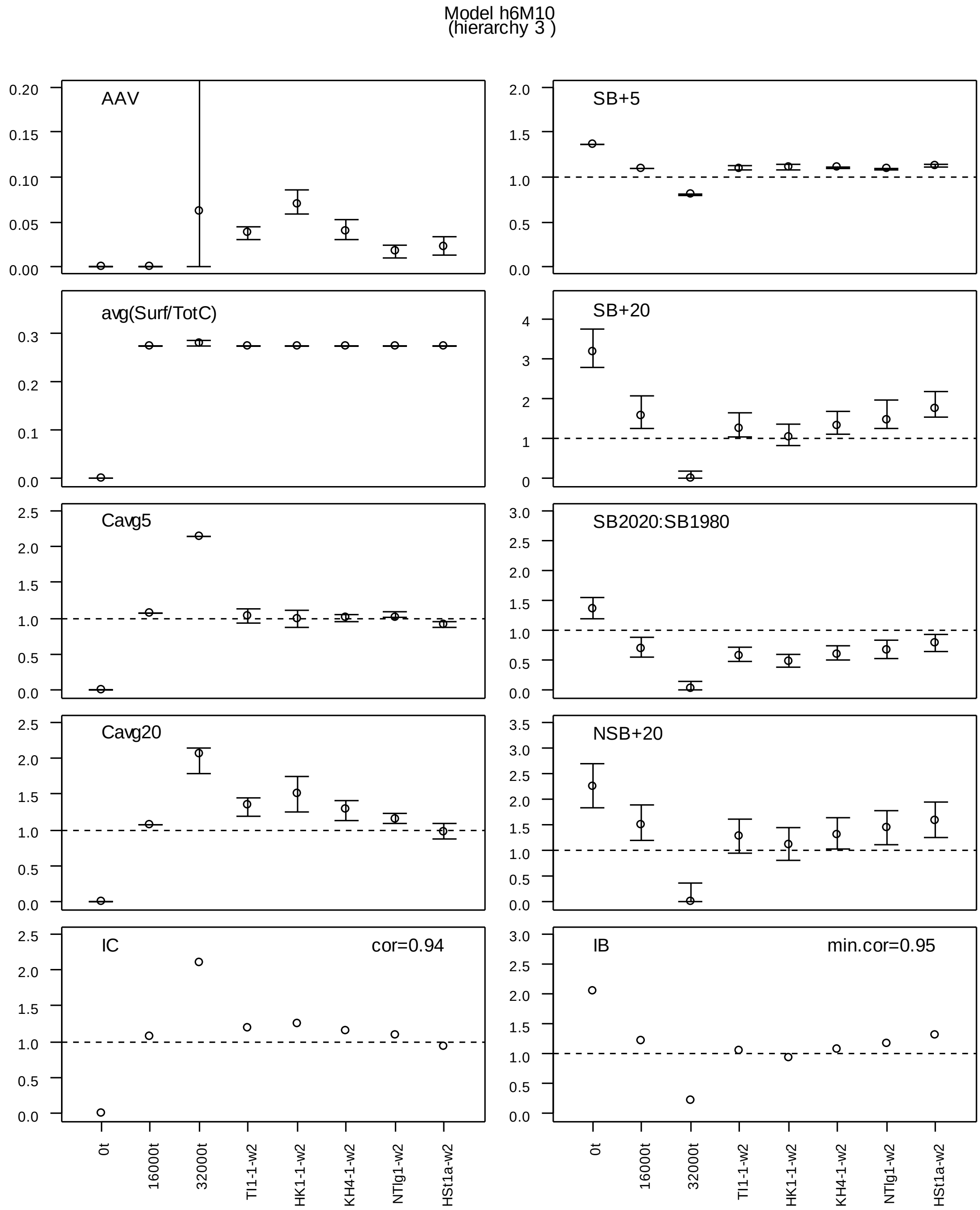


Figure 3-2. Comparison among potential Management Procedures with scenario 'h6M10'.

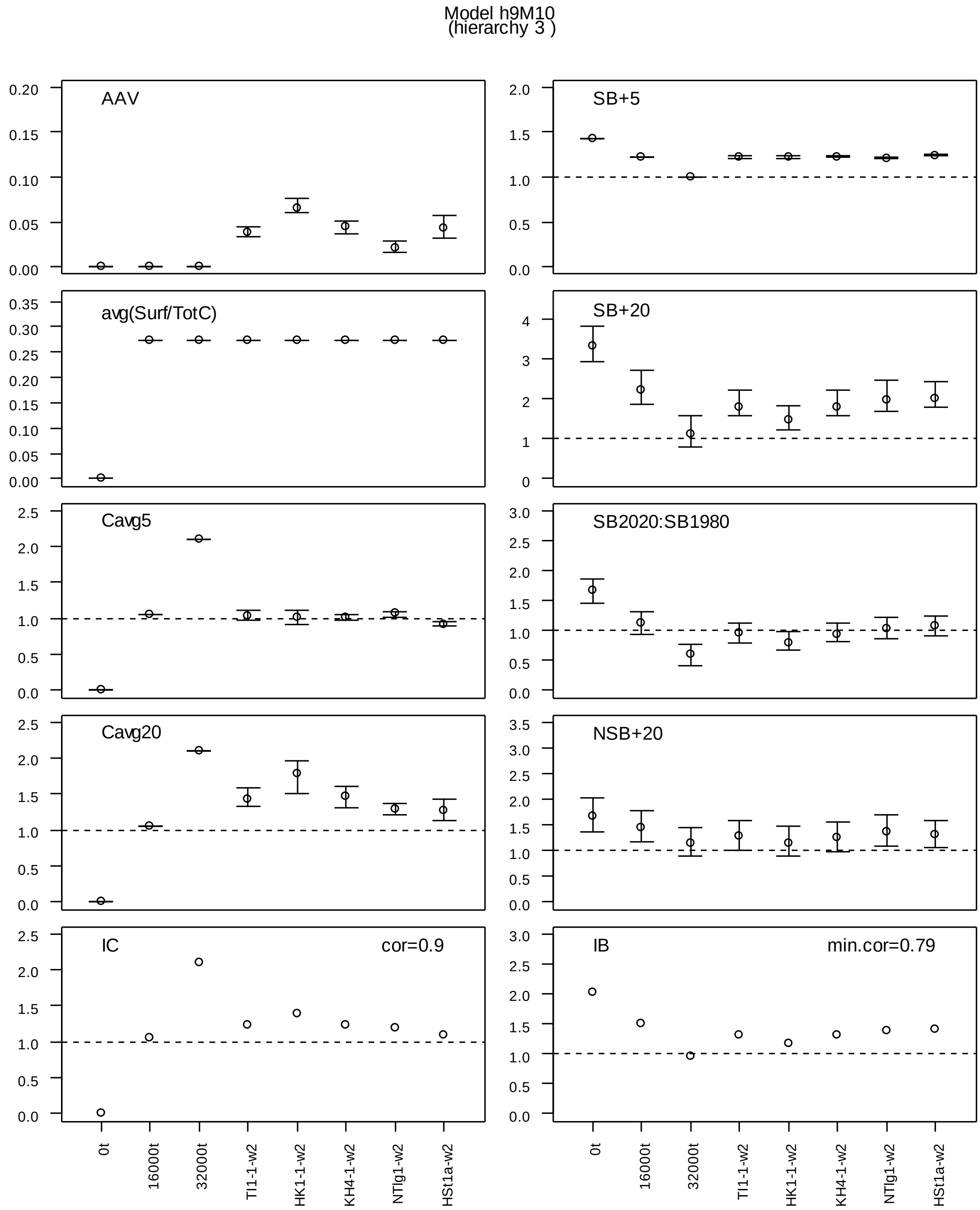


Figure 3-3. Comparison among potential Management Procedures with scenario 'h9M10'.

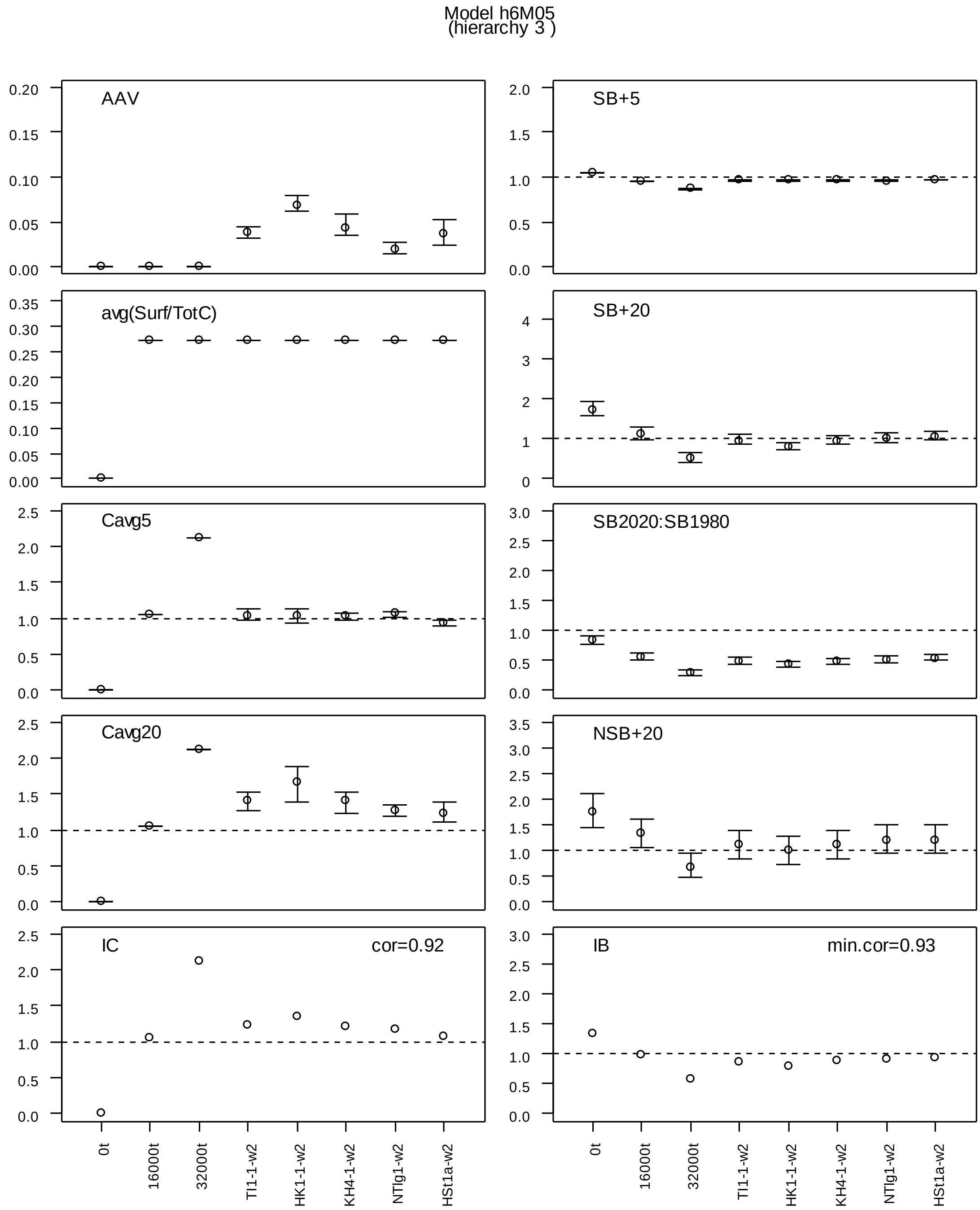


Figure 3-4. Comparison among potential Management Procedures with scenario 'h6M05'.

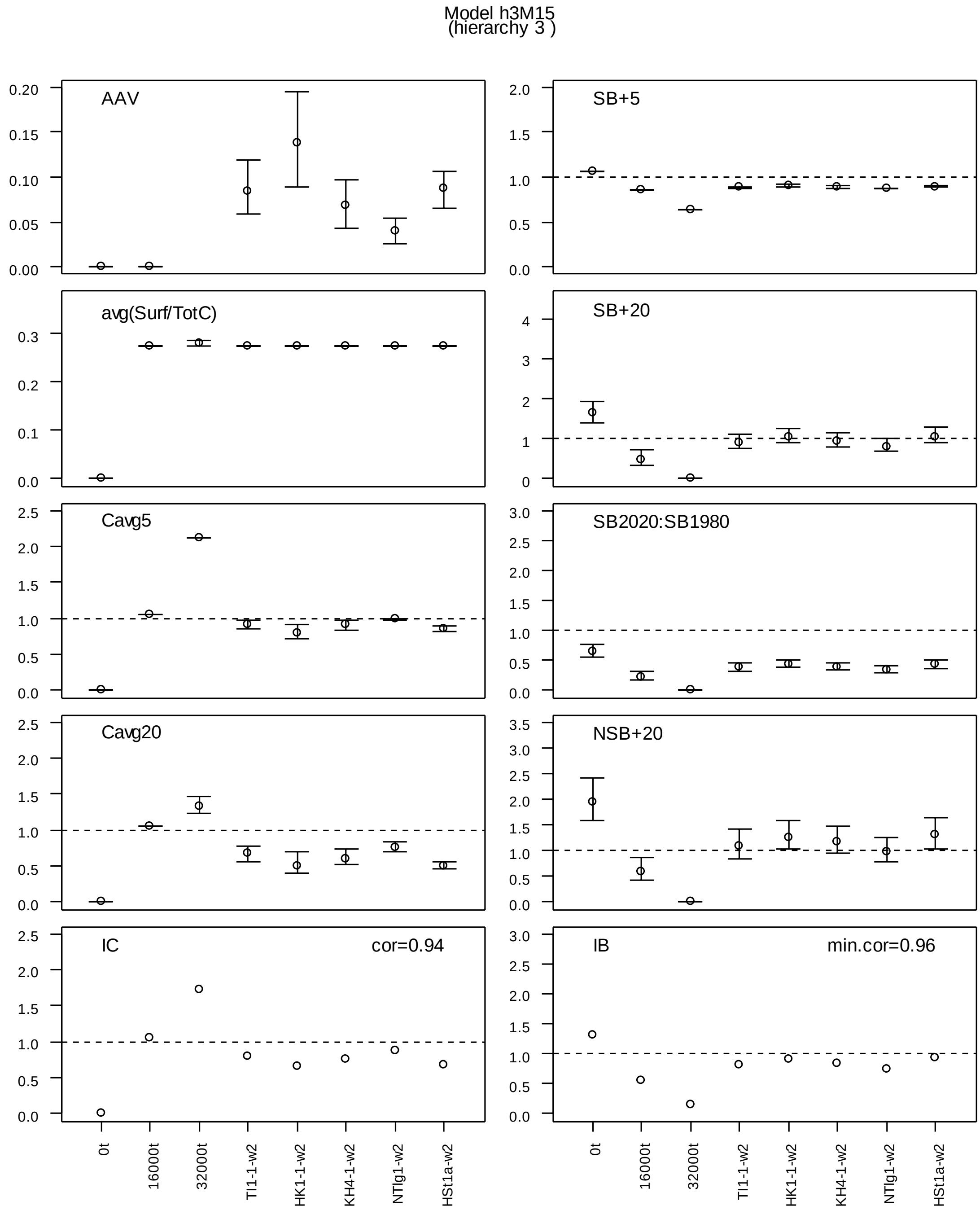


Figure 3-5. Comparison among potential Management Procedures with scenario 'h3M15'.

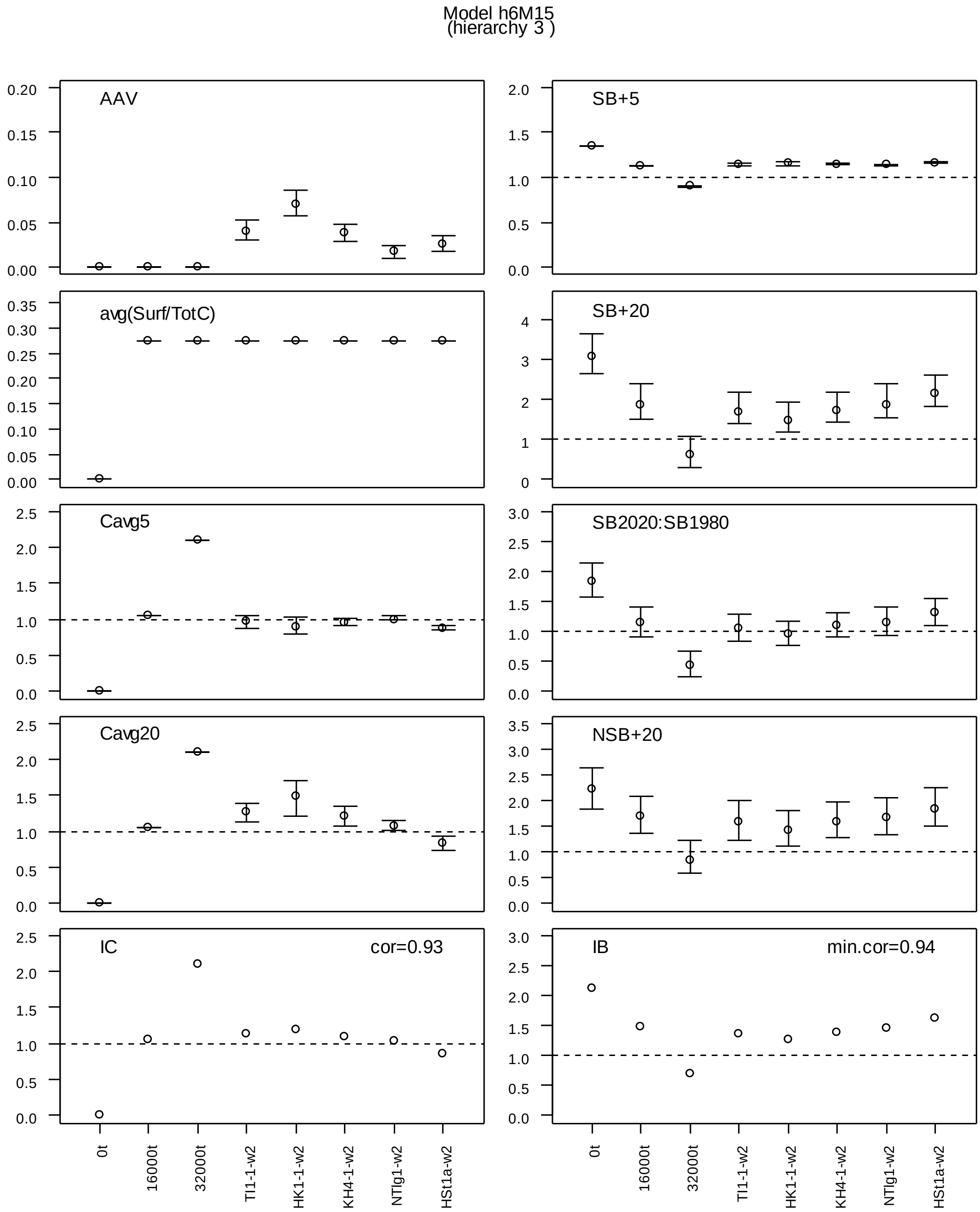


Figure 3-6. Comparison among potential Management Procedures with scenario 'h6M15'.

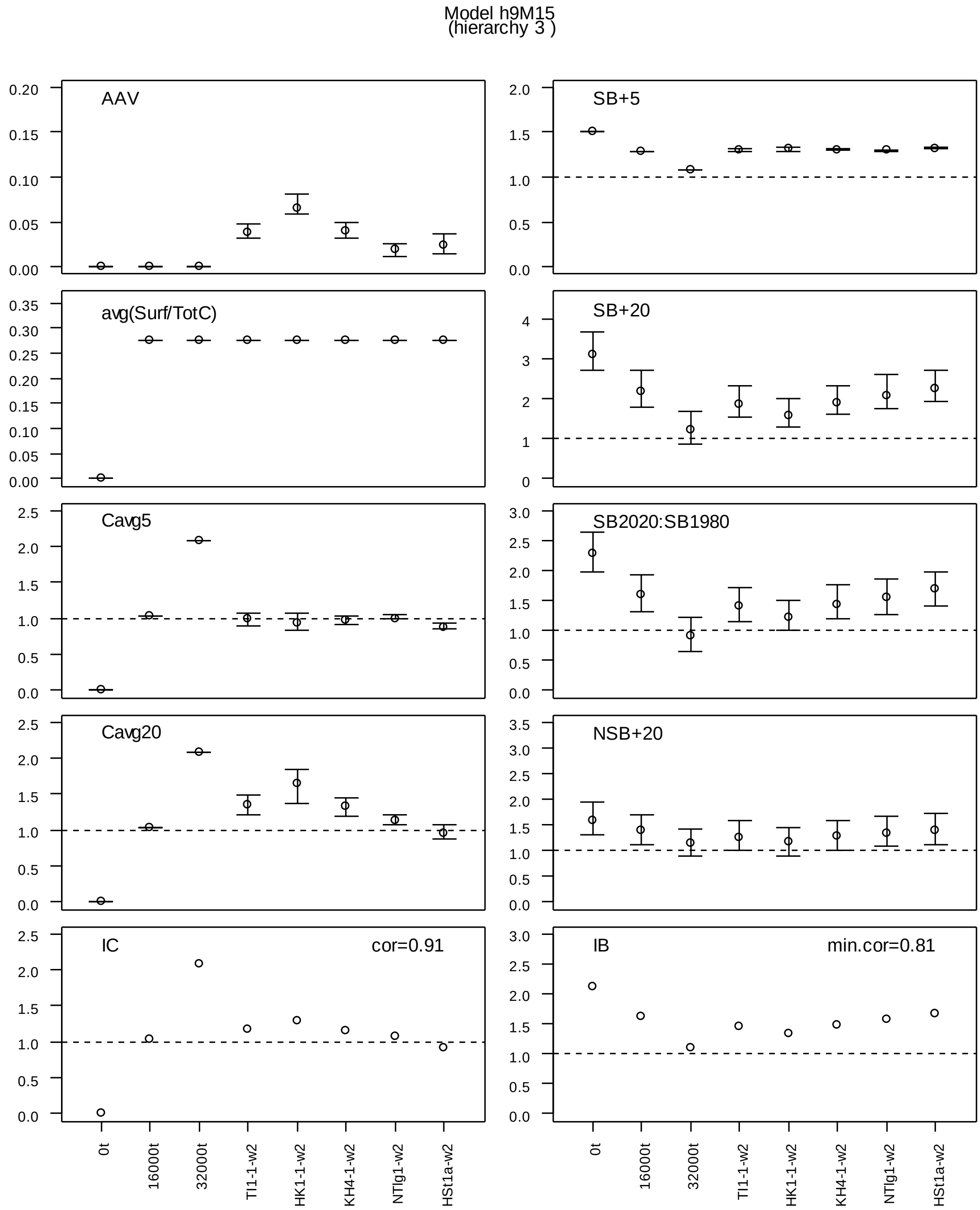


Figure 3-7. Comparison among potential Management Procedures with scenario ‘h9M15’.

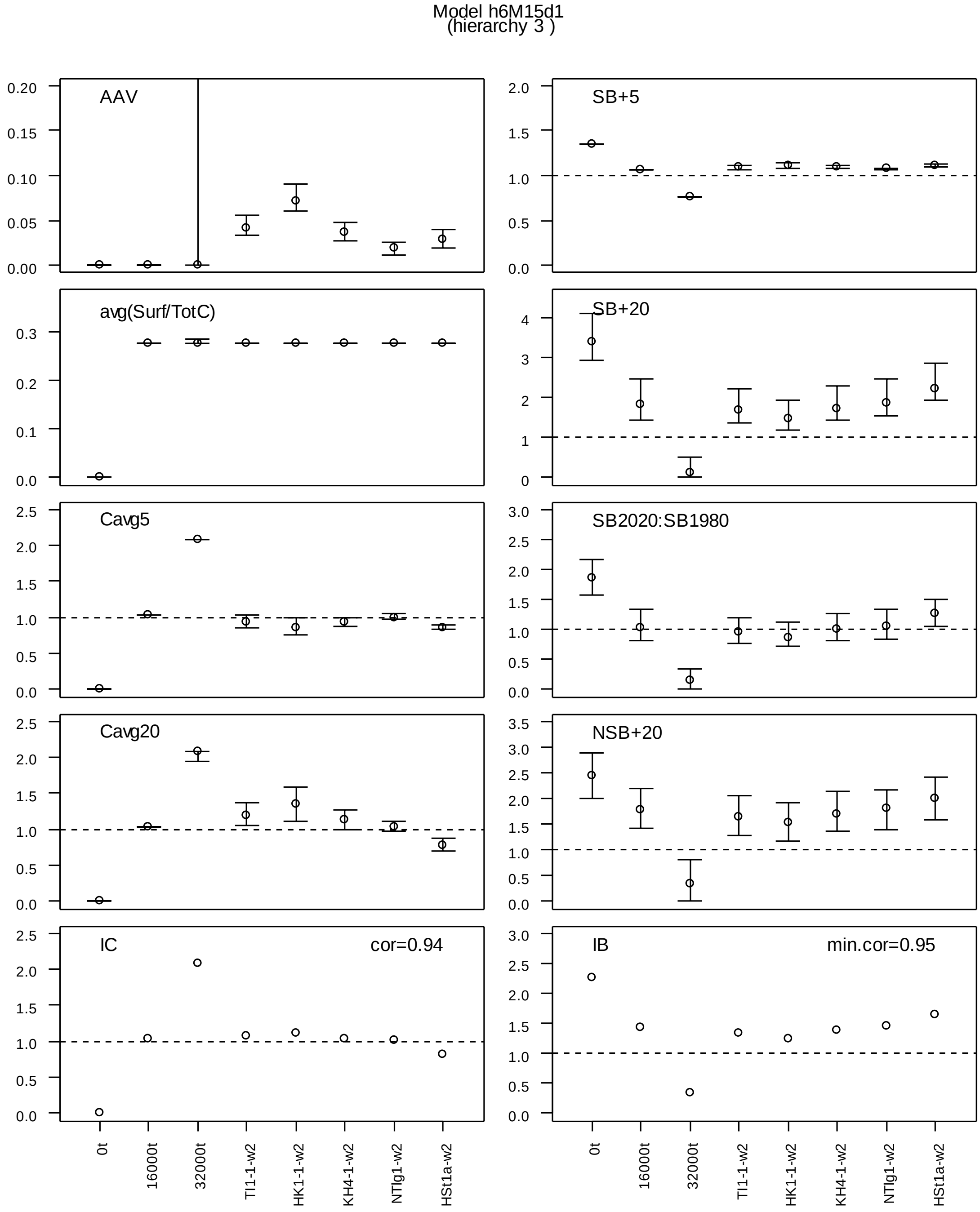


Figure 3-8. Comparison among potential Management Procedures with scenario 'h6M15d1'.

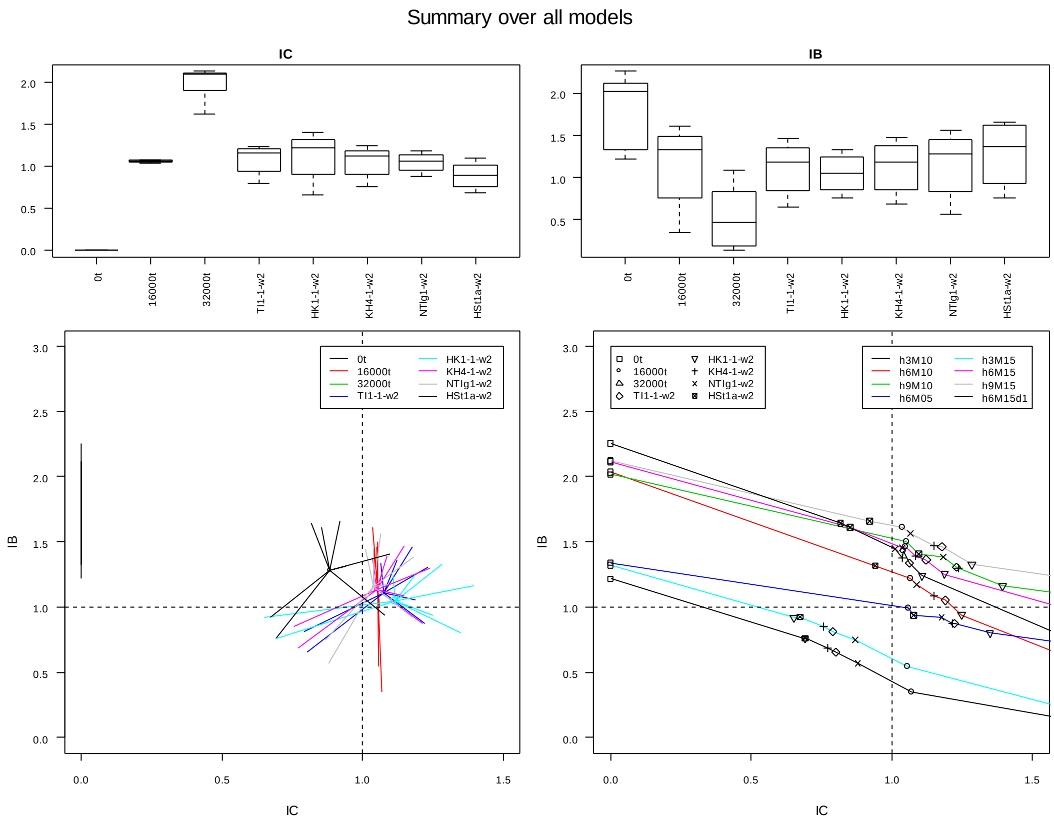


Figure 3-9. Comparison among potential Management Procedures for hierarchy 3 with overall combined summarization figures.

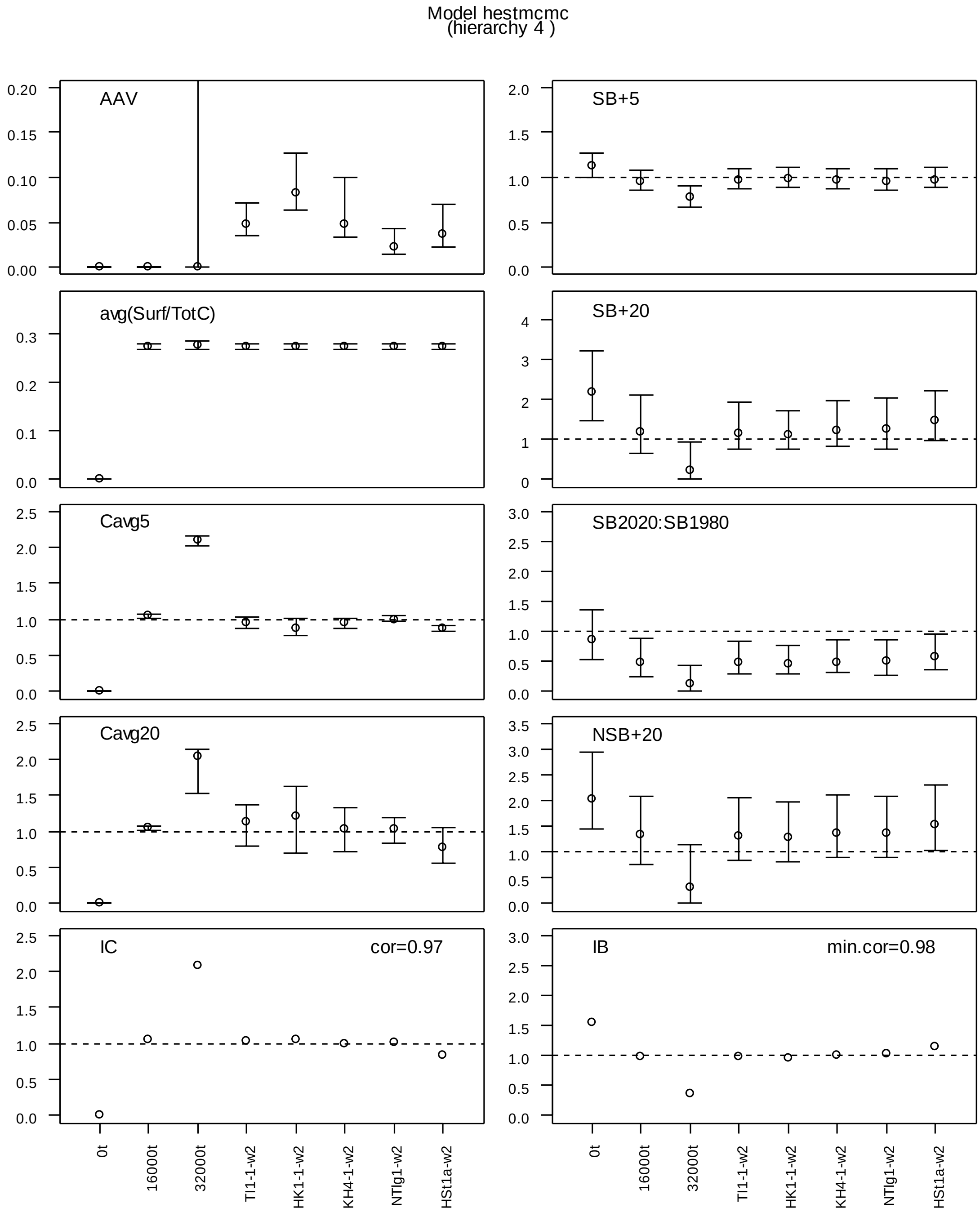


Figure 3-10. Comparison among potential Management Procedures with MCMC h-estimation. The 90th quantile of AAV is 818 for '32,000 t'.

Outline of "TI1-1-w2"

Hiroyuki Kurota and Tomoyuki Itoh

1. Basic Idea

In this quite simple MP, TACs are moved up and down by a pre-fixed amount depending on CPUE trend. TAC is specified by:

$$TAC_{y+1} = \begin{cases} TAC_y + c & \text{if} \quad \lambda > a \\ TAC_y & \text{if} \quad \lambda \le |a| \\ TAC_y - c & \text{if} \quad \lambda < -a \end{cases}$$

where

λ: the slope of the regression of ln(CPUE) over 10 years (from y-10 to y-1),

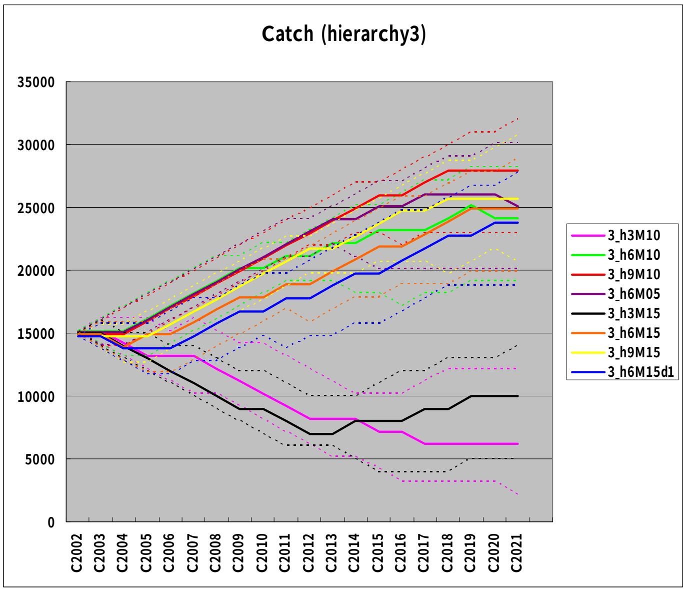
a, c: control parameters (a = 0.01, c = 1000 in the default case)

2. Notes

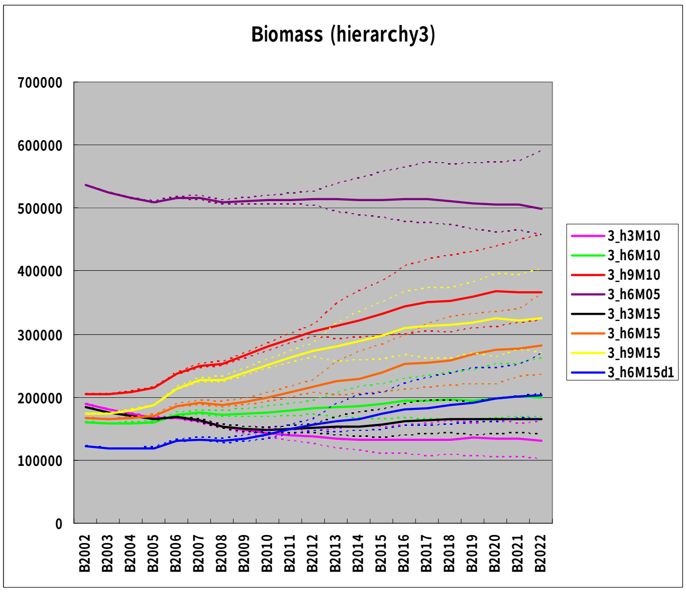
Figures showed results in the default case. TACs decreased smoothly for the two scenarios with poor productivity and the spawning biomass almost stopped decreasing within the 20 year simulation period. Also large oscillations of TACs were not observed for the productive scenarios. Thus, this simple MP behaved reasonably judging from our target.

When the control parameter a was too small, TACs changed almost every year responding to even slight change in CPUE trend. Also year-to-year variation of TACs was larger, as the other parameter c was larger (e.g. c = 1500). When periods for calculating CPUE trend were shortened to 5 years, the process and observation errors at hierarchy 3 prevented TACs from increasing smoothly for the productive scenarios and decreasing steadily for the two weak ones.

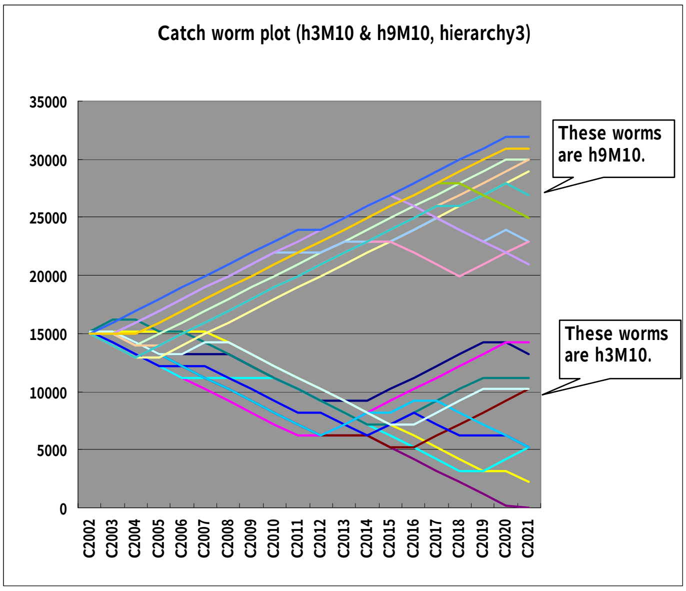
The change amount in this MP is determined in advance and this type of MP would be preferable from a practical perspective. It is necessary to investigate robustness to a sudden change of resource condition.



Catch (hierarchy3)
35000
30000
25000
20000
15000
10000
5000
0
C2002
C2003
C2004
C2005
C2006
C2007
C2008
C2009
C2010
C2011
C2012
C2013
C2014
C2015
C2016
C2017
C2018
C2019
C2020
C2021
3_h3M10
3_h6M10
3_h9M10
3_h6M05
3_h3M15
3_h6M15
3_h9M15
3_h6M15d1



Biomass (hierarchy3)
700000
600000
500000
400000
300000
200000
100000
0
B2002
B2003
B2004
B2005
B2006
B2007
B2008
B2009
B2010
B2011
B2012
B2013
B2014
B2015
B2016
B2017
B2018
B2019
B2020
B2021
B2022
3_h3M10
3_h6M10
3_h9M10
3_h6M05
3_h3M15
3_h6M15
3_h9M15
3_h6M15d1



Catch worm plot (h3M10 & h9M10, hierarchy3)
35000
30000
25000
20000
15000
10000
5000
0
C2002
C2003
C2004
C2005
C2006
C2007
C2008
C2009
C2010
C2011
C2012
C2013
C2014
C2015
C2016
C2017
C2018
C2019
C2020
C2021
These worms are h9M10.
These worms are h3M10.

Outline of "HK1-1-w2"

Hiroyuki Kurota

1. Basic Idea

This MP is characterized by TAC control depending on CPUE trend and a certain limit for amount of TAC change. TAC is specified by:

$$TAC_{y+1} = \begin{cases} TAC_y + c & if \quad \lambda > \dfrac{c}{k \times TAC_y} \\ TAC_y \times (1 + k\lambda) & if \quad \lambda \le \left| \dfrac{c}{k \times TAC_y} \right| \\ TAC_y - c & if \quad \lambda < -\dfrac{c}{k \times TAC_y} \end{cases}$$

where

λ: the slope of the regression of ln(CPUE) over 10 years (from y-10 to y-1),

k, c: control parameters (k = 5, c = 2000 in the default case)

2. Notes

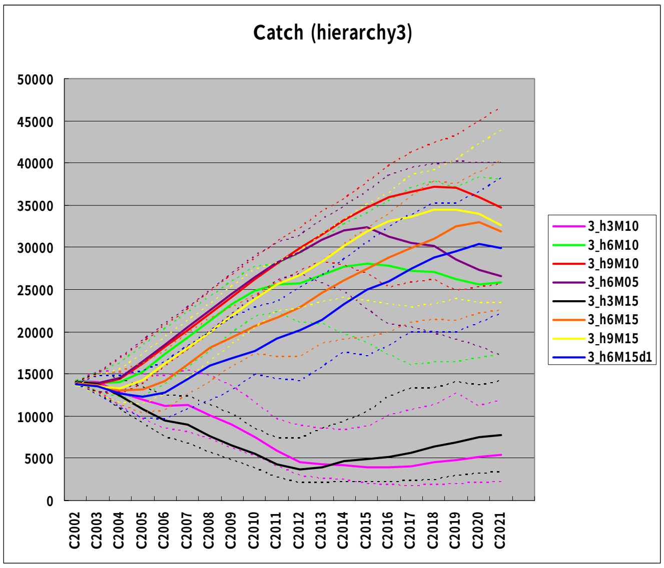
Figures showed results in the default case of this MP. TACs decreased smoothly for the two scenarios with poor productivity and the spawning biomass stopped decreasing and increased gradually within the 20 year simulation period. Also large oscillations of TACs were not observed for the productive scenarios. Thus, the MP behaved reasonably judging from our target.

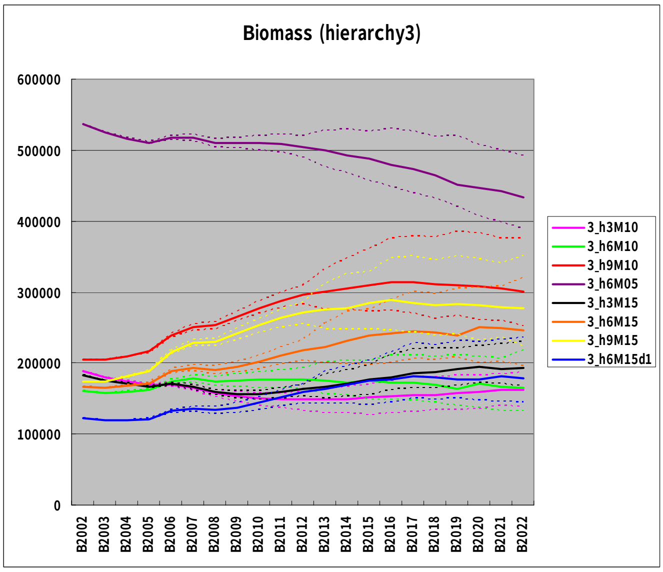
As limit of TAC change was larger (e.g. c = 3000), year-to-year variation in catch was larger, especially in productive scenarios. On the other hand, when the limit was small (c = 1000), the MP did not stop decreasing trend of spawning biomass within the 20 year simulation period in the two weak scenarios.

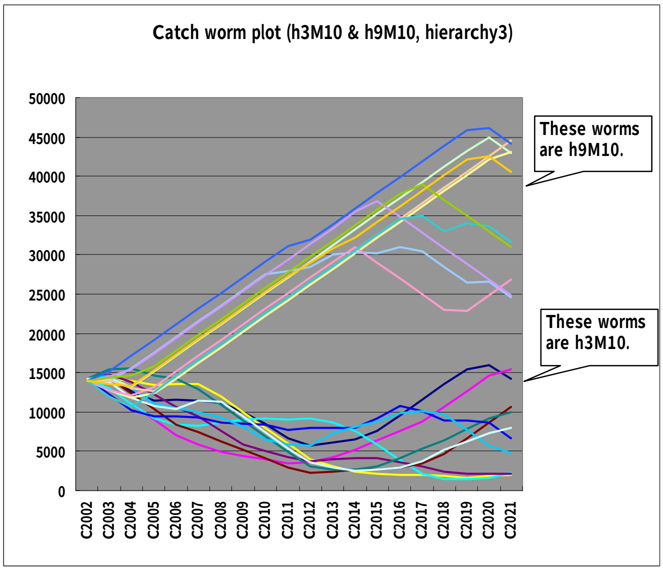
When k was small (k = 1), the MP did not stop declining trend of spawning biomass at the two scenarios with poor productivity. When k was over about 3, similar results to those in the default case were obtained, though as k was larger, spawning biomass came closer to the B_{MSY} level.

This MP sets limit of TAC change as a certain amount (c = 2000 ton). When a certain proportion to TAC_y (e.g. 10 %) was defined as limit value, interannual TAC fluctuation was larger in the productive scenarios and TACs were reduced more slowly in the scenarios with low productivity compared to the results in the default case.

When periods for calculating CPUE trend were shortened to 5 years, the process and observation errors at hierarchy 3 prevented TACs from quickly increasing for the productive scenarios and decreasing for the weak ones.


Catch (hierarchy3)
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
C2002 C2003 C2004 C2005 C2006 C2007 C2008 C2009 C2010 C2011 C2012 C2013 C2014 C2015 C2016 C2017 C2018 C2019 C2020 C2021
3_h3M10
3_h6M10
3_h9M10
3_h6M05
3_h3M15
3_h6M15
3_h9M15
3_h6M15d1


Biomass (hierarchy3)
600000
500000
400000
300000
200000
100000
0
B2002 B2003 B2004 B2005 B2006 B2007 B2008 B2009 B2010 B2011 B2012 B2013 B2014 B2015 B2016 B2017 B2018 B2019 B2020 B2021 B2022
3_h3M10
3_h6M10
3_h9M10
3_h6M05
3_h3M15
3_h6M15
3_h9M15
3_h6M15d1


Catch worm plot (h3M10 & h9M10, hierarchy3)
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
C2002 C2003 C2004 C2005 C2006 C2007 C2008 C2009 C2010 C2011 C2012 C2013 C2014 C2015 C2016 C2017 C2018 C2019 C2020 C2021
These worms are h9M10.
These worms are h3M10.

Outline of KH4-1-W2

Kazuhiko Hiramatsu

The TAC is calculated as follows.

$$TAC_{y+1} = \begin{cases} TAC_y \times \left(1 - \dfrac{C_1^2}{4C_2}\right) & \left(1 - \dfrac{C_1^2}{4C_2}\right) < \left(1 + C_1\lambda + C_2\lambda^2\right) \\ TAC_y \times \left(1 + C_1\lambda + C_2\lambda^2\right) & 0.1 \le \left(1 + C_1\lambda + C_2\lambda^2\right) \le \left(1 - \dfrac{C_1^2}{4C_2}\right) \\ TAC_y \times C_3 & \left(1 + C_1\lambda + C_2\lambda^2\right) < C_3 \end{cases}$$

where,

λ：the slope of the regression of ln(CPUE) versus time over the 10 years

C_1、C_2、C_3：control parameters (here $C_2 \leqq 0$ and C_3 fix to 0.1)、

The lower and upper limits for change in TAC are set to prevent abrupt reduction or overshooting of setting TAC. To avoid resource reduction in the low productivity scenarios, we consider rapid TAC reduction when λ<0.

After several trials of the combination of parameter values (C_1=1 and 2, C_2=0 to -16), the rule with C_1=2 and C_2=-16 is selected because of the stability of biomass and TAC trajectories at the end of the simulation period. Fig.A3-1 shows the relation between λ and change in TAC. The trajectories of TAC and biomass are shown in Figures A3-2.

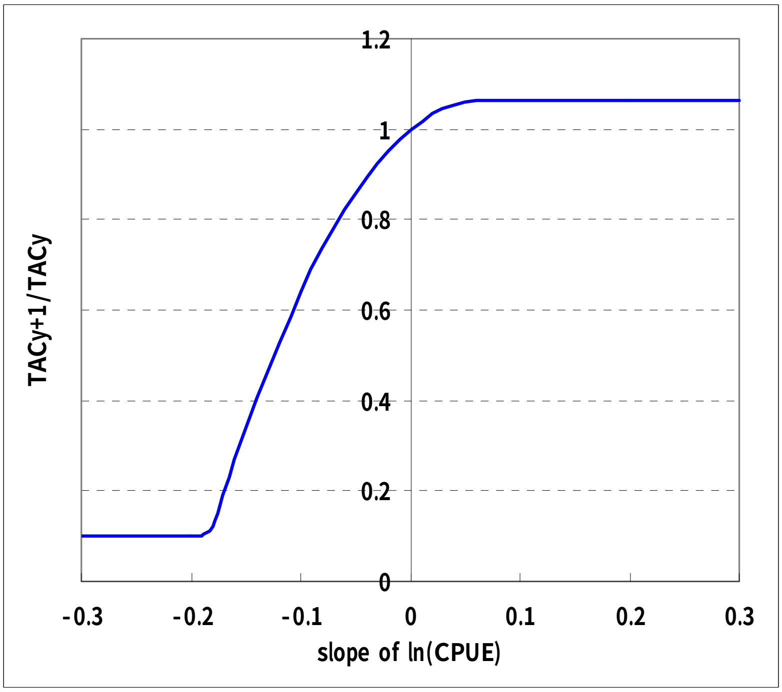


Figure A3-1. Relation between λ and change in TAC.

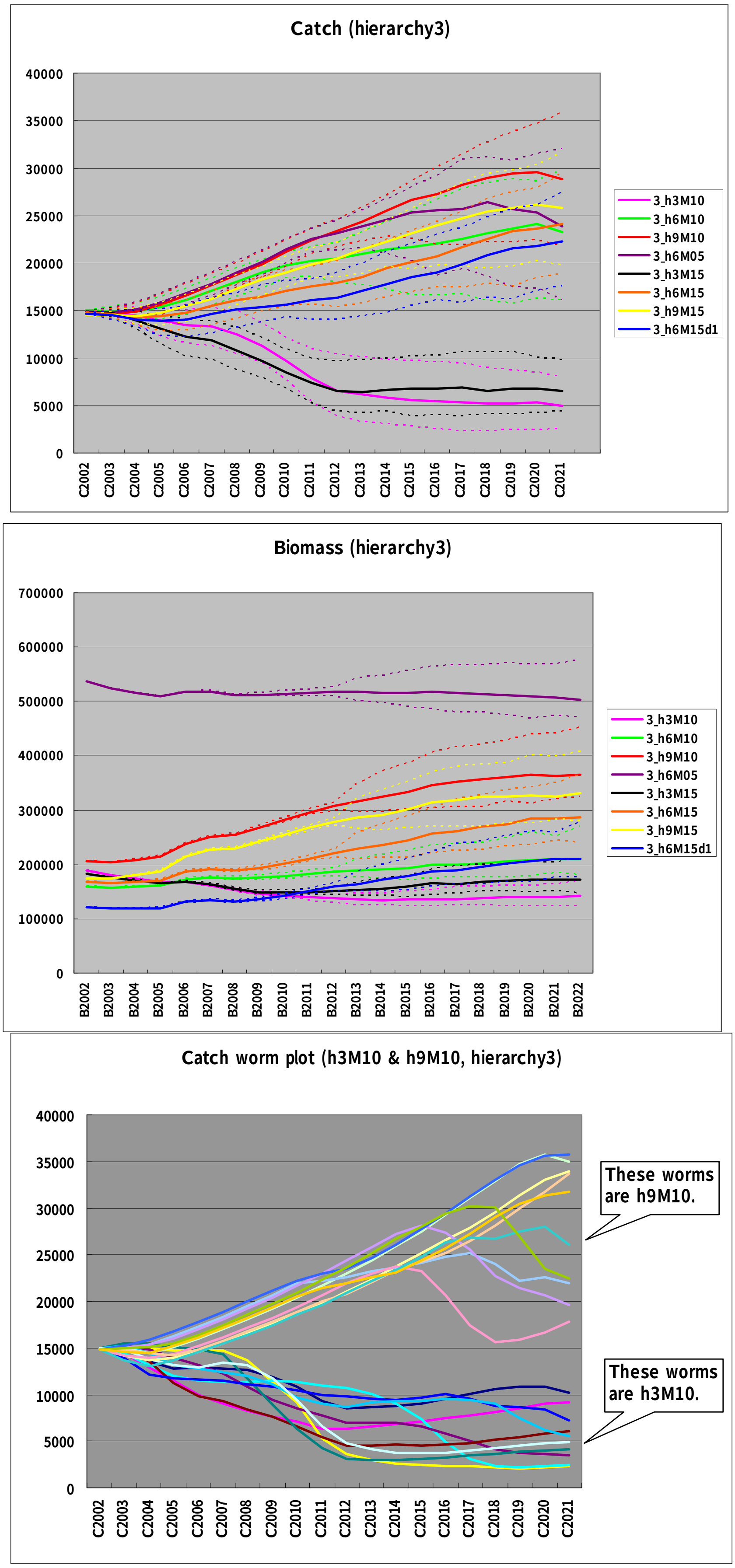


Figure A3-2. Results of KH4-1-w2.

Outline of “NTlg1-w2”

Norio Takahashi

1. Basic Idea

This is a rule-based MP such that if it is decided to reduce TAC, then the TAC reduction is carried out after certain year lag (namely “Give a warning call to industries” MP). Details of the rule are:

- Year 2002 is defined as the starting year of MP. If CPUE trend is negative, then TAC reduction is carried out after 2 years (year lag) by TAC value which was set (agreed) 2 years ago. But if the CPUE trend become positive after this 2 years lag, then TAC is increased (there remains a “hope”).
- CPUE trend is also examined in the year during the year lag (one year in this case). If the trend is positive, then TAC is increased. If the trend is negative, then TAC is set as *status quo* (i.e., in the situation which TAC can be increased the year lag is ignored).

TAC setting method is:

$$TAC_{y+1} = \begin{cases} TAC_y \times (1 + k\lambda) & \lambda \geq 0 \\ TAC_y \times (1 + ak\lambda) & \lambda < 0 \end{cases}$$

where

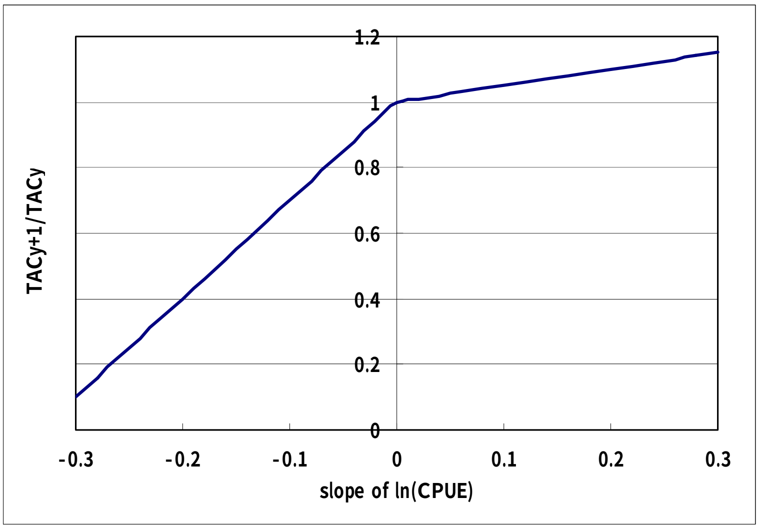
λ: the slope of the regression of ln(CPUE) versus time over 10 years,

a、k: parameters (a=6, k=0.5 in this case)

Set values of the time horizon for estimating the slope of the CPUE regression line, a, k, and the year lag duration were empirically determined by trying various values and comparing results. The effects of changing the following values were examined. Reference case was set to: Time horizon=5, a=6, k=0.5, year lag=2, and the effect of changing one parameter value (fixed others) on the result was examined.

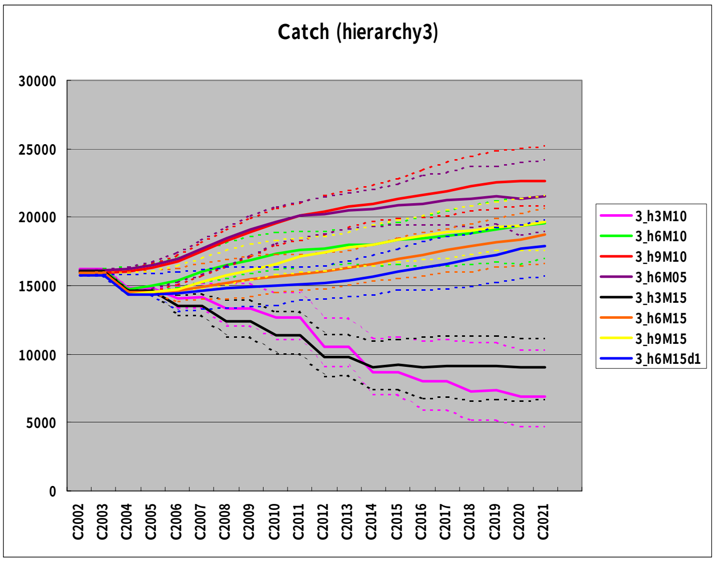
Parameters	Alternative values	
Time horizon of slope estimation	5	10
a	3	6
k	0.5	0.8
year lag	2	3

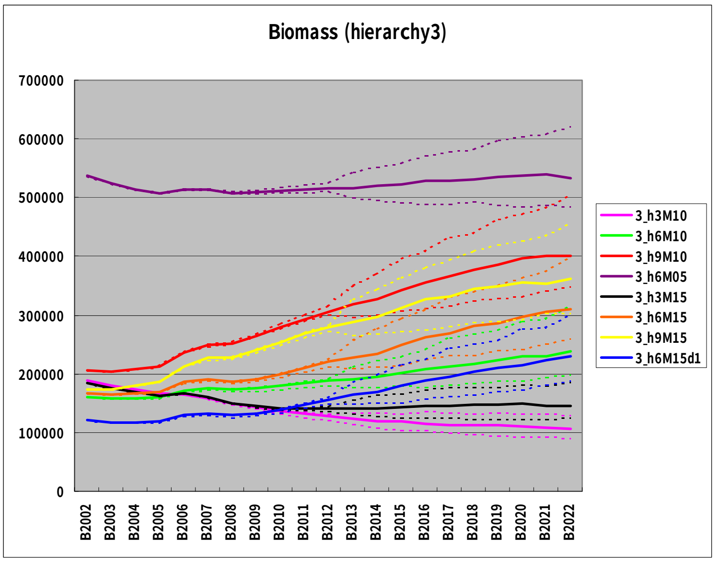
The following figure shows the graphical representation of CPUE-**λ** relationship for the TAC setting method above.

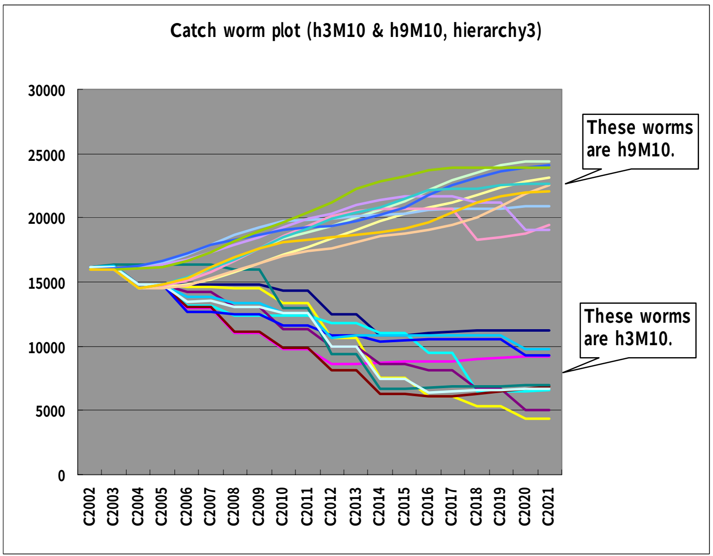


2. Notes

This MP adopts asymmetrical CPUE trend-TAC change relationship such that when the CPUE trend is positive TAC is increased slowly, while the trend is negative TAC is decreased rapidly. The following graphical representation of results shows that average dynamics of catch and biomass reached stable state to some extent after 20 years for most scenarios. When the year lag parameter was set to 3, biomass decline could not be stopped and future uncertainty increased for scenarios in which productivity is very weak. When the time horizon of calculating the slope of the CPUE regression line was set to a shorter term such as 5 years, the effect of the asymmetric CPUE trend-TAC relationship on catch fluctuation became large, whereas this MP responded more sensitively to CPUE change.


Catch (hierarchy3)
30000
25000
20000
15000
10000
5000
0
C2002 C2003 C2004 C2005 C2006 C2007 C2008 C2009 C2010 C2011 C2012 C2013 C2014 C2015 C2016 C2017 C2018 C2019 C2020 C2021
3_h3M10
3_h6M10
3_h9M10
3_h6M05
3_h3M15
3_h6M15
3_h9M15
3_h6M15d1


Biomass (hierarchy3)
700000
600000
500000
400000
300000
200000
100000
0
B2002 B2003 B2004 B2005 B2006 B2007 B2008 B2009 B2010 B2011 B2012 B2013 B2014 B2015 B2016 B2017 B2018 B2019 B2020 B2021 B2022
3_h3M10
3_h6M10
3_h9M10
3_h6M05
3_h3M15
3_h6M15
3_h9M15
3_h6M15d1


Catch worm plot (h3M10 & h9M10, hierarchy3)
30000
25000
20000
15000
10000
5000
0
C2002 C2003 C2004 C2005 C2006 C2007 C2008 C2009 C2010 C2011 C2012 C2013 C2014 C2015 C2016 C2017 C2018 C2019 C2020 C2021
These worms are h9M10.
These worms are h3M10.

Outline of 'HSt1a-w2'

Hiroshi SHONO

1. Tanaka's feedback method

We adopted the Tanaka's feedback method used when making the revised management procedure (RMP) in IWC. In this method, annual TAC is decided based on not only the year trend of CPUE (or Biomass) but also the absolute level of that. It gives us more robust MP-rule for TAC control to use the information about both CPUE trend and target CPUE (i.e. CPUE level) than that only using the trend of CPUE in many cases.

2. TAC specification

Annual TAC is calculated from the following equation:

$$TAC_{y+1} = \begin{cases} TAC_y[1+\gamma\{\alpha * g(CPUE) + \beta * h(CPUE)\}] & \alpha g() + \beta h() > 0 \\ TAC_y[1+\alpha * g(CPUE) + \beta * h(CPUE)] & \alpha g() + \beta h() \le 0 \end{cases} \tag{1}$$

where

$g()$: function of CPUE trend,

$h()$: function of CPUE level

$\alpha,\ \beta,\ \gamma$: parameters (for the weighting)

We utilized the following functional forms as $g()$ and $h()$ in this case. The structure of $h()$ is almost same as that of so-called 'Hilborn's 2nd model'. (The Excel-sheet by Hilborn was distributed to us during 2002 SAG/SC meeting.)

$$g(CPUE) = \lambda^T$$

$$h(CPUE) = \frac{average(CPUE)}{\mathrm{target}(CPUE)} - 1$$

$$average(CPUE_{y+1}) = \frac{1}{L}\sum_{i=1}^{L} CPUE_{y-1} \tag{2}$$

$$\mathrm{target}(CPUE_{y+1}) = \frac{1}{L}\sum_{i=1}^{L} level(CPUE_{y+1-i})$$

$$level(CPUE_{y+1}) = level(CPUE_y) + \frac{CPUE_{2022}^{\mathrm{target}} - CPUE_{2000}}{22}$$

where

λ^T : the slope of the regression of log(CPUE) versus time over T years,

$T,\ L$: parameters (of the time period for calculation)

$CPUE_{2022}^{\mathrm{target}}$: parameter (the value of target CPUE in 2022)

We estimated these parameters so as to minimize the following index used the Solver in the Excel-sheet by Hilborn.

$$S = \sum_m \log\left(\frac{SSB_{2022}^m}{B_{msy}^m}\right)^2 \tag{3}$$

$$(m = h3M10, h6M10, h9M10, h6M05, h3M15, h6M15, h9M15, h6M15d1)$$

On the basis of estimates, these parameters in the reference case were set to:

$$\alpha = 1.0,\ \beta = 0.2,\ \gamma = 0.5,\ T = 10,\ L = 10,\ CPUE_{2022}^{\text{target}} = 0.65 \tag{4}$$

We tried to other forms of function $g()$ and/or a part of $h()$ as follows:

$$g(CPUE) = \frac{1}{1 + \exp\{-k(\lambda^T - t)\}} - 1 \tag{5}$$

where k, t: parameters (of Sigmoid-function)

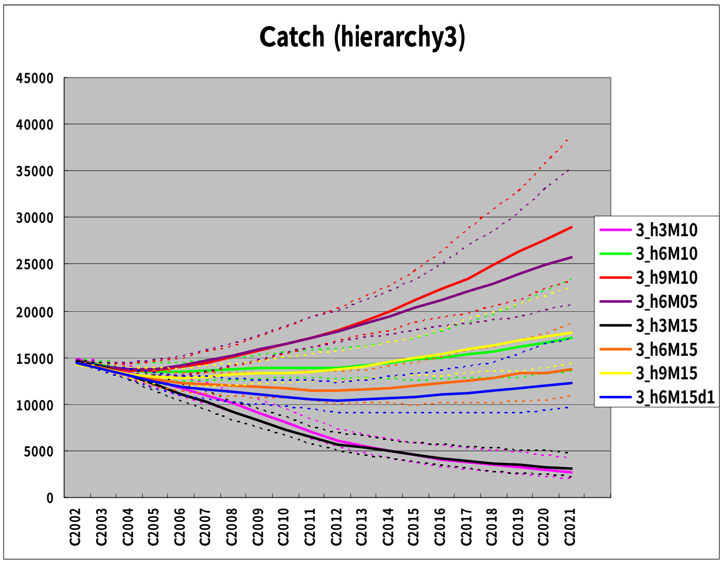
$$level(CPUE_{y+1}) = level(CPUE_y) + \frac{CPUE_{2022}^{\text{target}} - CPUE_y}{22}$$

$$\left(or\ level(CPUE_{y+1}) = level(CPUE_y) + \frac{CPUE_{2022}^{\text{target}} - CPUE_y}{2022 - (y+1)} \right) \tag{6}$$

And also we carried out several sensitivity analyses changing the values of parameters. However, the performance (of other functional forms and/or other values of parameters) seems to be not so good. Therefore, the results were omitted in this case.

3. Note

Annual trends of CPUE and biomass seemed to be rather stable as a whole. Especially, Biomass level of scenario h3M10 and h3M15 is a little increased because of using the non-symmetrical TAC control rule. On the other hand, it is difficult to set the adequate level of target CPUE. (The assumption in this case seems to be quite good.) If the current CPUE becomes larger than target one, then the values of CPUE (and/or Biomass) may fluctuate rather largely.


Catch (hierarchy3)
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
C2002
C2003
C2004
C2005
C2006
C2007
C2008
C2009
C2010
C2011
C2012
C2013
C2014
C2015
C2016
C2017
C2018
C2019
C2020
C2021
3_h3M10
3_h6M10
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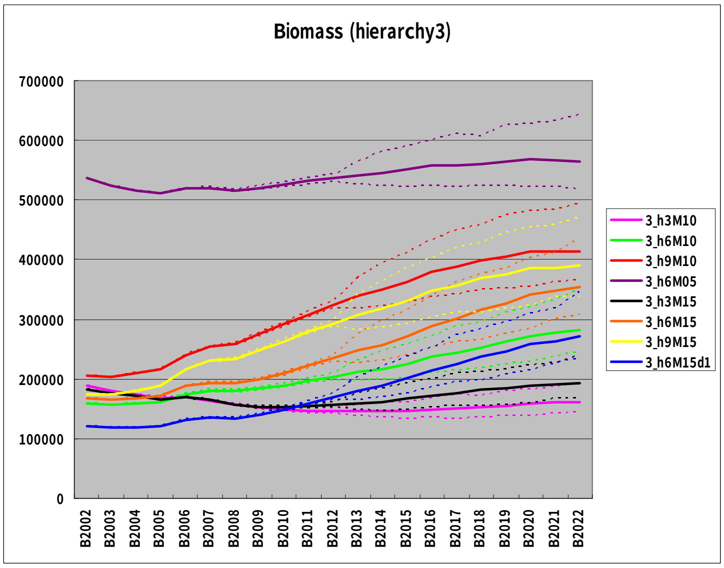
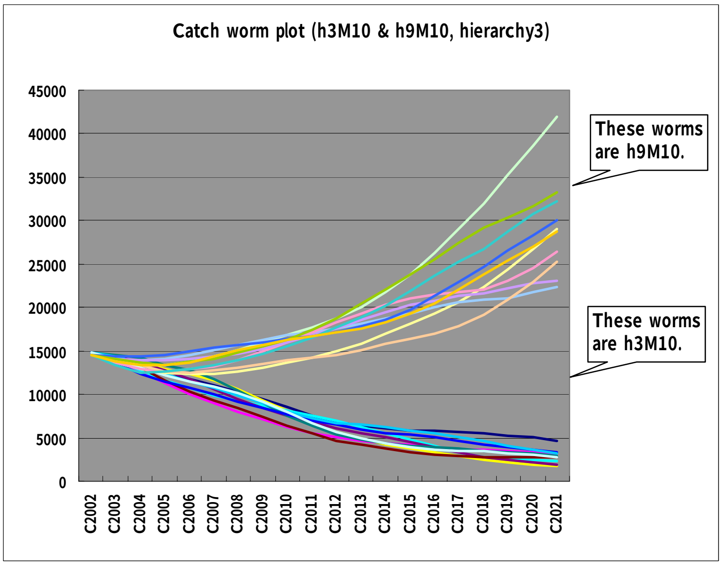
3_h6M05
3_h3M15
3_h6M15
3_h9M15
3_h6M15d1


Biomass (hierarchy3)
700000
600000
500000
400000
300000
200000
100000
0
B2002
B2003
B2004
B2005
B2006
B2007
B2008
B2009
B2010
B2011
B2012
B2013
B2014
B2015
B2016
B2017
B2018
B2019
B2020
B2021
B2022
3_h3M10
3_h6M10
3_h9M10
3_h6M05
3_h3M15
3_h6M15
3_h9M15
3_h6M15d1


Catch worm plot (h3M10 & h9M10, hierarchy3)
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
C2002
C2003
C2004
C2005
C2006
C2007
C2008
C2009
C2010
C2011
C2012
C2013
C2014
C2015
C2016
C2017
C2018
C2019
C2020
C2021
These worms are h9M10.
These worms are h3M10.