Further exploration of CPUE-based management procedures.

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Summary: Results of second exploration of potential Management Procedures were presented. Still, all efforts were focused development of simple Management Procedures based on longline CPUE. Approaches used to explore further MPs included 1) to explore further parameter spaces, 2) to replace input parameters from CPUE in number to CPUE in weight, 3) to use absolute CPUE values in place of slope of CPUE changes as input parameters, 4) to introduce some indices of recruitments as input parameters, and 5) to develop composite model. Composite approaches to utilize multiple components tended to give better performance based on TAC and stock trajectories. Behaviors of some MP indicated that 20 years projection was not adequate to judge MP performance in some cases. Inclusion of 50 years projection as a robustness check was proposed.

要約：管理方策案の第 2 段階の模索結果を示した。依然として、はえ縄 CPUE に基づいた単純な管理方策案の開発に全努力を傾注した。開発の方向としては、1)パラメータの検討、2)尾数 CPUE の代りとして重量 CPUE の使用、3)CPUE の傾きの代りに CPUE 絶対値の使用、4)加入情報を入力データとして使用、5)複合モデルの開発などをおこなった。TAC 動向、資源動向からの判断においては、複数の因子を用いた複合的なアプローチがうまく機能する傾向が見られた。一部の MP の動向から、状況によっては 20 年間の将来予測では MP の性能を評価するのに不充分であることが示された。頑健性のチェックとして 50 年間の将来予測を含めることを提案した。

1. Processes taken since the previous MP Workshop:

This document briefly describes our progress in developing candidate Management Procedures (MP) for SBT. The new version of operating models based on the agreement at the 2nd Management Workshop (Anon., 2003) was provided on July 19, 2003 by V. Haist.

As the first step, the same set of MPs presented at the 2nd Management Procedure Workshop with the same parameters (Hiramatsu et al., 2003) were applied to explore behaviors of new set of operating models, and to identify major changes from the previous version. In general, the performance of reference set scenarios were considered within a reasonable level, except that almost all MPs examined troubled to stop stock decline for the H30M05 scenario. For H30M05, several MP allocated increased TAC despite of stock decline. Almost all MPs had a difficulty to control those scenarios with non-linear relationship between stock abundance and CPUE (i.e. scenarios with

'OMEGA'). This is quite natural since all MPs we examined implicitly assumed linear relation between stock and CPUE.

The next step was to identify causes of poor performance and develop further MPs that at least showed better performance especially with those scenarios providing difficulties at the previous exercises. Here, we decided to stay with CPUE based MPs, mainly due to a limitation of time available. However, we are also keen to examine alternative inputs parameters during the next phase.

Approaches used to explore further MPs included 1) to explore further parameter spaces, 2) to replace input parameters from CPUE in number to CPUE in weight, 3) to use absolute CPUE values in place of slope of CPUE changes as input parameters, 4) to introduce some indices of recruitments as input parameters, and 5) to develop composite model. Points noted during these processes were summarized in Section 4.

We noted that a certain level of performance could be obtained with most of MP we tried by changing control parameters. At this stage, we have concentrated to explore new idea to utilize input information to manage stock. Three agreed objectives, i.e. maximizing catch, minimizing risk of stock depletion, and stability of fisheries, are mutually conflicting to some extent. According to relative importance for the Commission among three objectives, the best performed MP and the best set of control parameters will vary. Then, the comparison and selection among different ideas were intentionally deferred.

2. General principles in judging performance of MPs:

During an MP exploration process, we followed our own judgment standard of MP performance. Also, the examples shown under each idea were selected on the same basis. This section describes our judgment standard.

Most of judgments were made qualitatively based on TAC and SSB trends. Performance statistics were rarely used. Some trials have been made to develop quantitative indicators, one for each objective, using a set of performance statistics already agreed and reflecting our own feelings. However, only initial trials could be done within the time frame before the Meeting. Some of exploratory works is summarized in Kurota et al (2003).

General judgment standards were:

- None of scenario showed stock depletion.
- If stock is in declining trend, stock decline should stop and preferably start recovering with 20 years.
- If stock is in increasing trend, no overshoot would occur at least with deterministic run within 50 years. The reasons extended time horizon for this criteria will be described in Section 4.

- Smooth and gradual TAC changes are preferred. Large TAC change in one year and frequent changes of TAC in opposite directions are two characteristics to be avoided.
- Direction of changes of TAC and stock trends should be kept to the same as much as possible. I.e. The cases such as TAC increase despite of stock decline or TAC decrease despite of stock increase should be avoided as much as possible.

These standards more or less reflect the fact that the Japanese Government and industries consider the stability of fisheries as the highest priority among three objectives.

No specific consideration is made on the level to be recovered until 2020, such as 1980 level and Bmsy level.

3. General description of MPs explored:

This section summarizes the concepts of MPs included here. More detailed explanation of procedures and notes on characteristics are in Appendices 3-13 with one example of outputs, TAC and stock trends in hierarchy 3 for all scenarios in both reference and robustness sets. In the case of simple re-application of MP presented at the 2nd MPWS, only outputs for reference set was included.

<u>Application of the same MPs presented at the 2nd MPWS:</u>

The followings are the same MPs with the same control parameters presented at the 2nd MPWS. These are to examine changes in behaviors of operating models after incorporated agreed changes. Only change made here is to incorporate a standard constraint of minimum and maximum TAC changes as agreed at the 2nd MPWS.

TI1-fix : Adjust TAC with a pre-fixed quantity when an observed regression of ln(cpue) is above or below a pre-fixed threshold. (Appendix 3)

KH5-v5 : Asymmetric response to TAC according to an observed value of CPUE slope. (Appendix 4)

NTlg1 : Incorporate delay in applying TAC adjustment especially when reducing TAC. TAC is determined based on CPUE slope. (Appendix 5)

<u>Exploration of control parameters:</u>

HK1-dfl : Reference procedures developed during the 2002 SAG/SC with upper and lower limit for TAC changes. (Appendix 6)

HStnk : Adjust TAC based on both CPUE slope and distance to the target CPUE. There is no changes made in MP structure from the one presented at the 2nd MPWS as ‘HS’ but control parameters are adjusted to give better performance corresponding to the new set of operating models. (Appendix 7)

Exploration of input parameters:

Three types of input parameters were examined in addition to the CPUE slope. All of these explorations constrain minimum and maximum TAC changes as 100t and 3,000t, respectively.

1) CPUE in weight:

HK2-bms : Use slope of ln(CPUE(wt)) in place of ln(CPUE(N)) as an input parameter for 'HK1-dfl'. The results should be considered in a comparison with 'HK1-dfl'. (Appendix 8)

2) Absolute CPUE values:

STlv1 : Adjust TAC corresponding to CPUE of the most recent year. Relation between the amount of TAC change and CPUE value is defined as three connecting lines with two reflection points. (Appendix 9)

Stlv1.1 : Adjust TAC based on both CPUE value and CPUE slope. This MP calculates TAC using 'ST1v1' and 'NTlg1' (with no delay in TAC adjustment) independently and take the smallest of two as the final TAC. (Appendix 10)

3) Age 4 CPUE as an indicator of recruitments:

HK3-ag4 : Use slope of CPUE of age 4 in place of CPUE of age 4 and older (age 4+) as an input parameter for 'HK1-dfl'. Here, age 4 CPUE is used as one potential indicator of recruitments. (Appendix 11)

HK4-lv4 : Adjust TAC corresponding to the age 4 CPUE of the most recent year. Relation between the amount of TAC change and CPUE value is defined as three connecting lines with two reflection points. (Appendix 12)

HK5-hyb : Composite of 'HK1-dfl' and 'HK4-lv4' in the same way as 'STlv1.1'. (Appendix 13)

Graphical outputs developed by CSIRO scientists are shown for all of these MPs in Appendices 1 and 2.

4. Pointes noted:

CPUE(N) .vs. CPUE(W)

It was originally considered that CPUE in weight would be more representative for overall stock behaviors and more stable. Fig. 1 shows changes of CPUE in number and CPUE in weight under the constant catch at the current level (15,380t). As expected, CPUE in weight seemed stable slightly more than CPUE in numbers.

The comparison between CPUE(N) and CPUE(W) under the same MP were made between 'HK1-dfl' and 'HK2-bms'. The results did not show a significant difference in performance for reference sets between 'HK1-dfl' and 'HK2-bms'. However, the MP with CPUE(W) had a trouble to manage scenarios with omega option. Stability, in the other words insensitivity, of CPUE(W) is considered to make it harder to detect stock decline in those scenarios.

CPUE slope .vs. CPUE values

Historical trend of CPUE showed small up and down around overall changes. For the last two decades, there are small bump in CPUE observed between 1993 and 1996. Slope of CPUE tends to vary sensitive to the period taken into account because of this small bump. Also, when CPUE slope is used as index of stock changes, a linear relationship between CPUE and stock is implicitly assumed. Then, a violation of this assumption such as Omega scenarios causes significant impacts on performance of MPs based on CPUE slope.

As a potential alternative, we considered CPUE values in place of CPUE slope. The comparisons of MPs using these two types of input parameters were made between 'NTlg1' and 'STlv1' for CPUE of all ages (age 4+), and between 'HK3-ag4' and 'HK4-lv4' when using age 4 CPUE. In both cases, the use of CPUE values resolved the poor control with Omega scenarios and showed less inconsistency between stock trends and TAC changes. However, insensitivity or time delay in detection to quick change in direction of trends caused sudden depletion of stock not within 20 year period but within 50 year period. This issue about projection period will be discussed later.

CPUE all ages (age 4+) .vs. CPUE age 4

Majority of exploitation of SBT has occurred before reaching maturity. Combination of long life span, late maturity, and premature harvests makes it extremely difficult to manage this species corresponding to SSB level. Size of SSB has been determined and might be depleted before recruiting to the spawning stock. Then, actions taken corresponding to the SSB decline tends to be too late. One potential way to manage this type of stock is to control harvest level corresponding to recruitments.

Currently, age 4 CPUE is the earliest possible indicator of recruitments available from the operating model. In the real world, despite of long and intensive efforts trying to develop reliable recruitment indices, we are still in a struggling phase. Hopefully, tagging data, and potentially Taiwanese LL2 CPUE, can be utilized to monitor recruitment in addition to age 4 CPUE.

'HK3-ag4', 'HK4-lv4', and 'HK5-hyb' examined potential to use recruitment information to manage SBT stock. So far, the performances of MPs based on recruitment information are not discriminatory from those based on CPUE of all ages. Because of time limitation, our exploration with this option is just at an initiation stages and we plan to explore further to use recruitment information for adjustment in TAC allocation among fisheries as the next step.

Composite approaches

Through exploration process, we have recognized that at least two or more indicators are needed to grasp key characteristics of stock behaviors. Then, several composite MPs of two components were explored including 'HStnk', 'HK5-hyb', and 'STlv1.1'.

So far, two types of approaches are taken, linear weighted addition ('HStnk') and minimum TAC approach ('HK5-hyb', and 'STlv1.1'). When appropriate components and weightings are chosen, both approaches seem work fine. This is one area we intend to put our efforts in the next phase.

Drastic depletion after 20 years' projection

Fig.2 shows one example showing perfectly reasonable performance during 20 years projection but showing drastic depletion afterwards. Fig. 3 shows an opposite example that seems hopeless when looking only 20 year period but start recovering afterwards. Twenty years is long time from fishery management prospect, but it also should be noted that period is shorter than even one generation of SBT. In order to prevent unexpected surprise, we propose to check with 50 years deterministic projection for MP passed through the first selection.

References

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Hiramatsu, K., T.Itoh, H.Kurota, H.Shono, N.Takahashi, S.Tsuji 2003. Results of the initial exploration of potential Management Procedures based on the CPUE index., CCSBT-MP/0304/11.

Kurota, H., H. Shono, N. Takahashi, K.Hiramatsu, S.Tsuji, 2003, Some consideration toward the selection of a management procedure., CCSBT-ESC/0309/41.

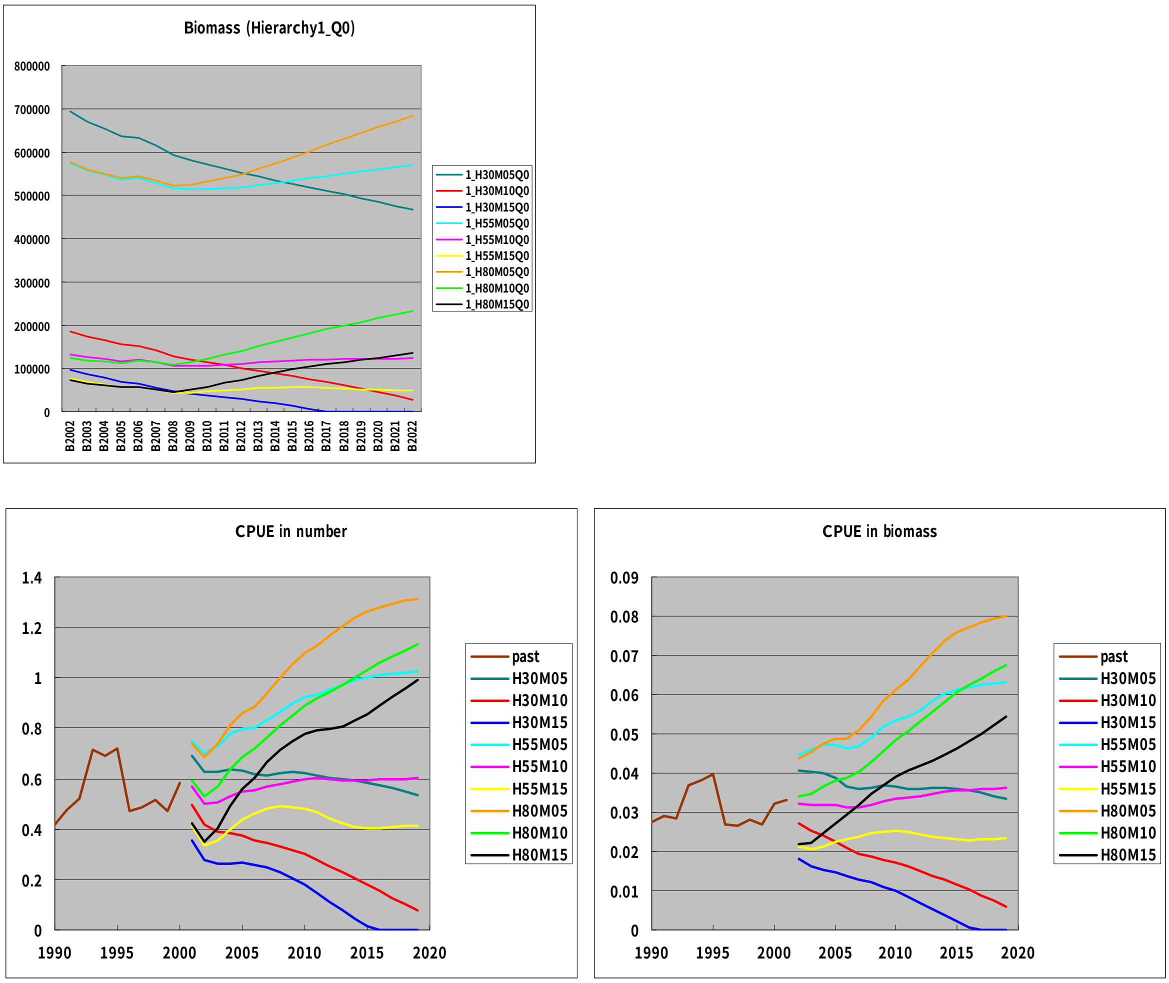


Fig. 1 Comparison of trends among SSB, CPUE in number and CPUE in weight.

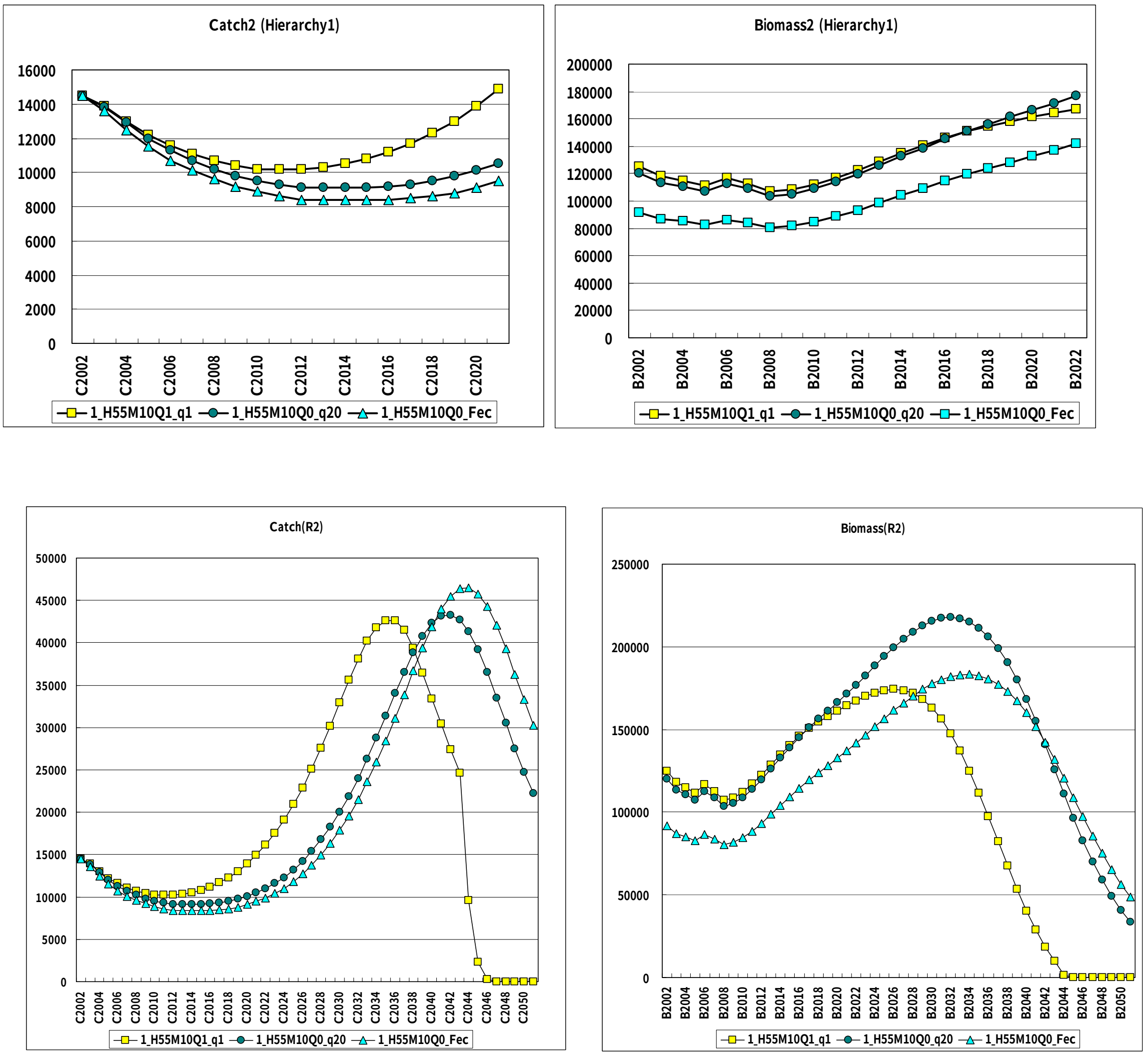


Fig. 2 Example of different performance according to projection period - 1: The case with reasonable performance within 20 years but drastic changes afterwards.

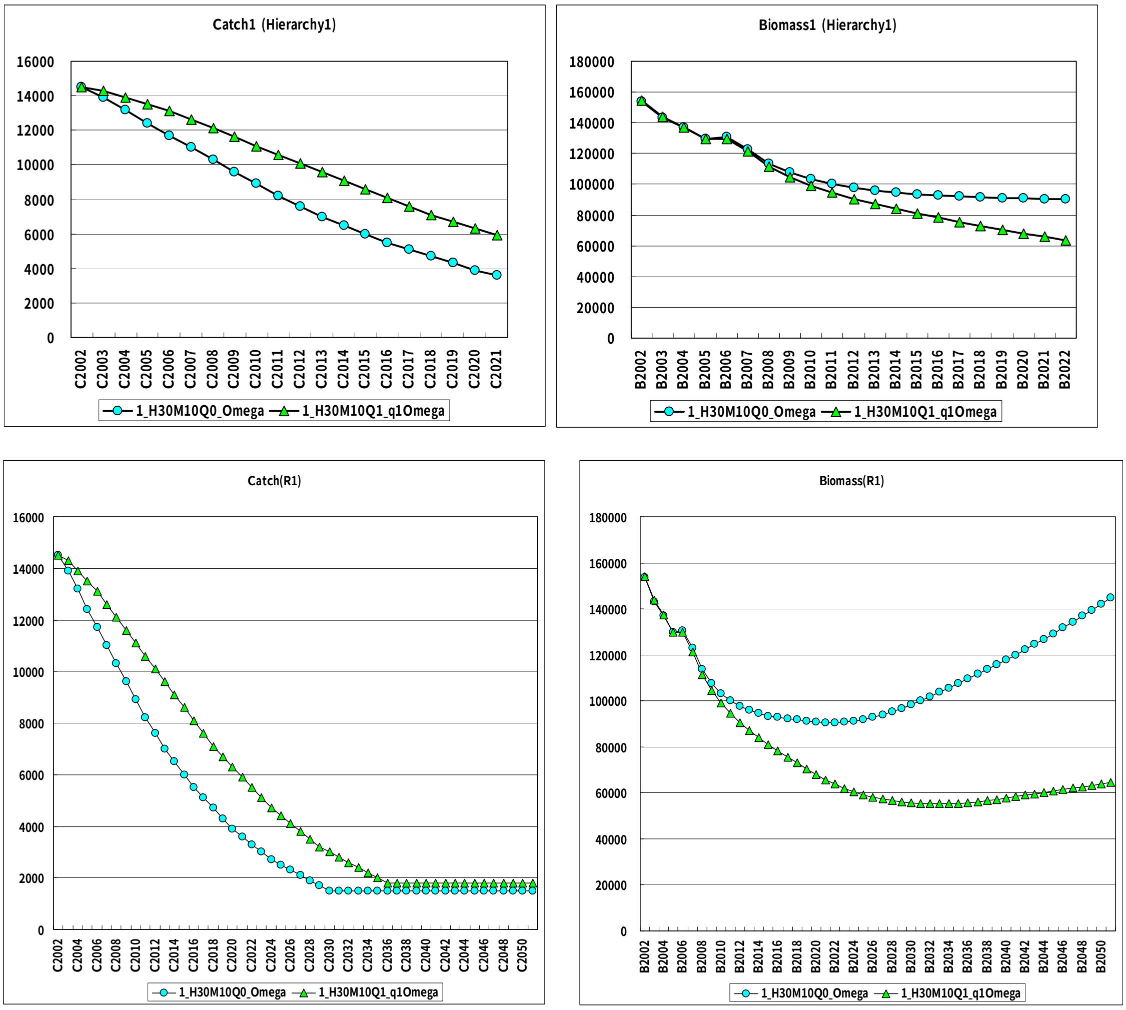
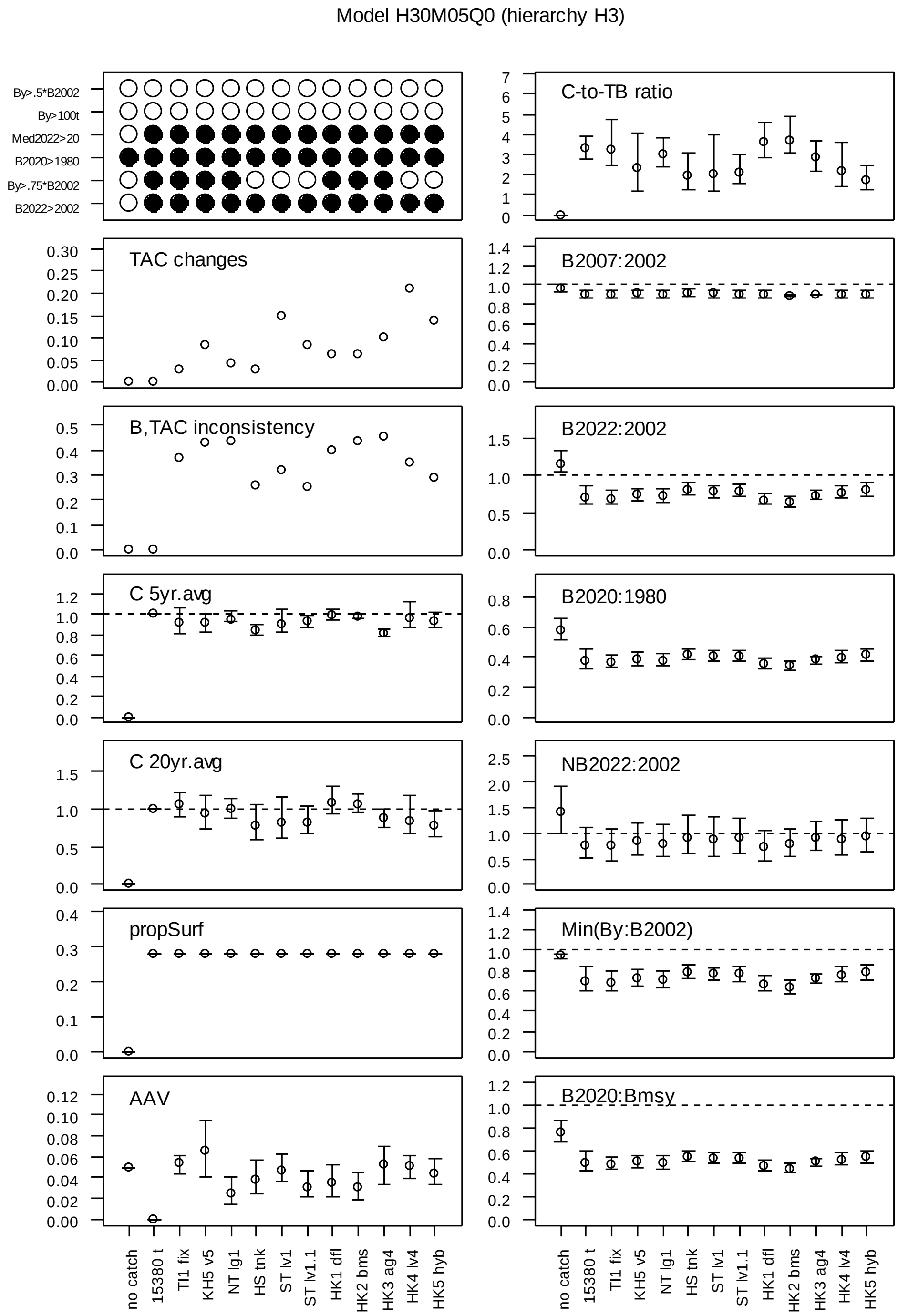


Fig. 3 Example of different performance according to projection period - 2: The case with poor performance within 20 years but getting better afterwards.

Appendix 1. Graphical comparison of reference set.



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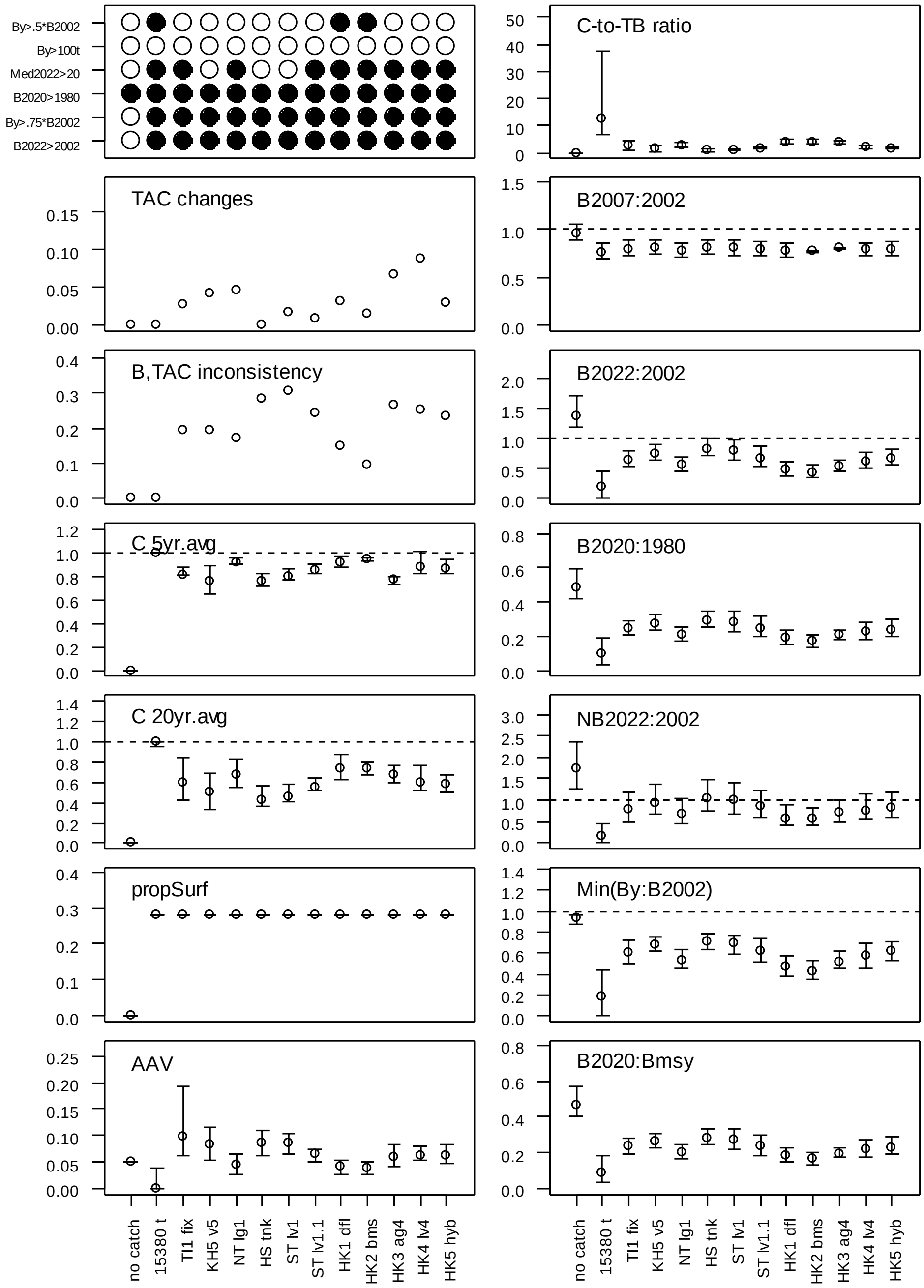

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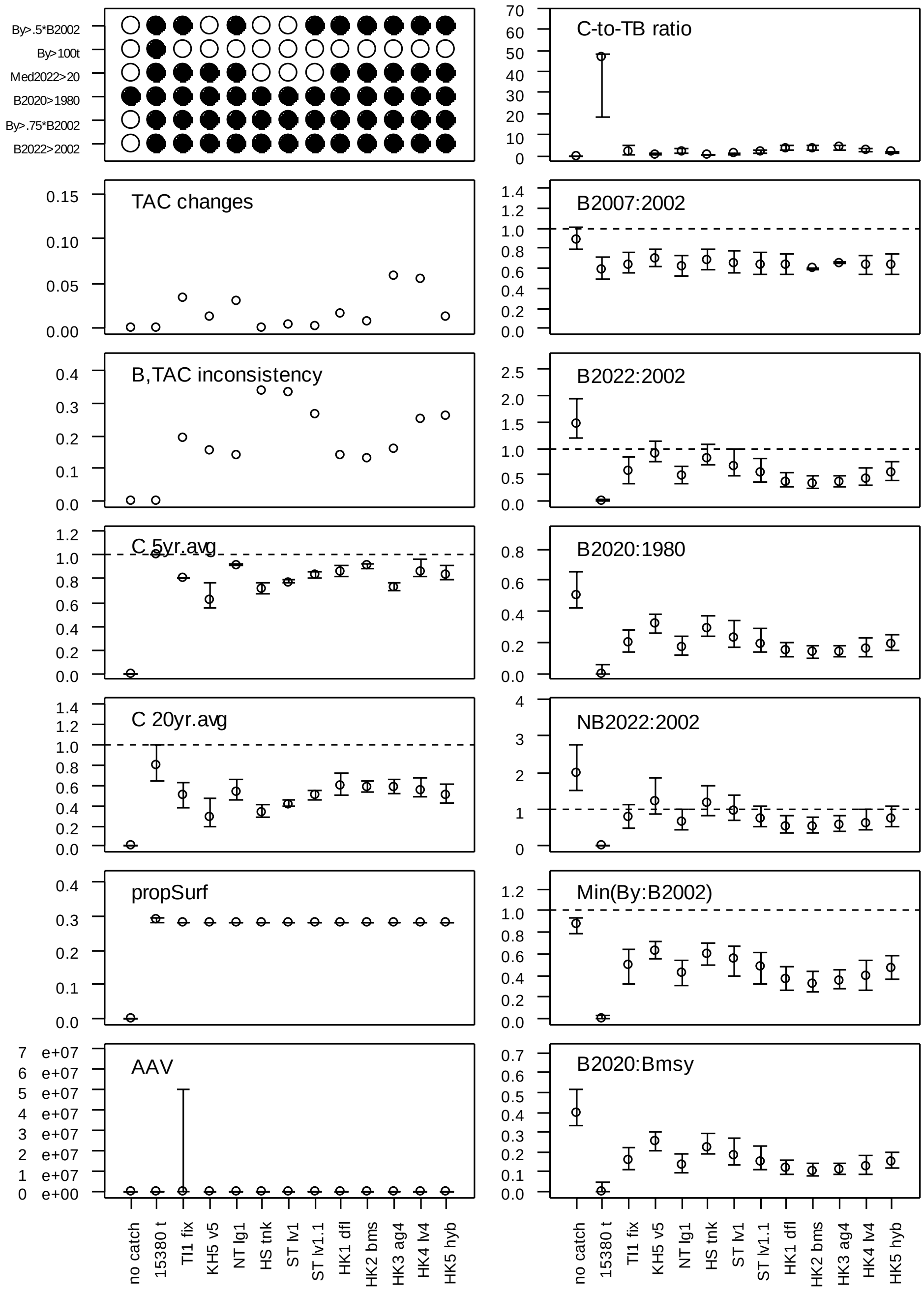

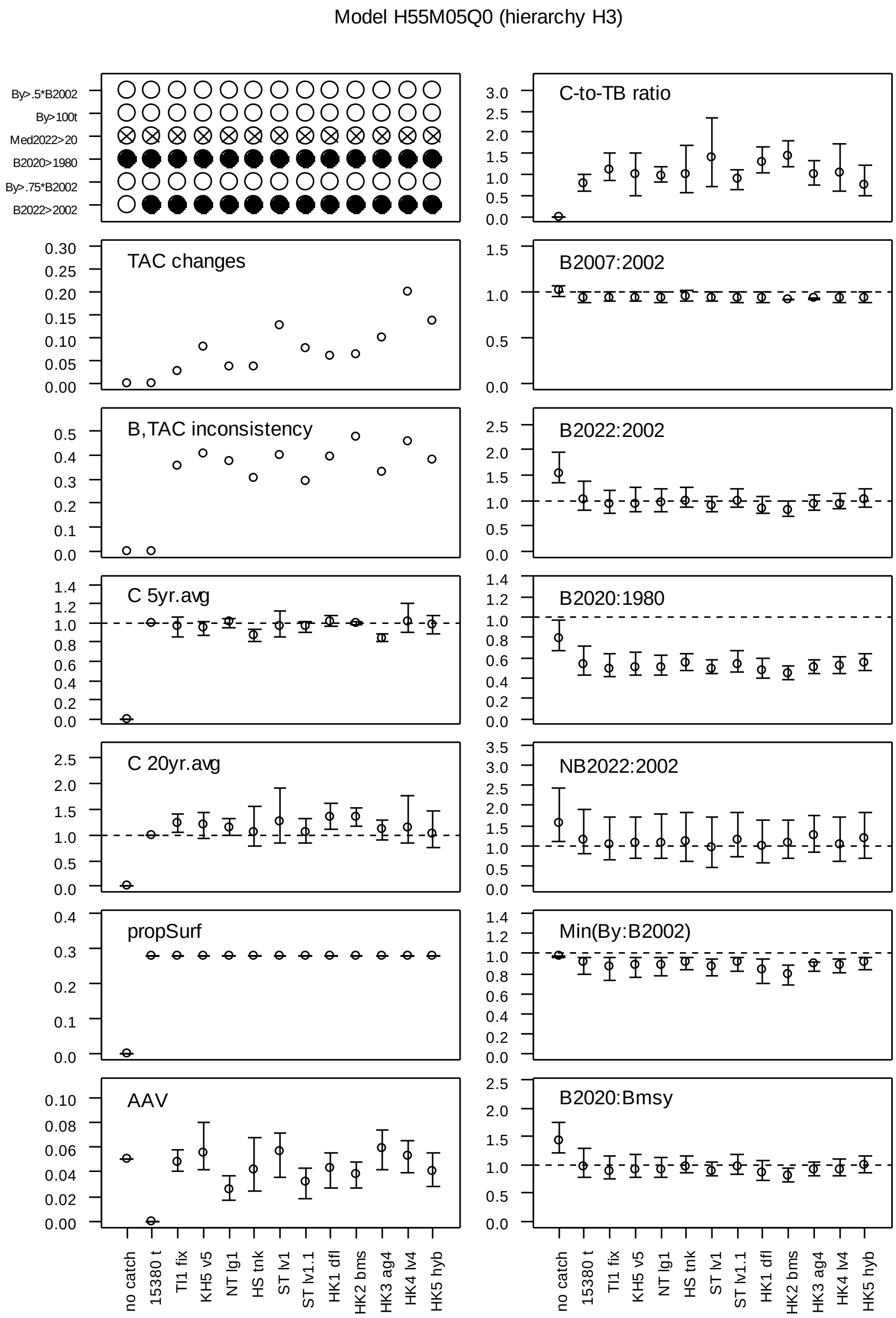
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Med2022>20
B2020>1980
By>.75*B2002
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C-to-TB ratio
TAC changes
B2007:2002
B,TAC inconsistency
B2022:2002
C 5yr.avg
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C 20yr.avg
NB2022:2002
propSurf
Min(By:B2002)
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no catch
15380 t
TI1 fix
KH5 v5
NT lg1
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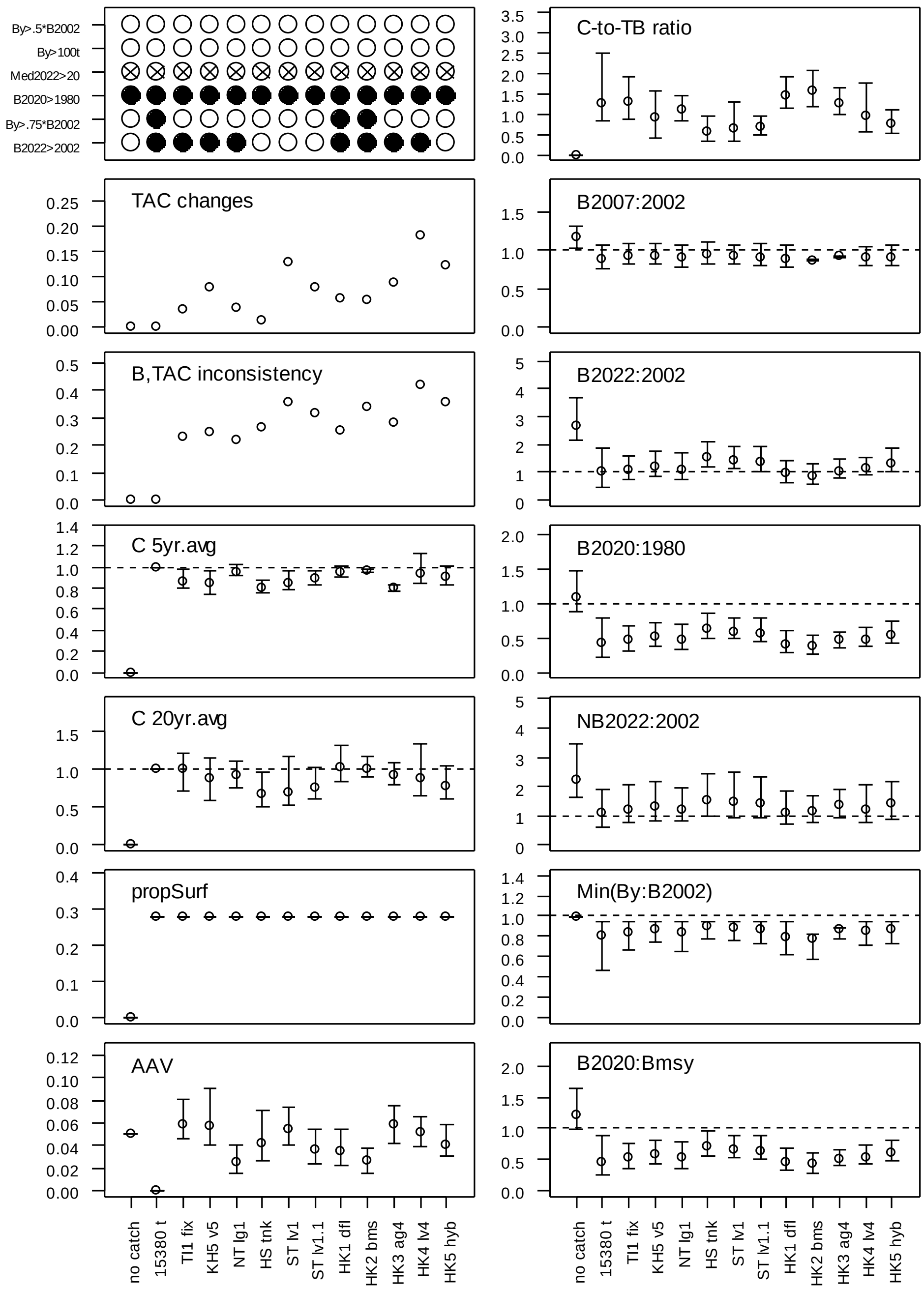

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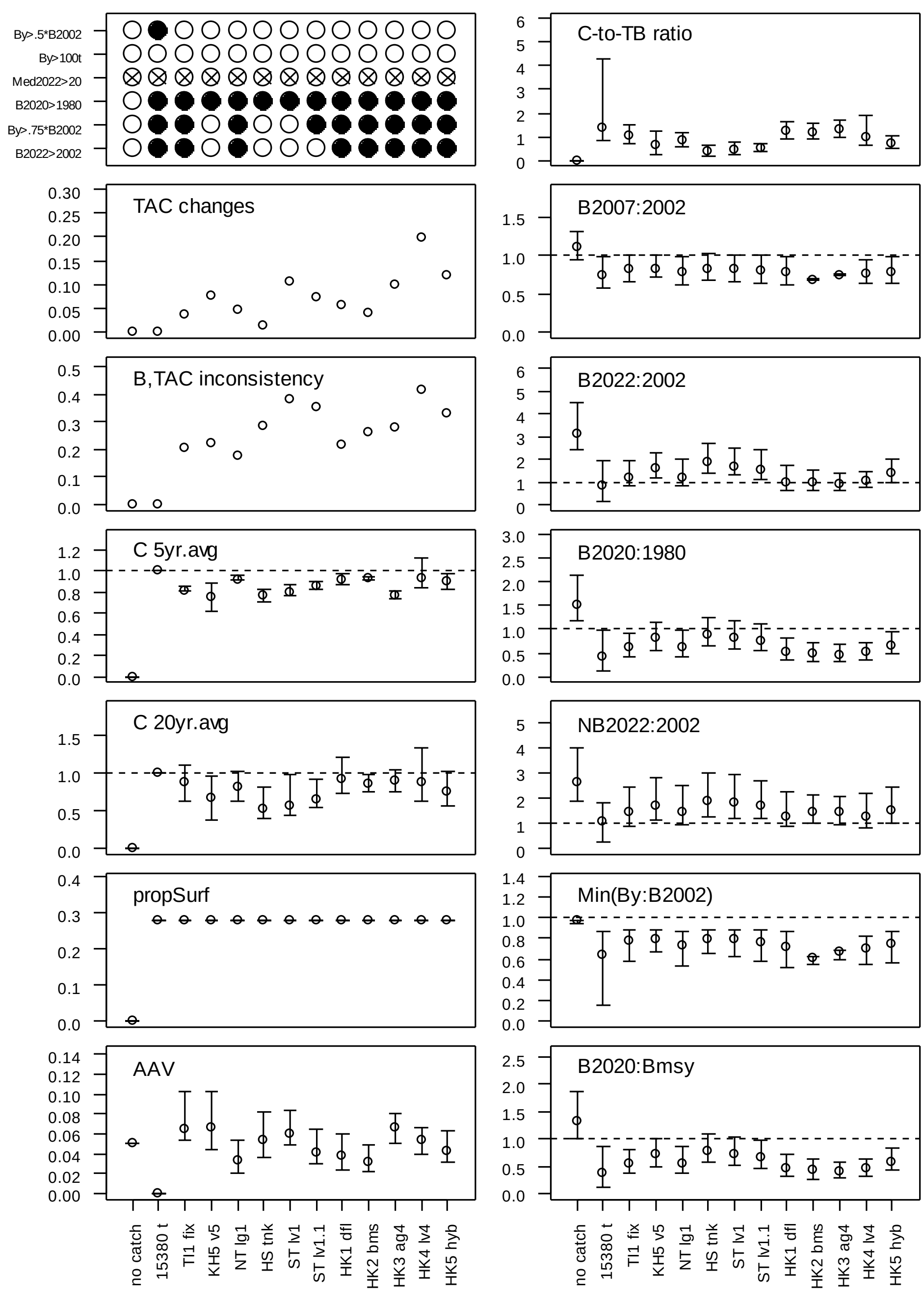

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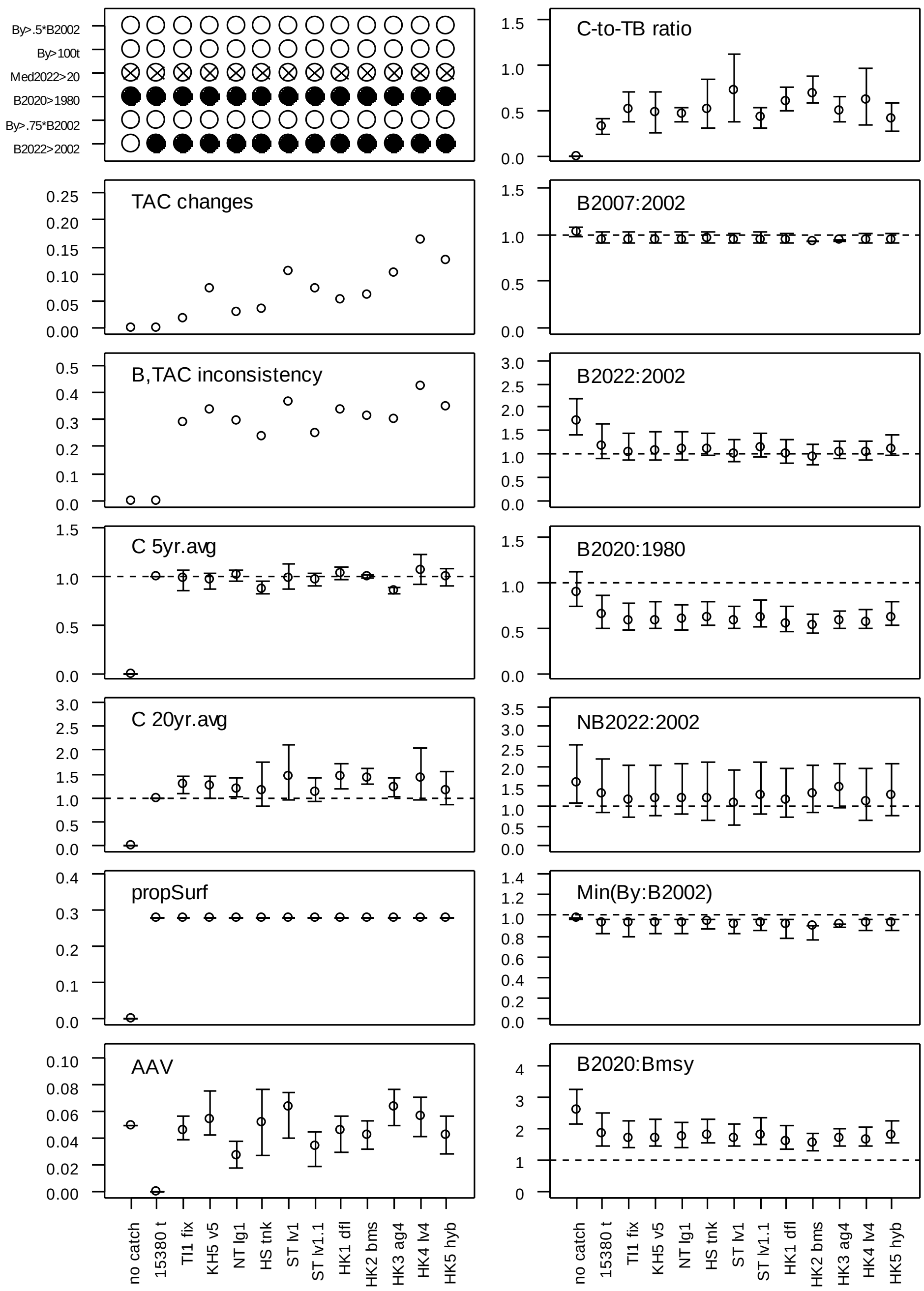

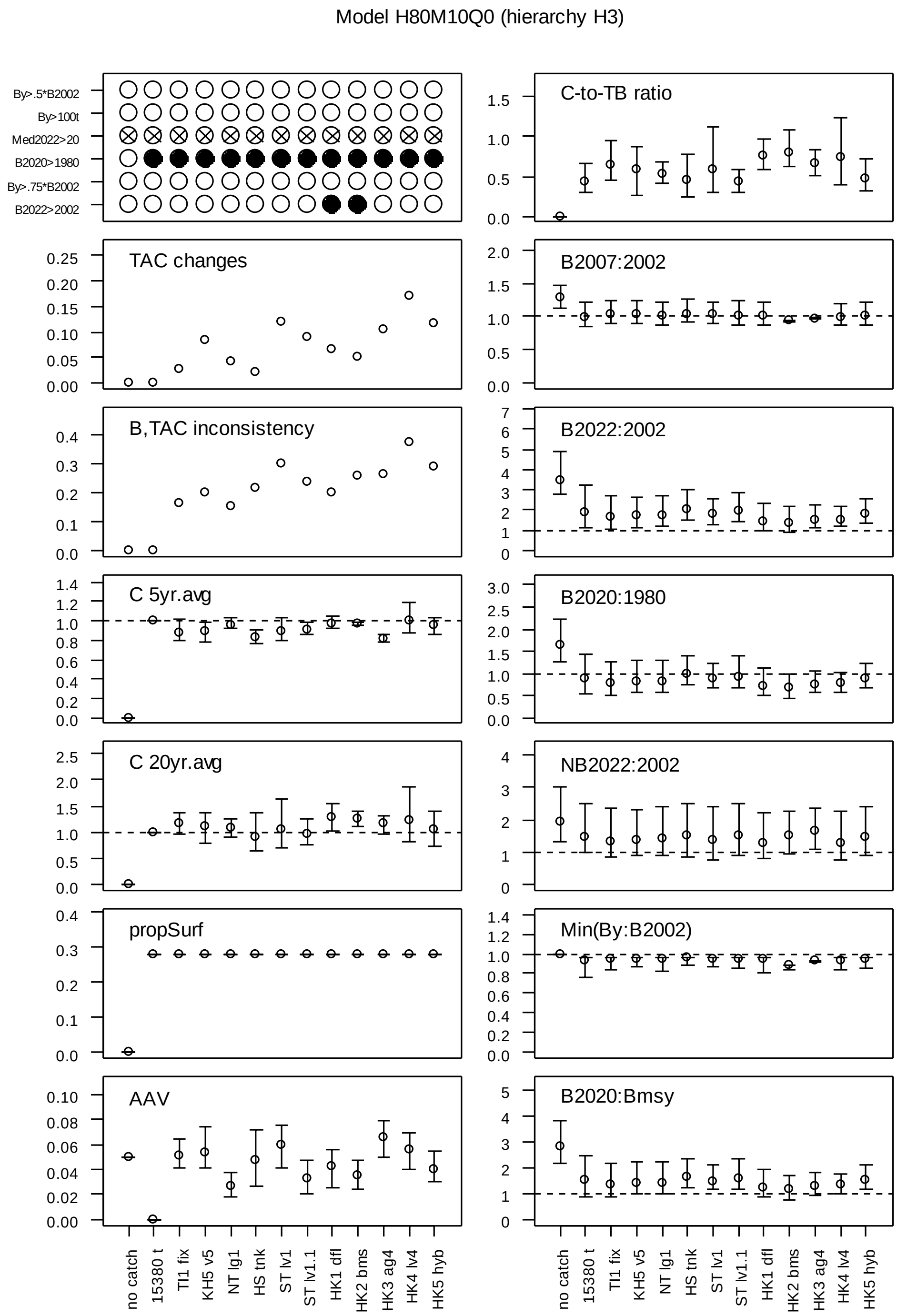
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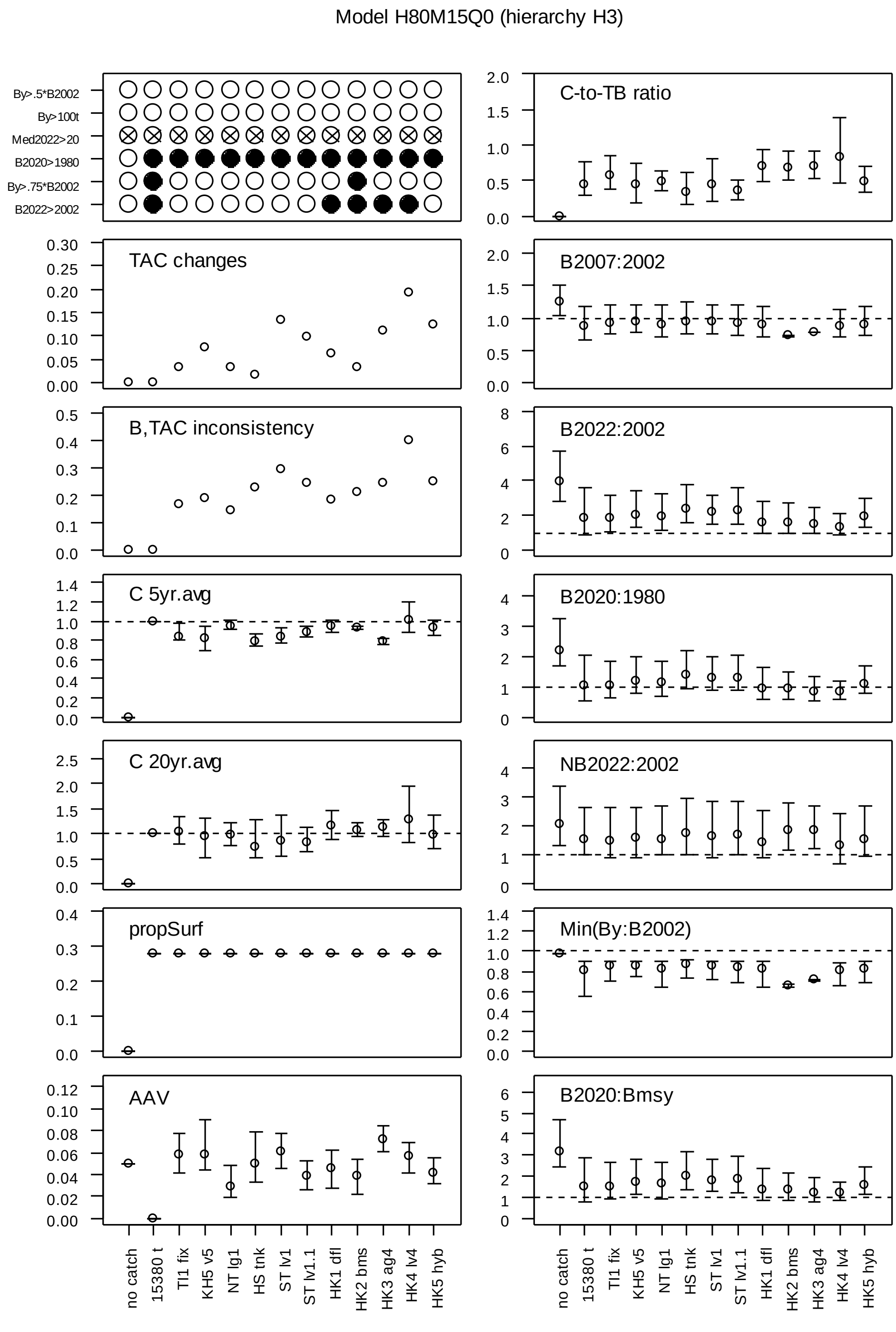
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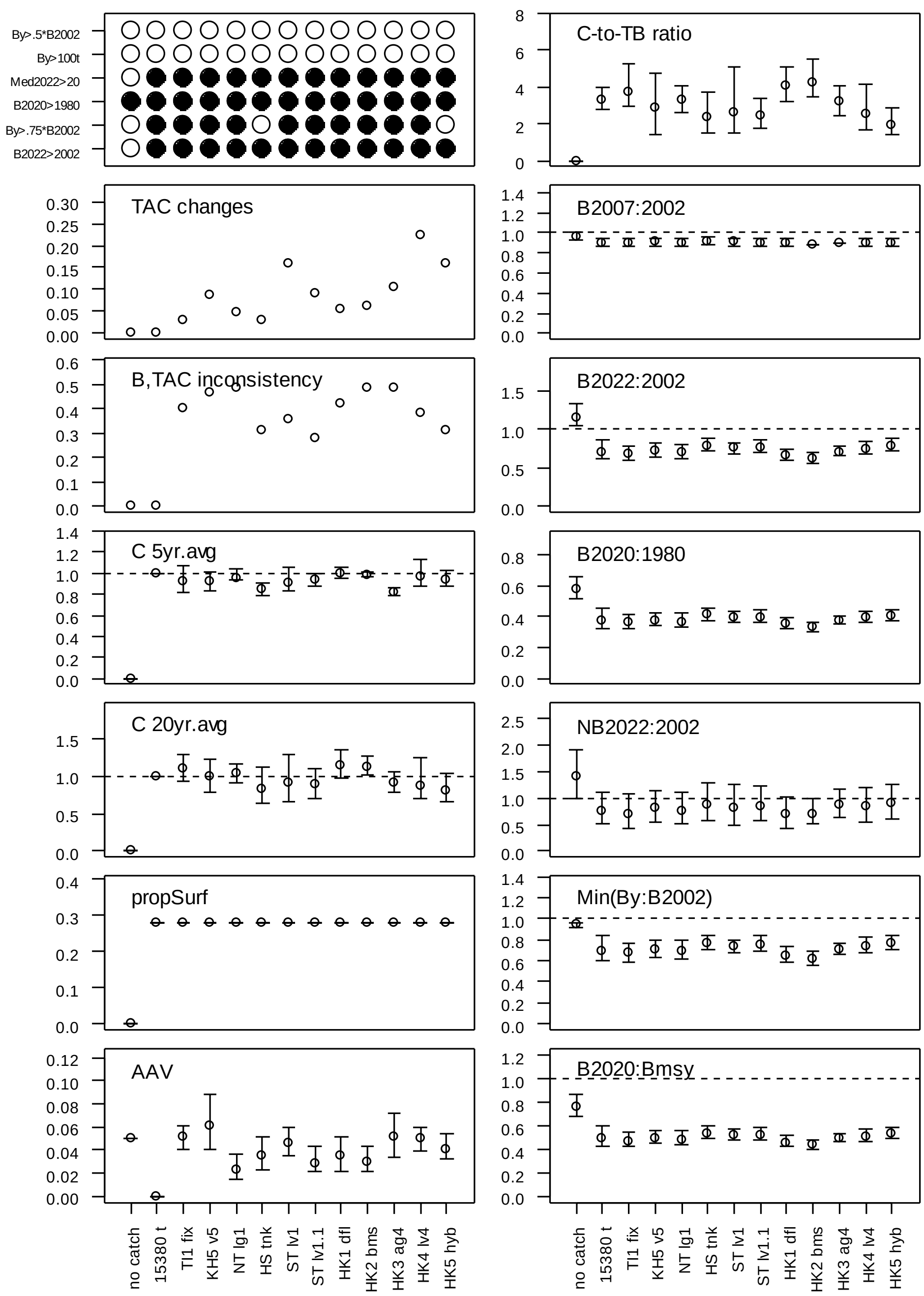

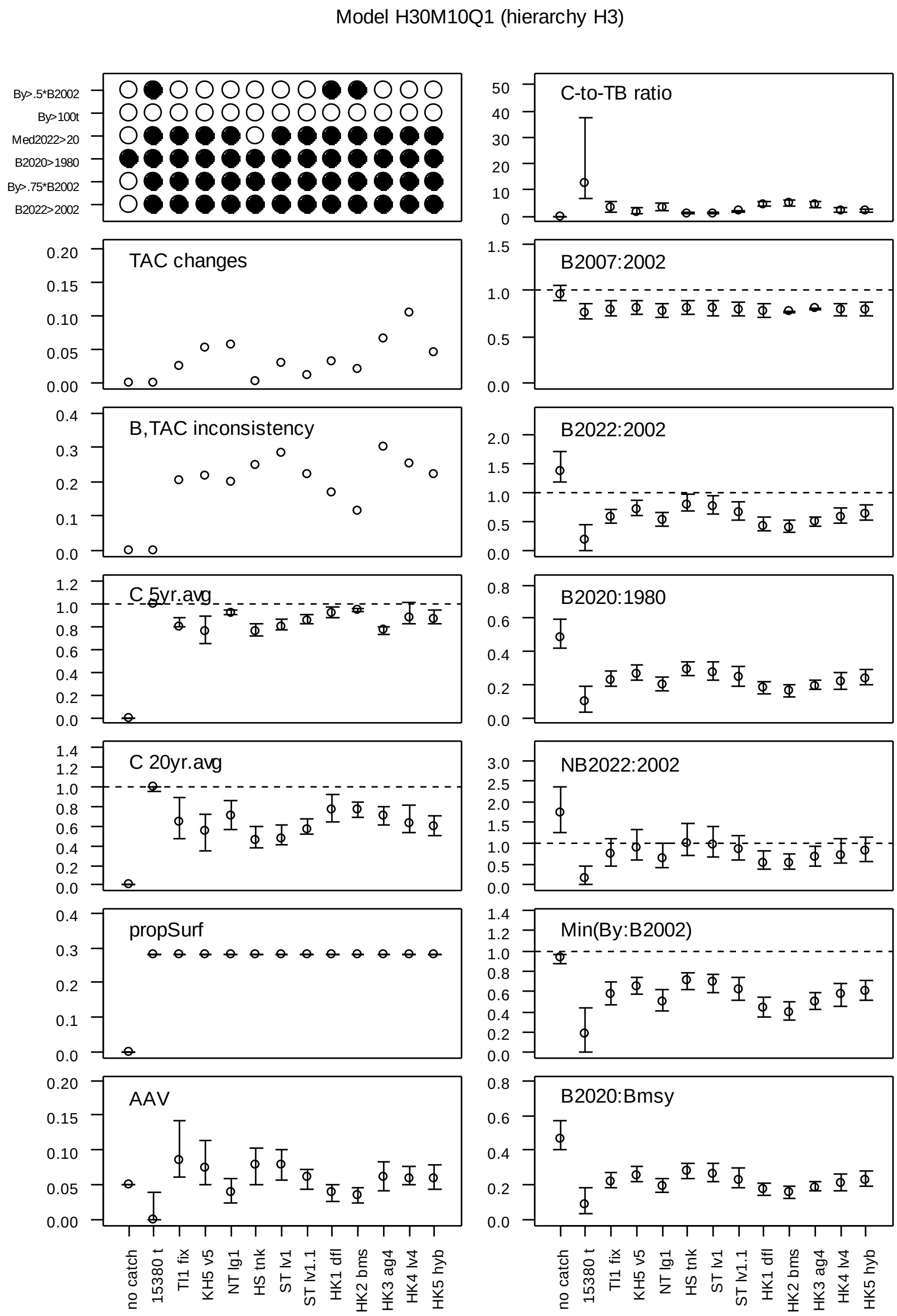
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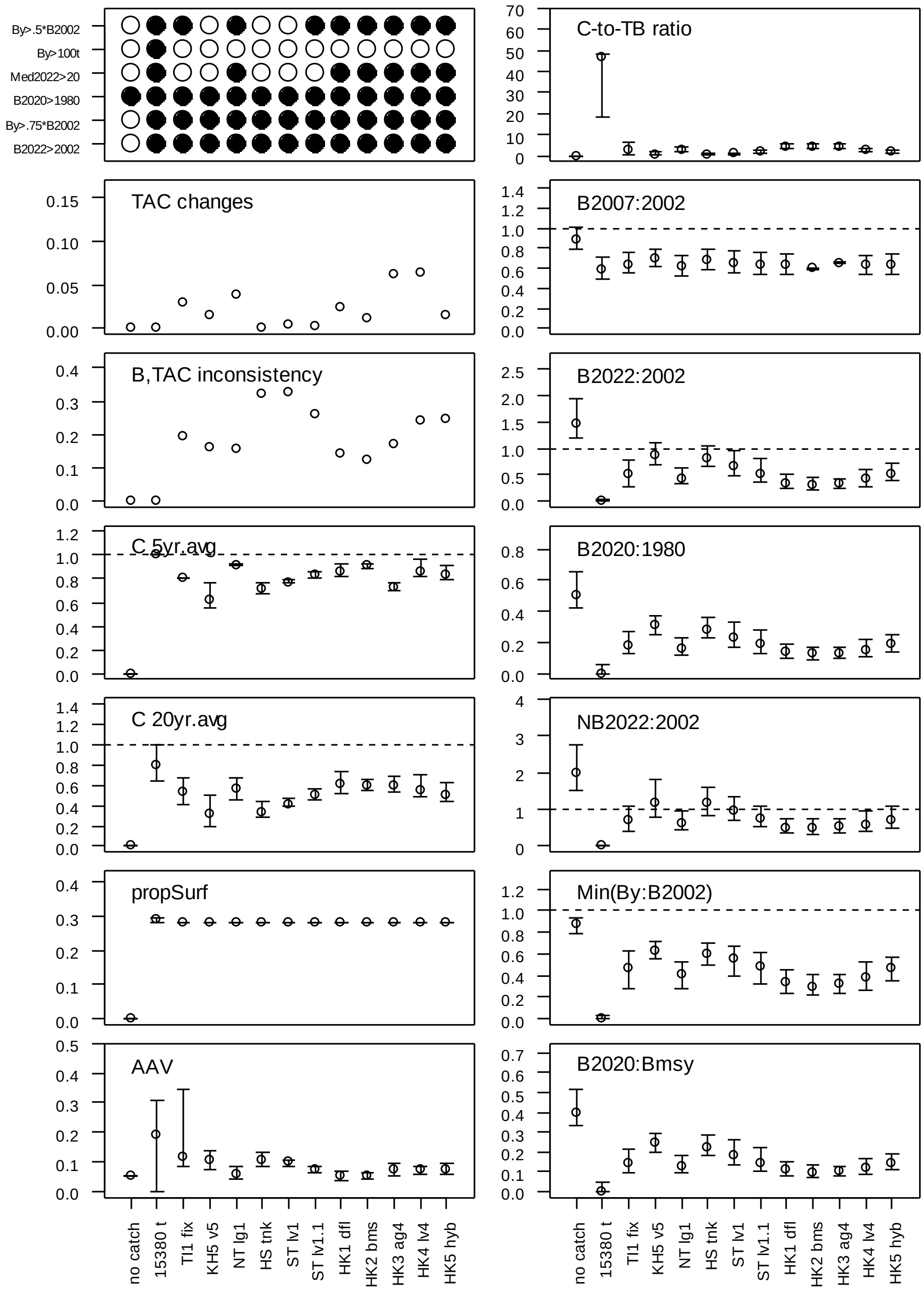

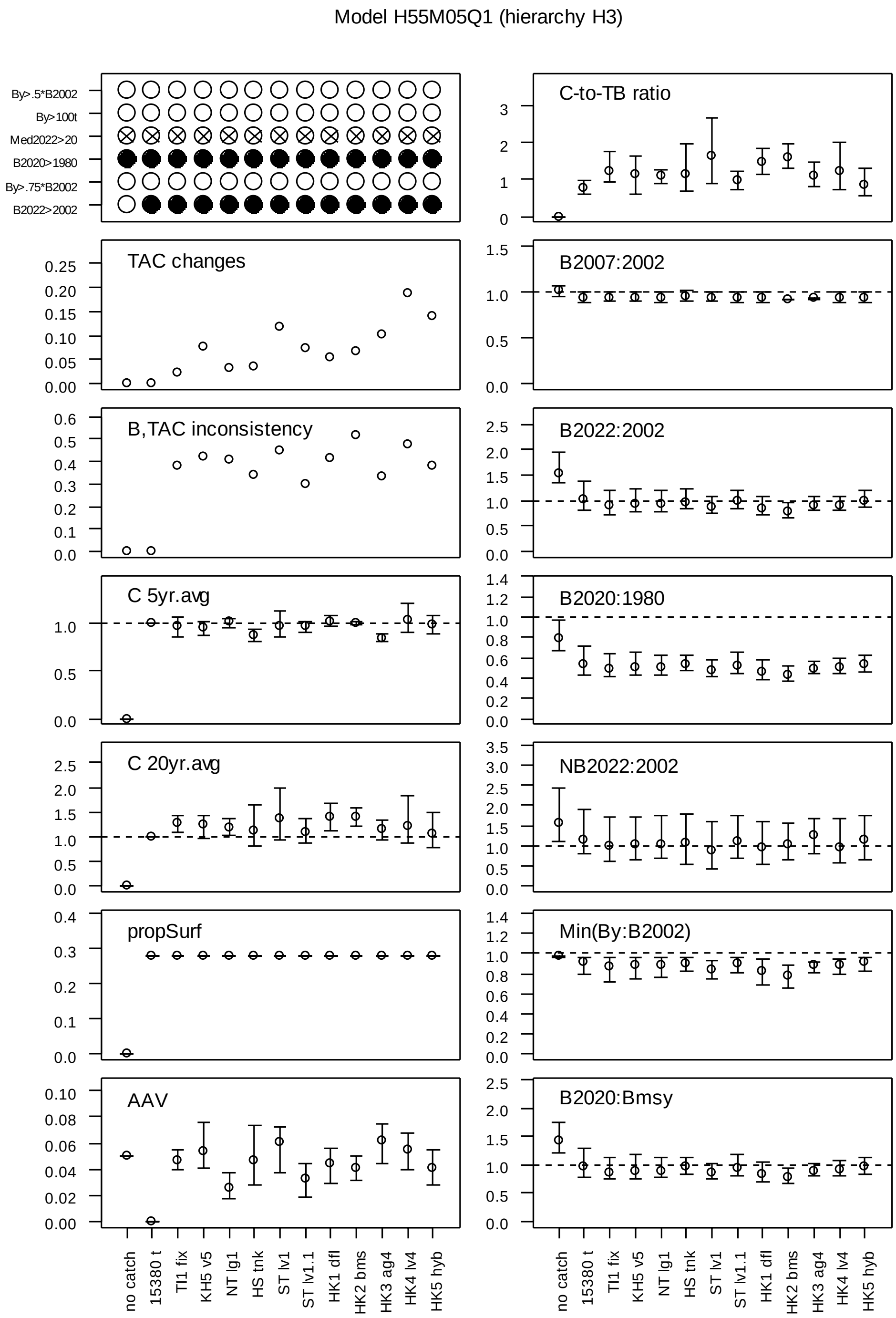
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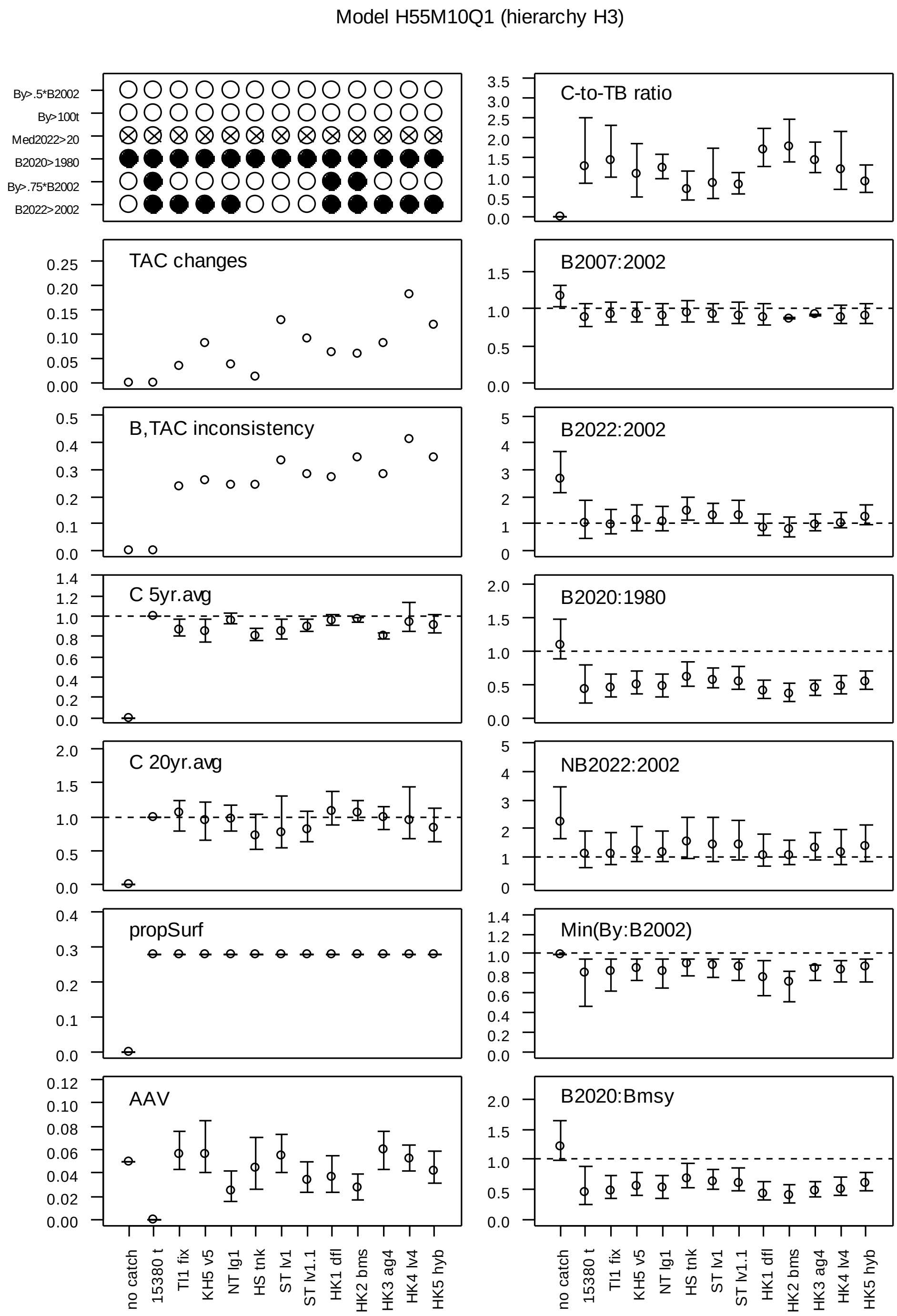
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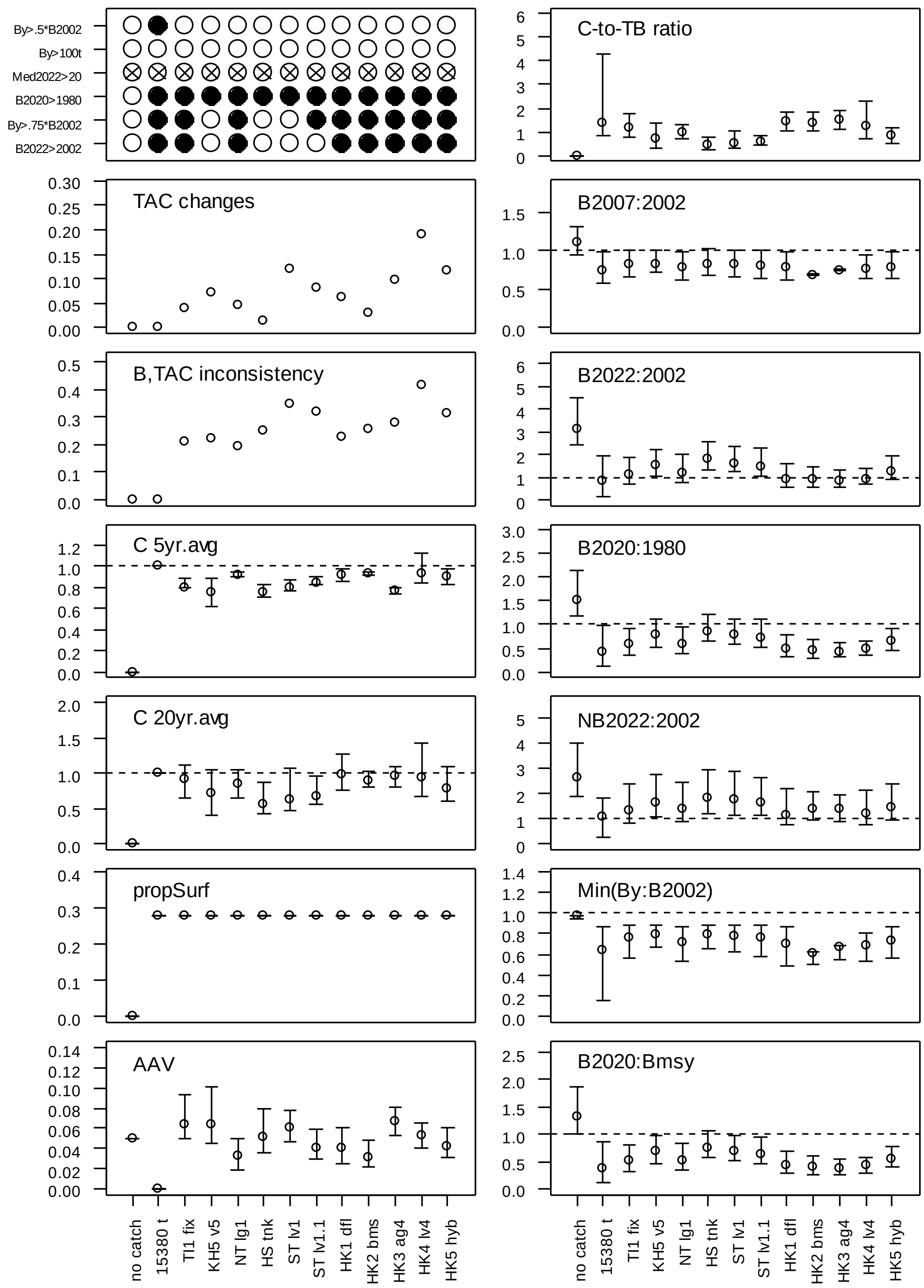

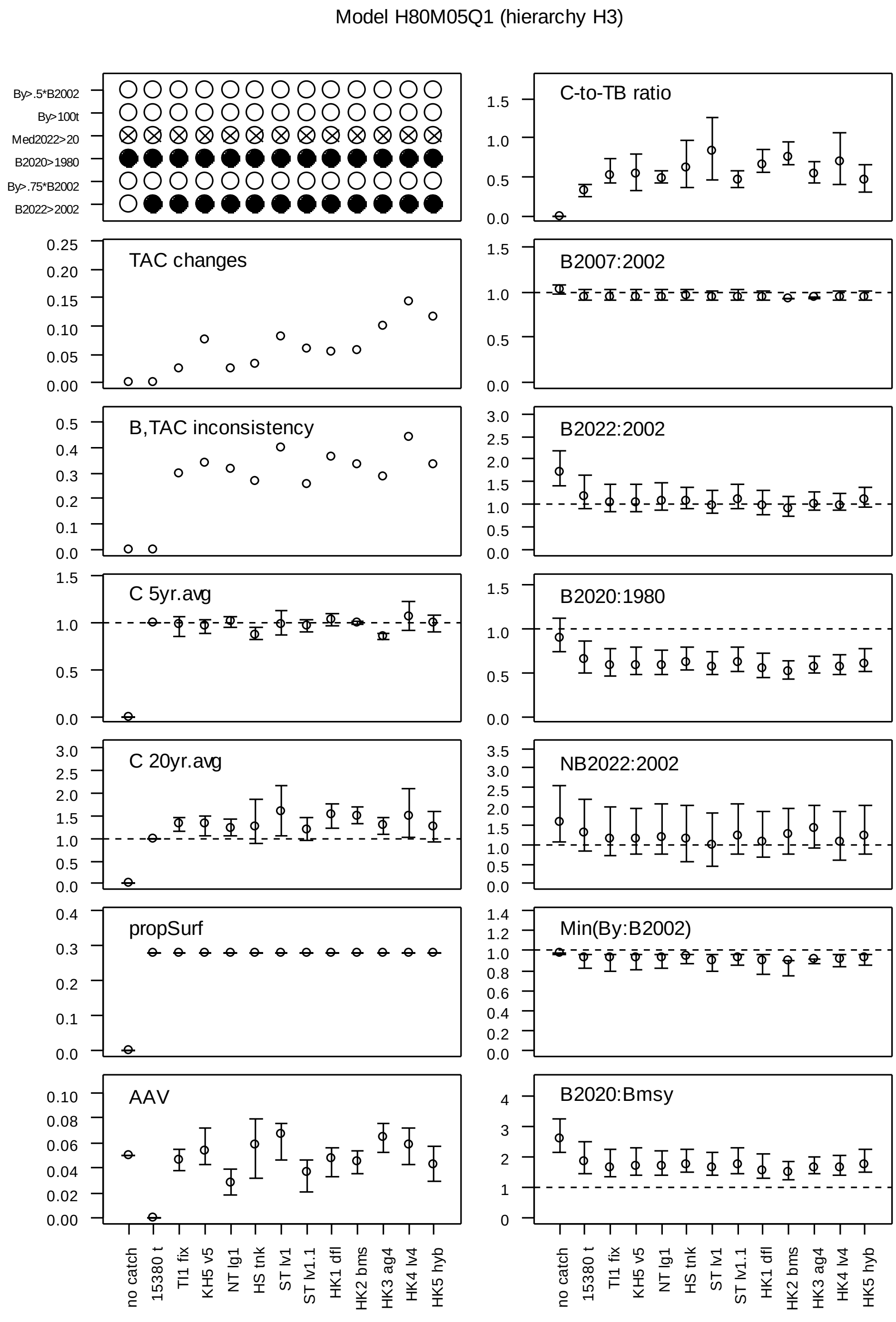
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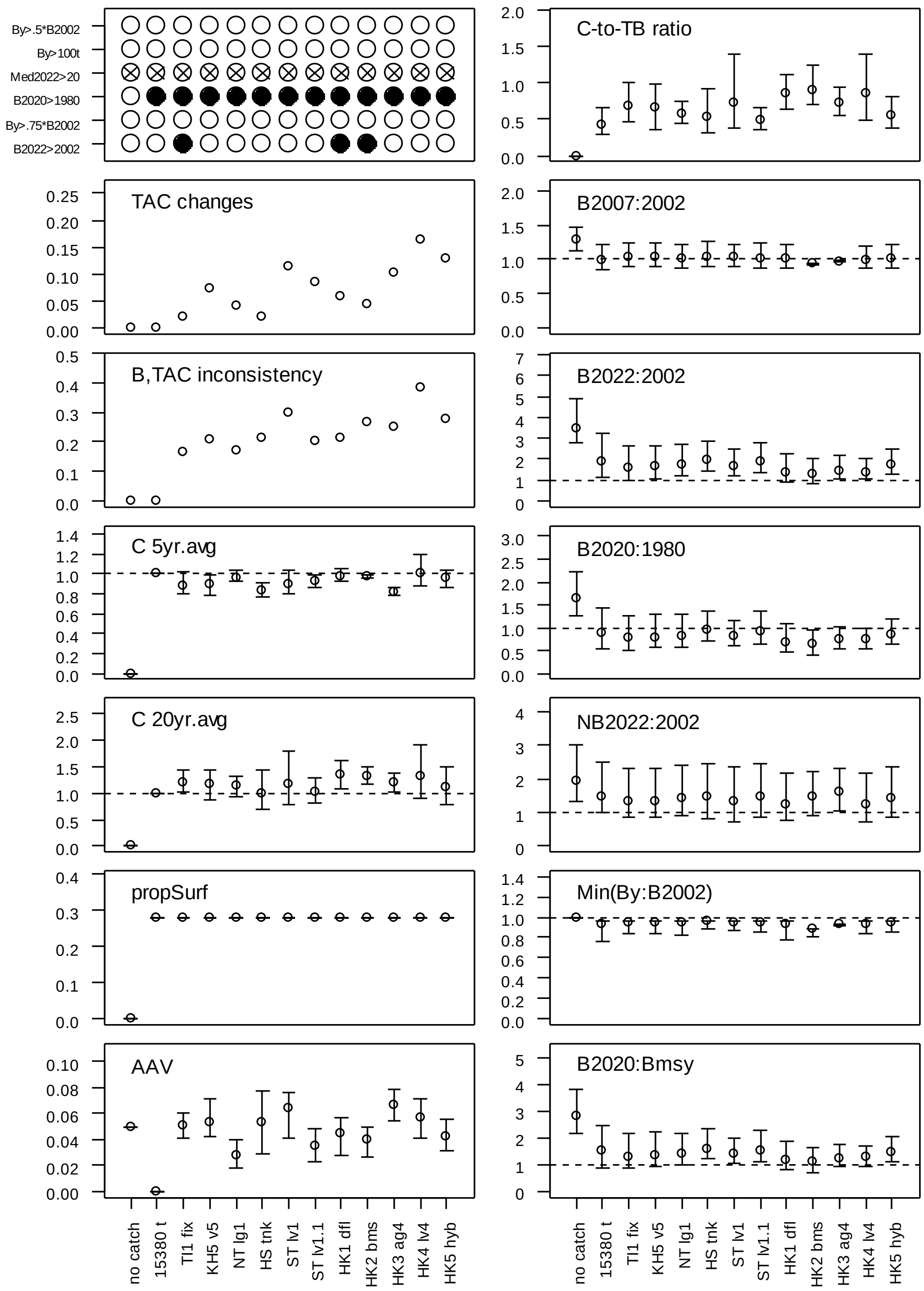

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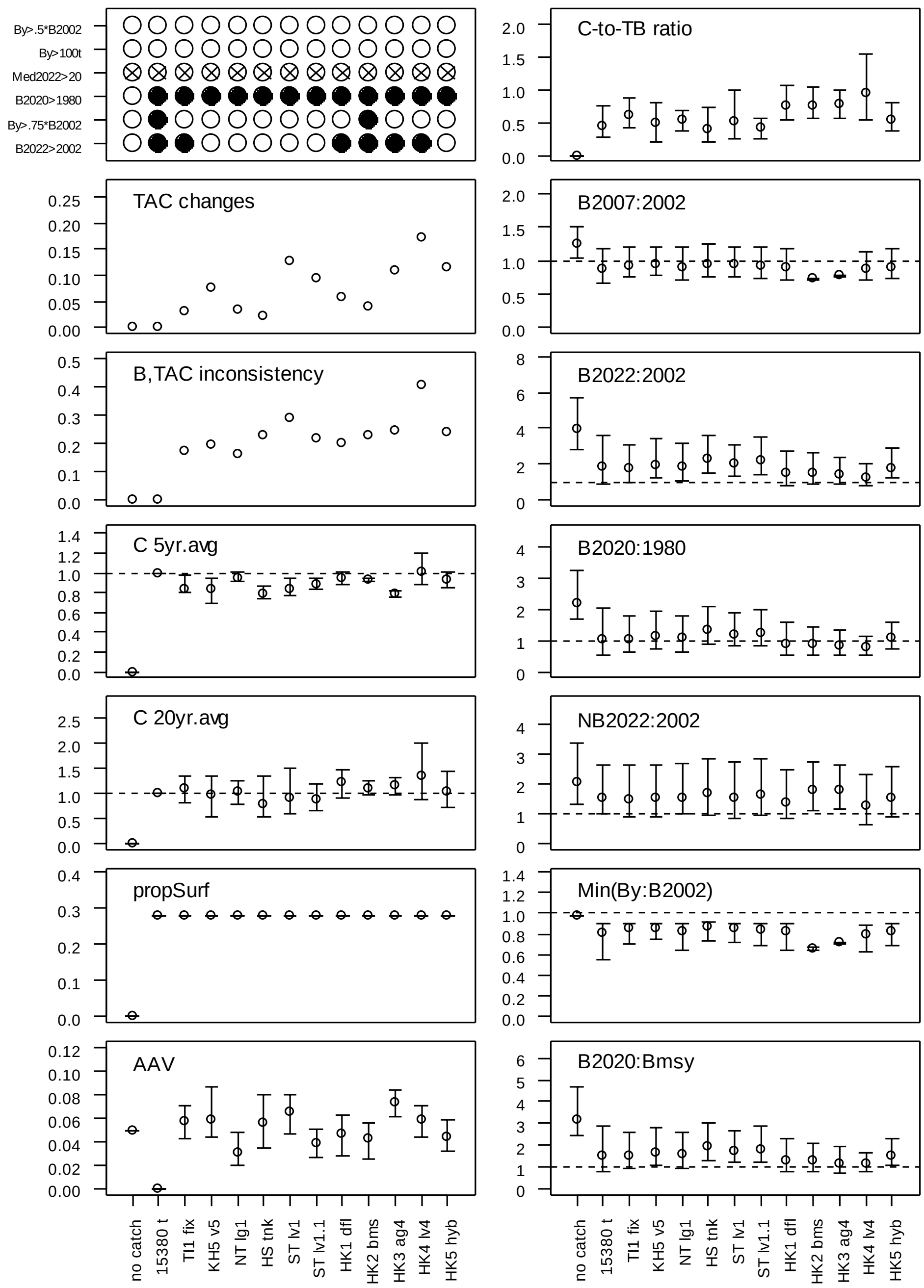

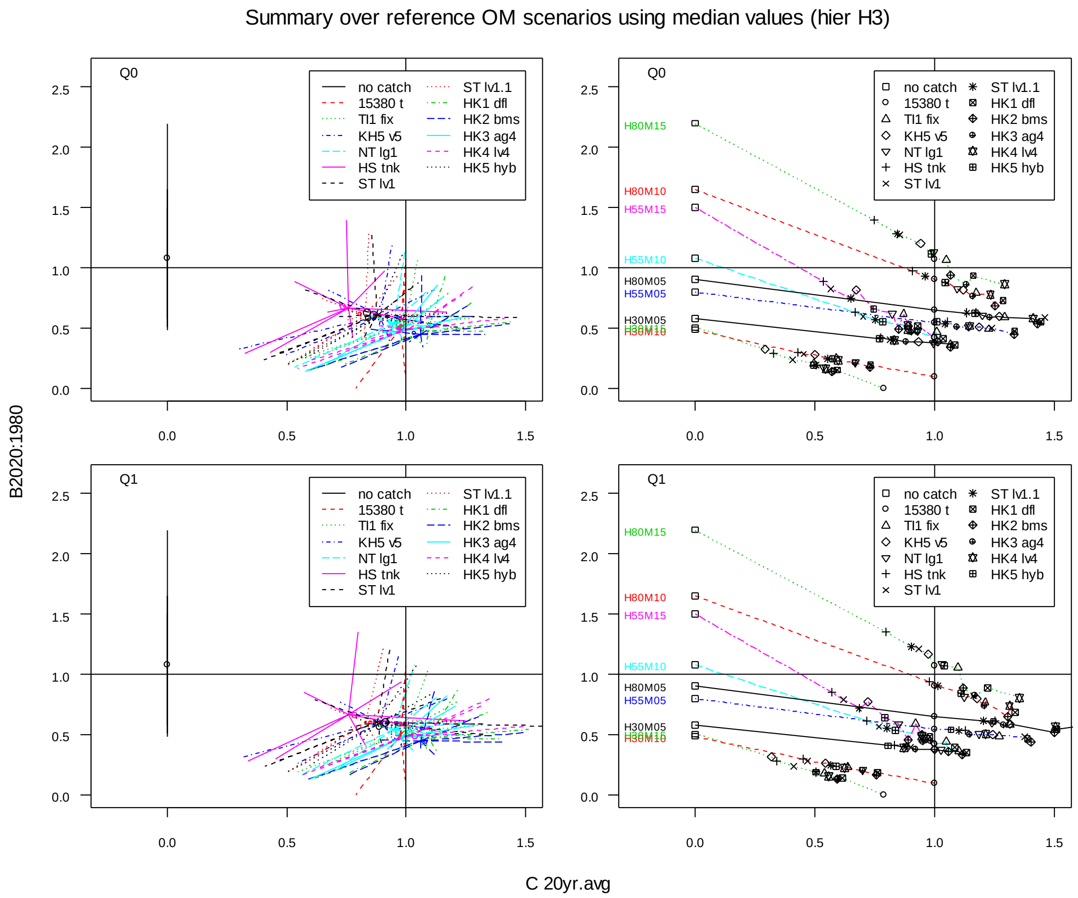
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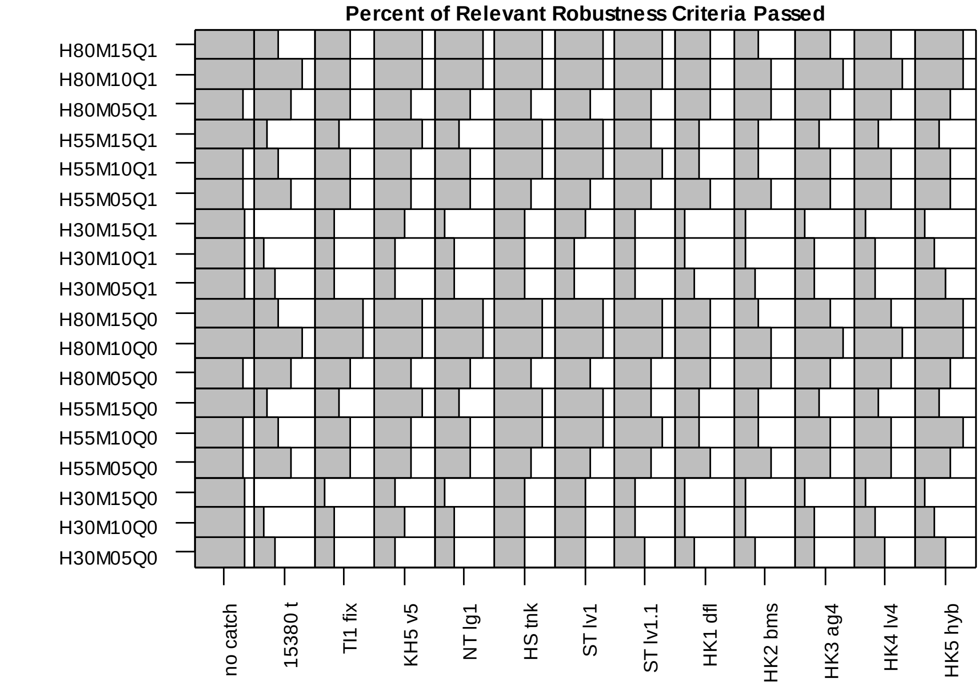
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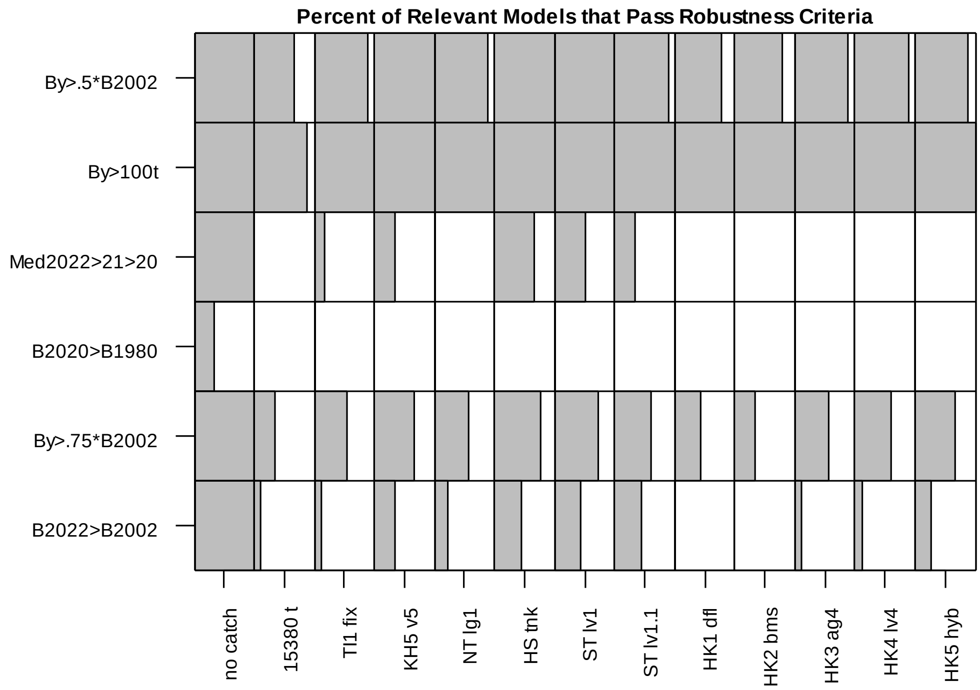
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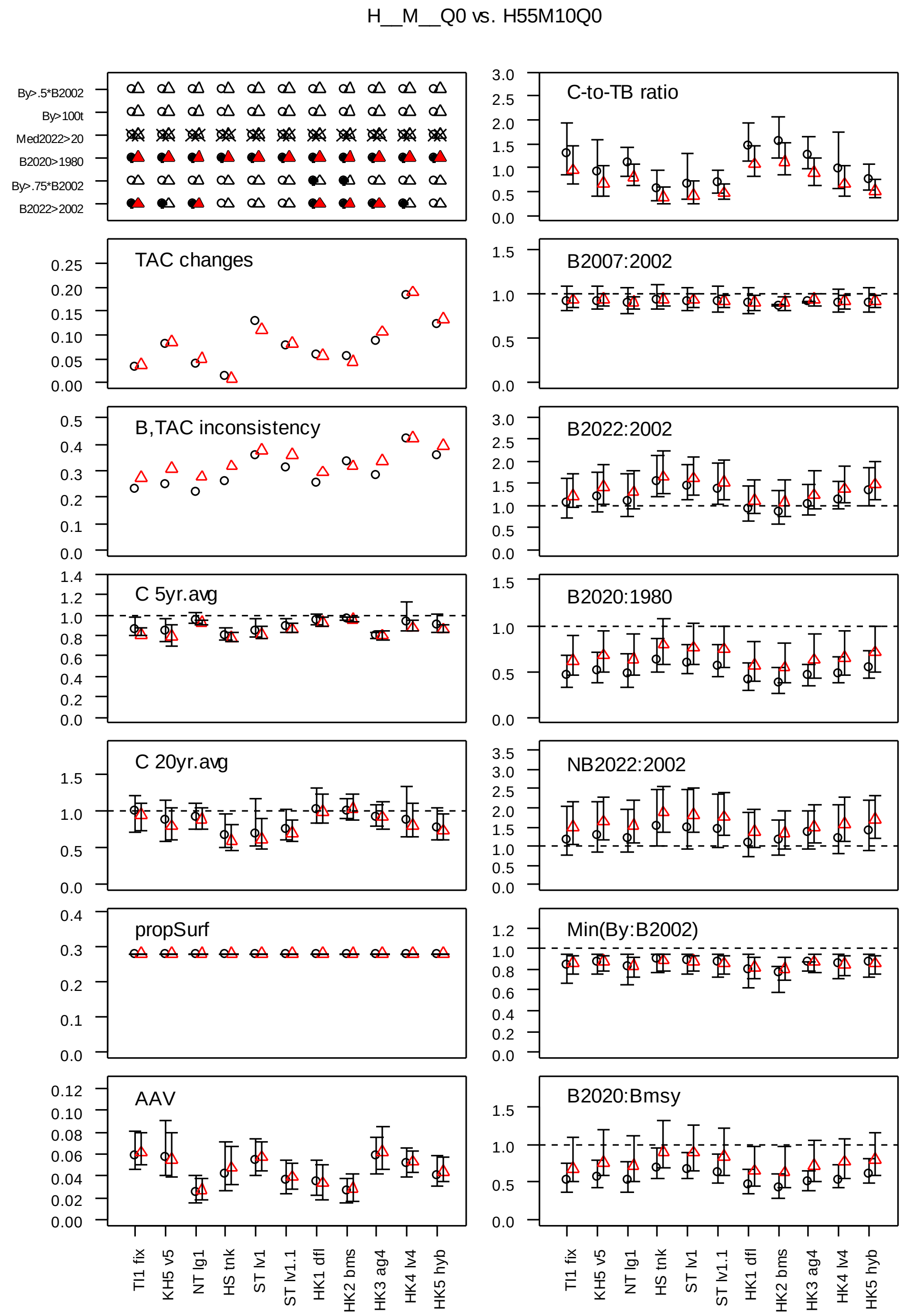
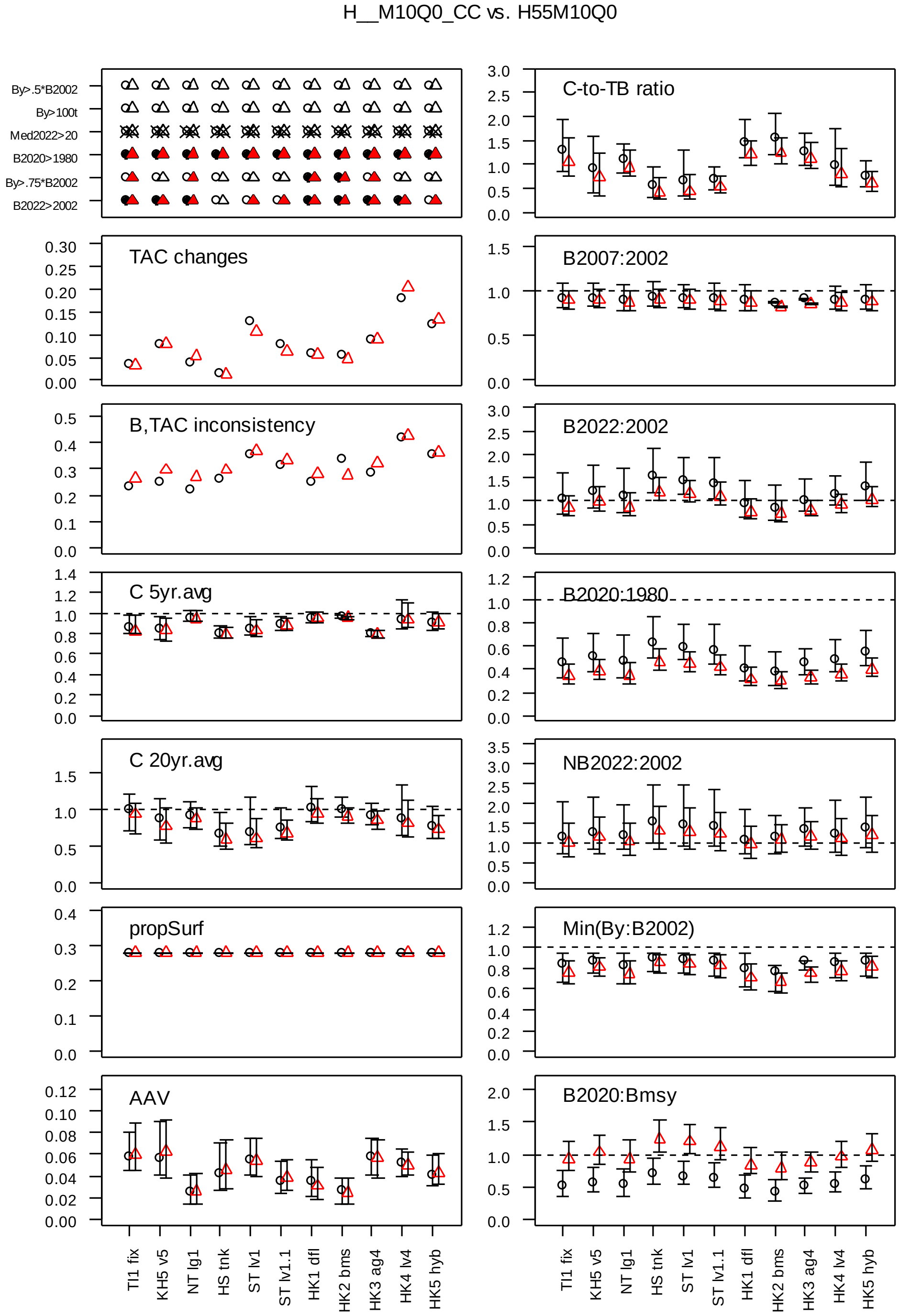
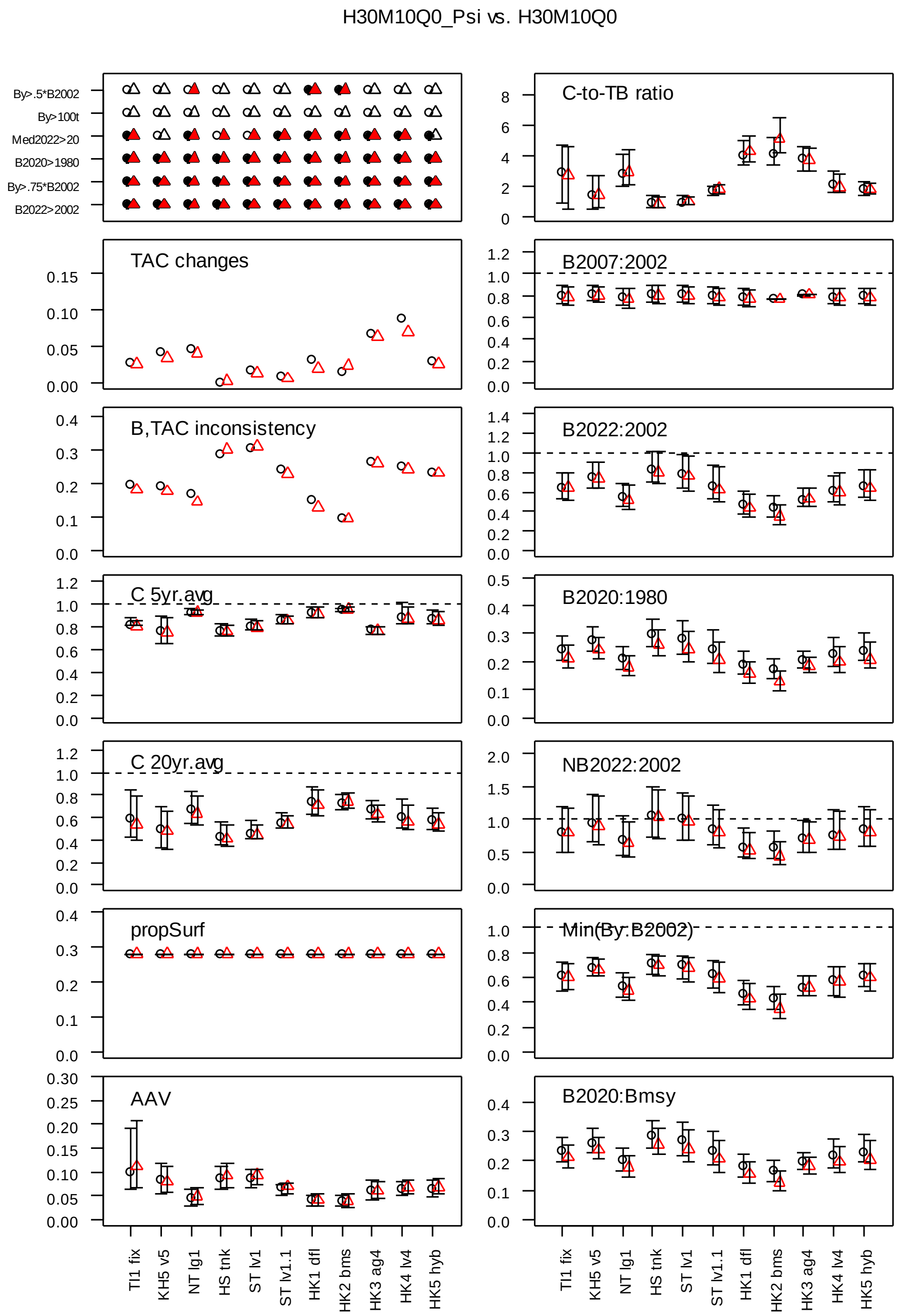
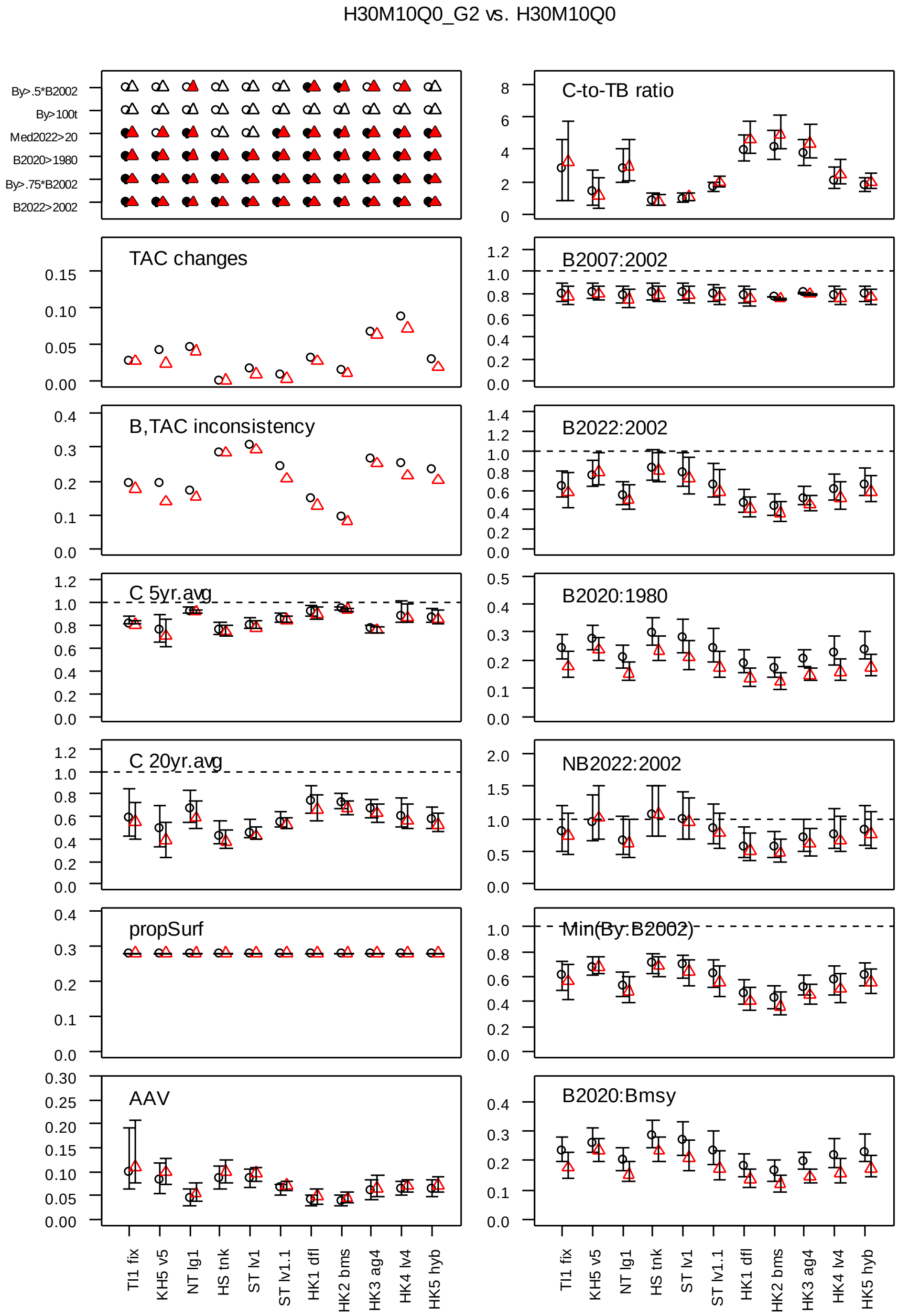
ST lv1.1
HK1 dfl
HK2 bms
HK3 ag4
HK4 lv4
HK5 hyb

Appendix 2. Graphical comparison of robustness sets.

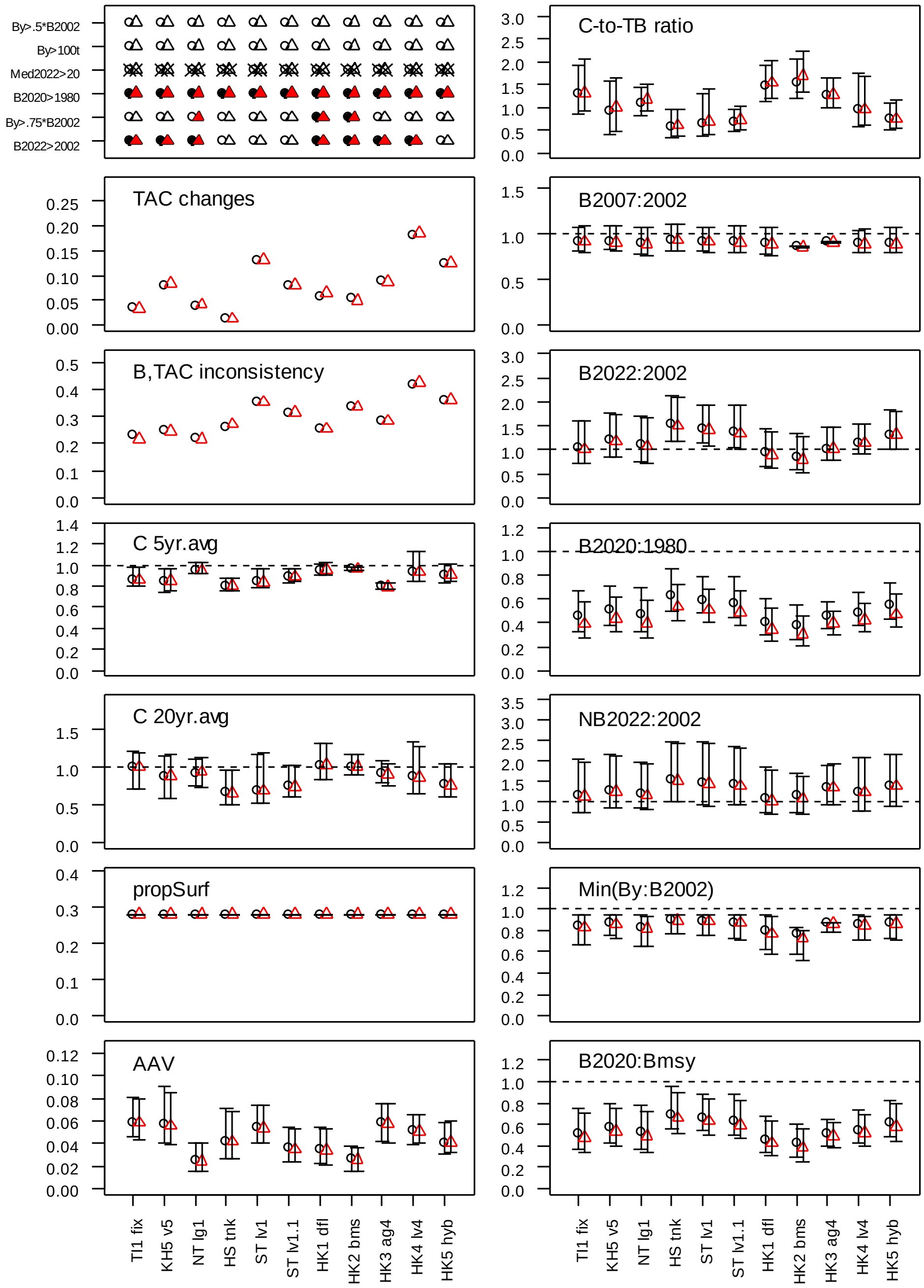


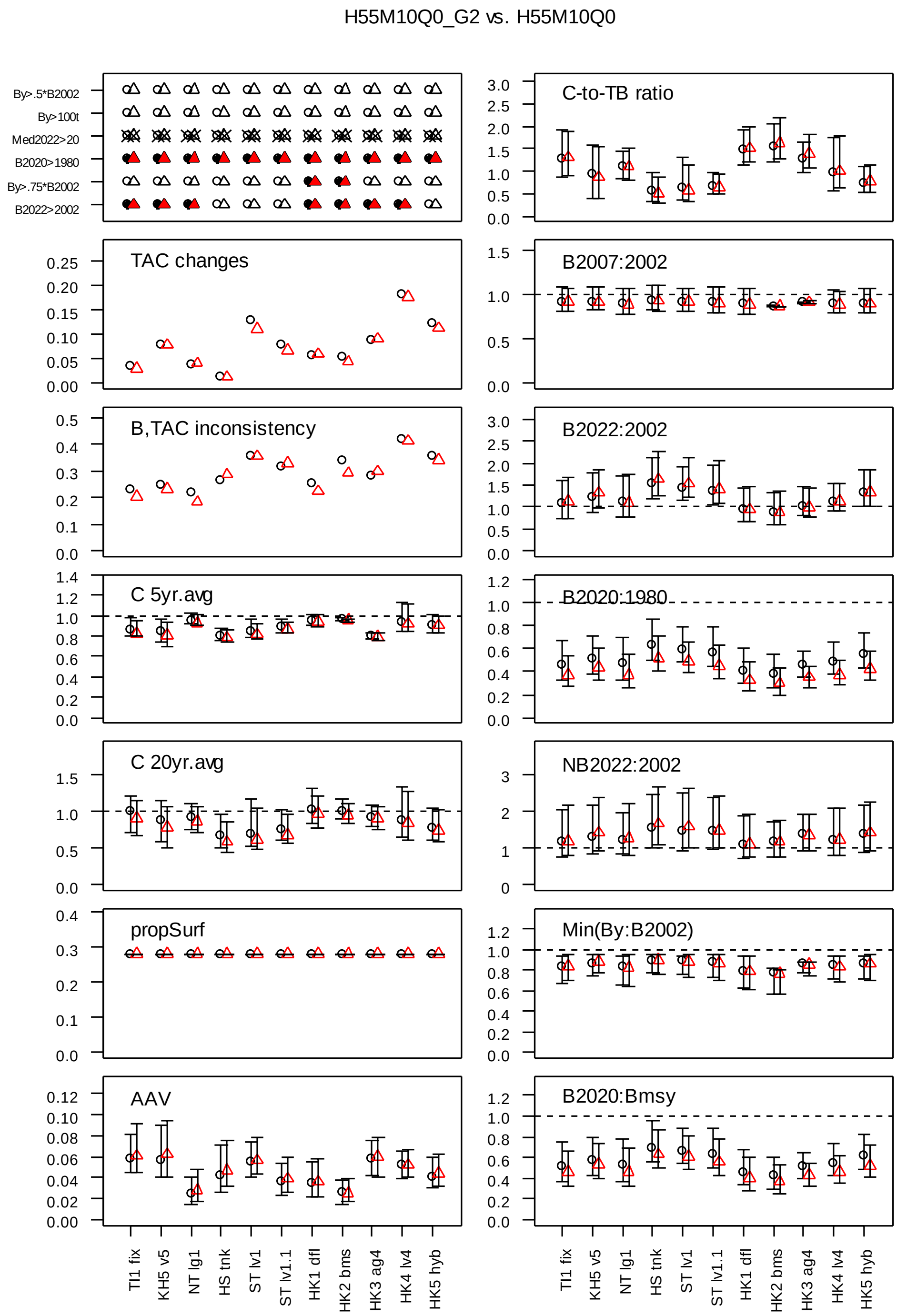

H__M10Q0_CC vs. H55M10Q0
By>.5*B2002
By>100t
Med2022>20
B2020>1980
By>.75*B2002
B2022>2002
C-to-TB ratio
TAC changes
B2007:2002
B,TAC inconsistency
B2022:2002
C 5yr.avg
B2020:1980
C 20yr.avg
NB2022:2002
propSurf
Min(By:B2002)
AAV
B2020:Bmsy
TI1 fix
KH5 v5
NT lg1
HS tnk
ST lv1
ST lv1.1
HK1 dfl
HK2 bms
HK3 ag4
HK4 lv4
HK5 hyb

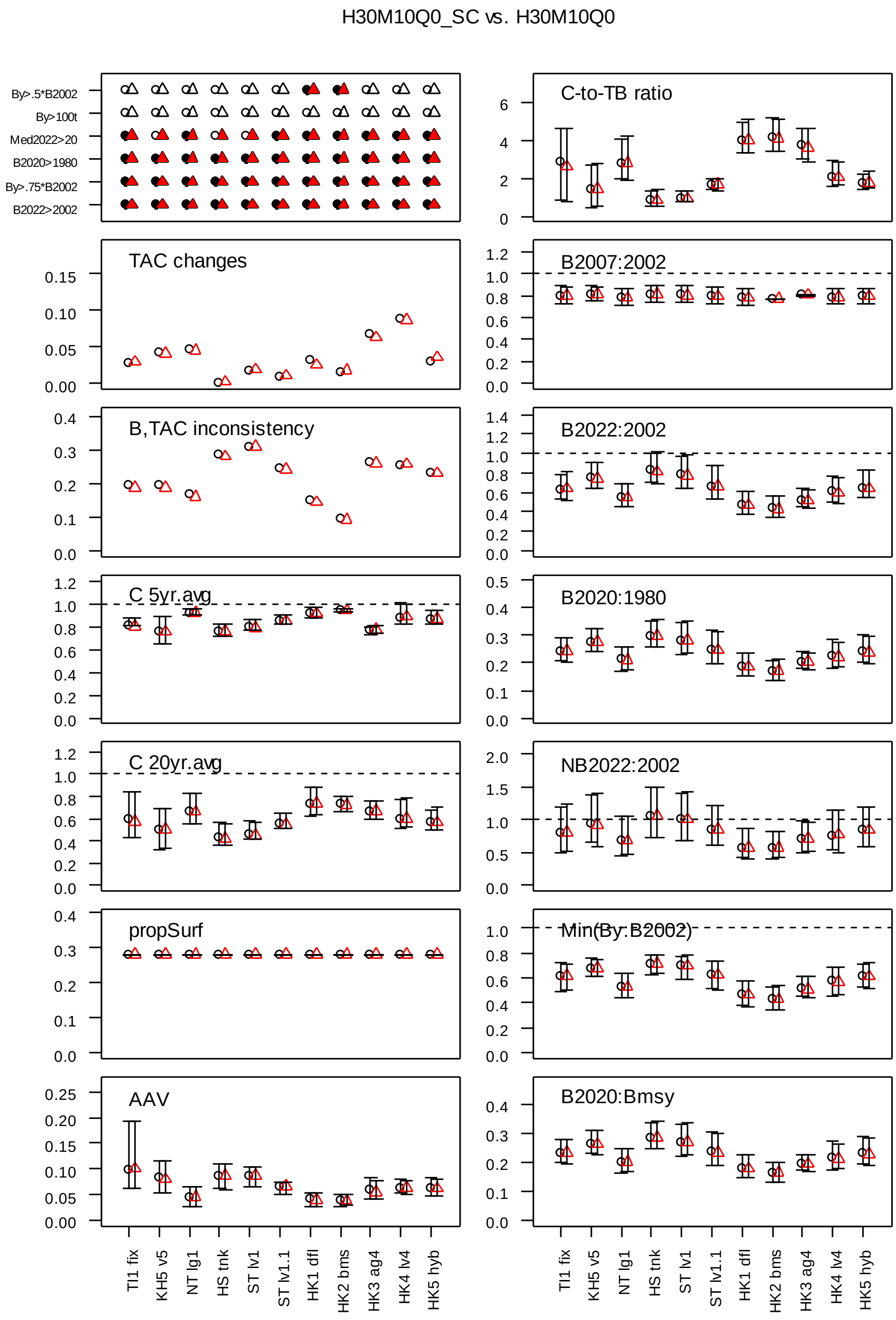

H30M10Q0_Psi vs. H30M10Q0
By>.5*B2002
By>100t
Med2022>20
B2020>1980
By>.75*B2002
B2022>2002
C-to-TB ratio
TAC changes
B2007:2002
B,TAC inconsistency
B2022:2002
C 5yr.avg
B2020:1980
C 20yr.avg
NB2022:2002
propSurf
Min(By:B2002)
AAV
B2020:Bmsy
TI1 fix
KH5 v5
NT lg1
HS tnk
ST lv1
ST lv1.1
HK1 dfl
HK2 bms
HK3 ag4
HK4 lv4
HK5 hyb


H30M10Q0_G2 vs. H30M10Q0
By>.5*B2002
By>100t
Med2022>20
B2020>1980
By>.75*B2002
B2022>2002
C-to-TB ratio
TAC changes
B2007:2002
B,TAC inconsistency
B2022:2002
C 5yr.avg
B2020:1980
C 20yr.avg
NB2022:2002
propSurf
Min(By:B2002)
AAV
B2020:Bmsy
TI1 fix
KH5 v5
NT lg1
HS tnk
ST lv1
ST lv1.1
HK1 dfl
HK2 bms
HK3 ag4
HK4 lv4
HK5 hyb

H55M10Q0_Psi vs. H55M10Q0




H55M10Q0_G2 vs. H55M10Q0
By>.5*B2002
By>100t
Med2022>20
B2020>1980
By>.75*B2002
B2022>2002
C-to-TB ratio
TAC changes
B2007:2002
B,TAC inconsistency
B2022:2002
C 5yr.avg
B2020:1980
C 20yr.avg
NB2022:2002
propSurf
Min(By:B2002)
AAV
B2020:Bmsy
TI1 fix
KH5 v5
NT lg1
HS tnk
ST lv1
ST lv1.1
HK1 dfl
HK2 bms
HK3 ag4
HK4 lv4
HK5 hyb



H30M10Q0_SC vs. H30M10Q0
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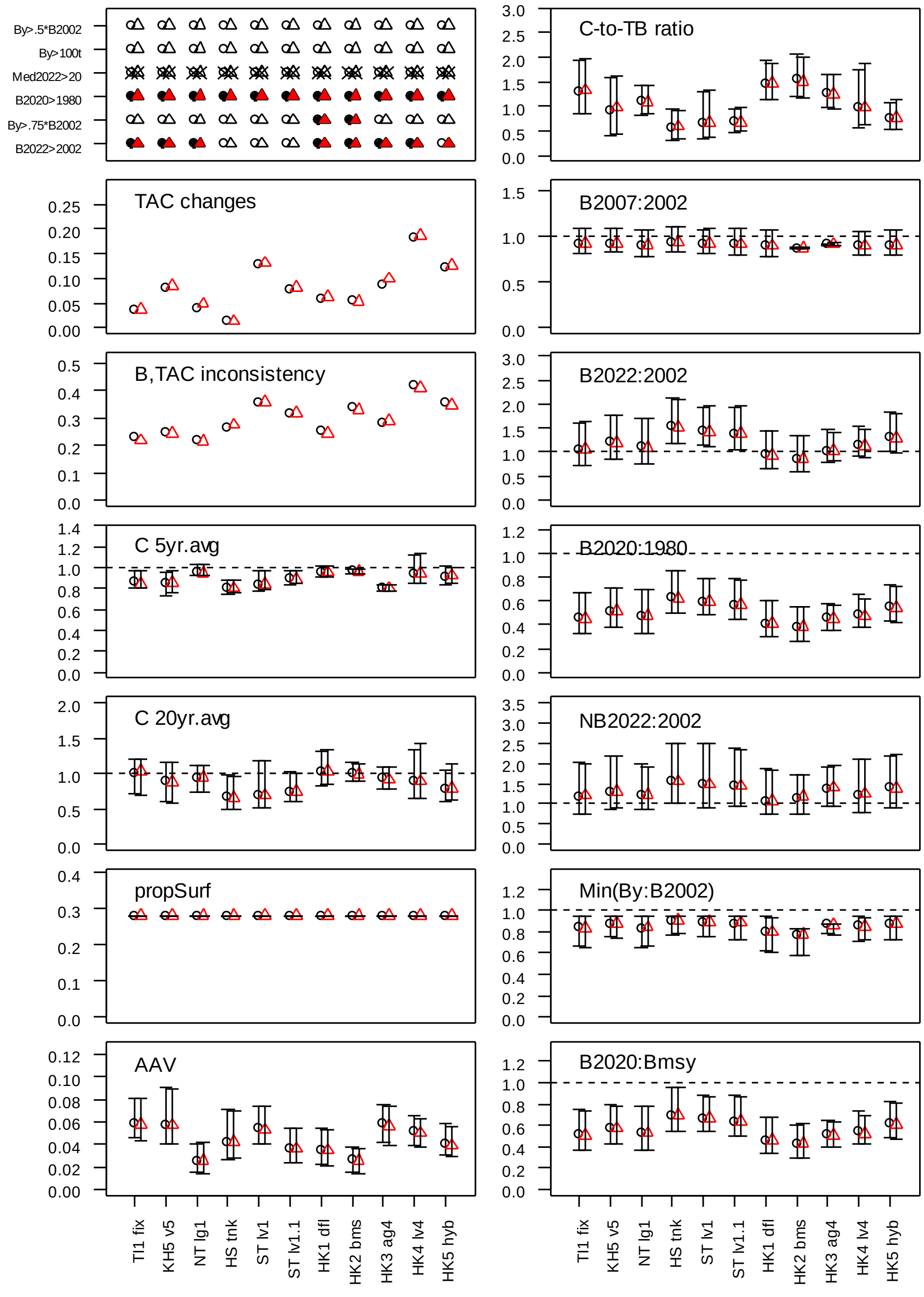
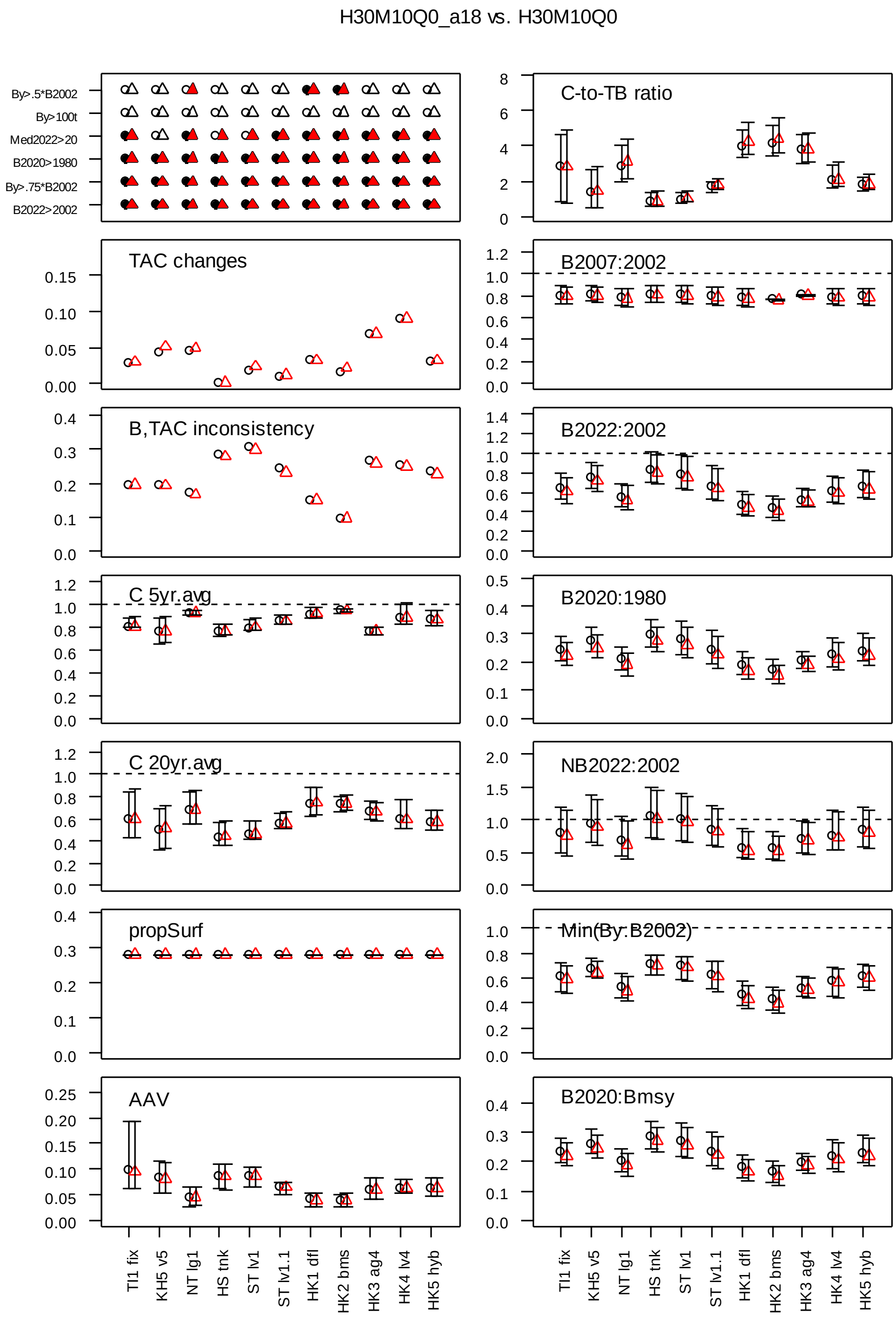
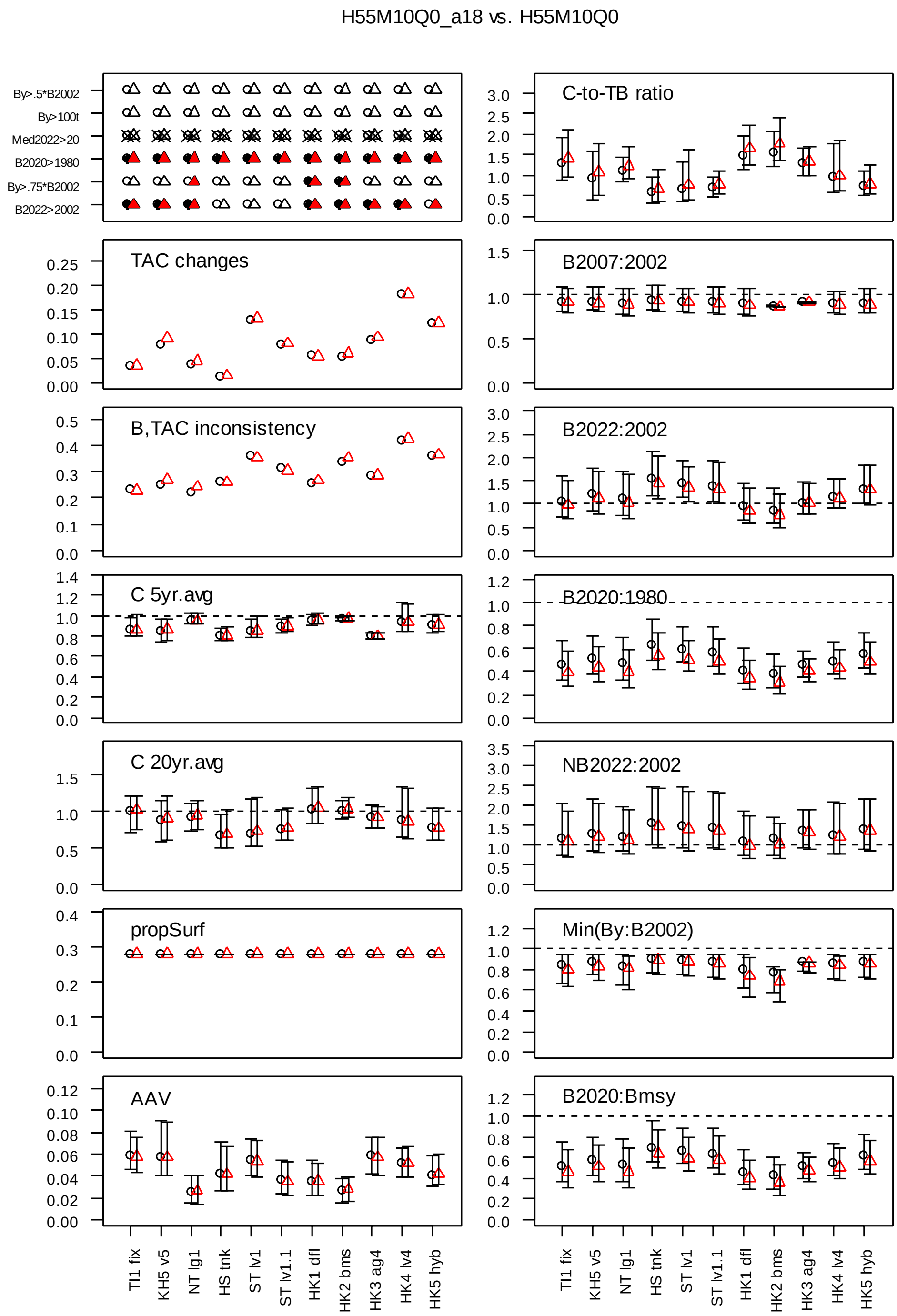
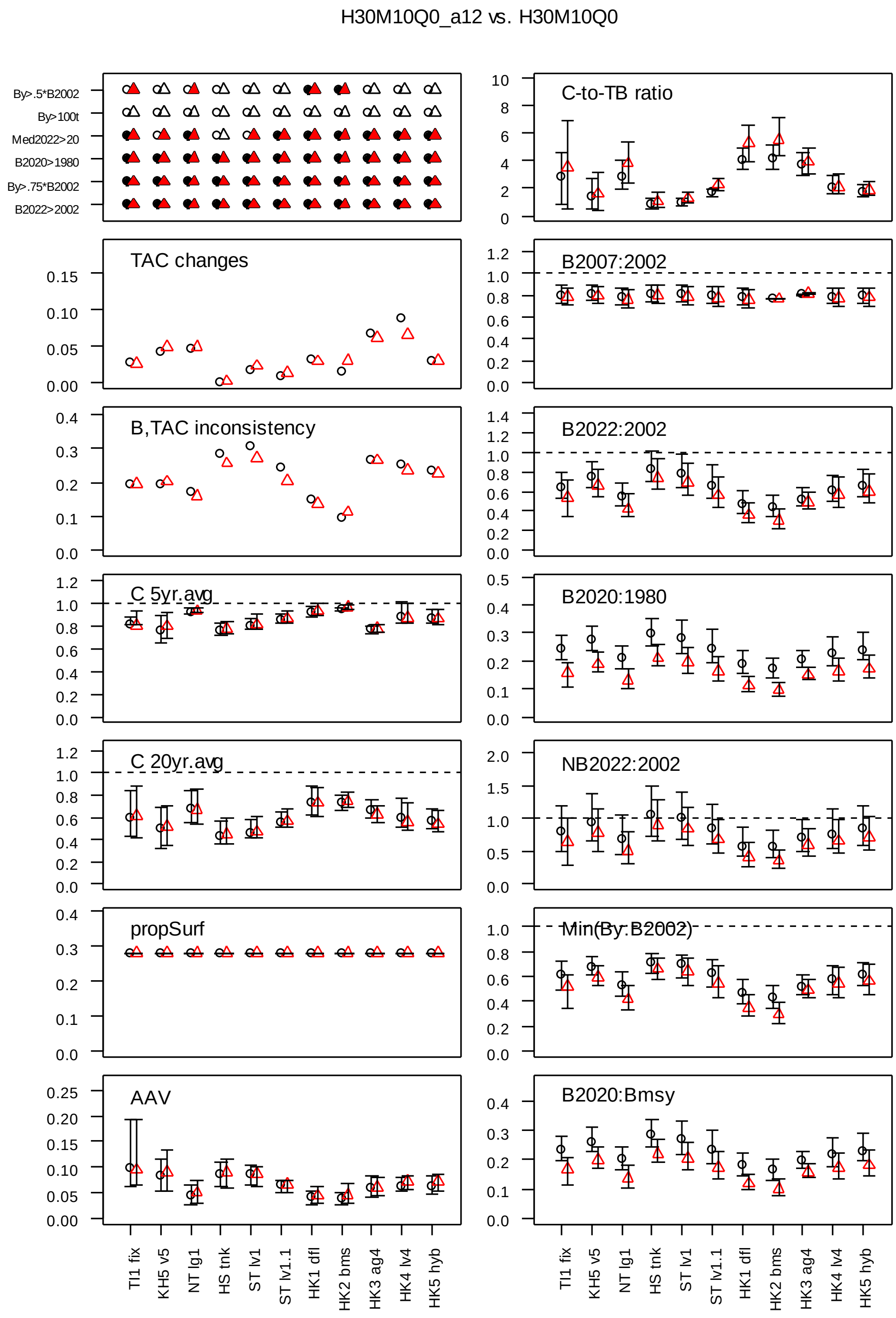
By>100t
Med2022>20
B2020>1980
By>.75*B2002
B2022>2002
C-to-TB ratio
TAC changes
B2007:2002
B,TAC inconsistency
B2022:2002
C 5yr.avg
B2020:1980
C 20yr.avg
NB2022:2002
propSurf
Min(By:B2002)
AAV
B2020:Bmsy
TI1 fix
KH5 v5
NT lg1
HS tnk
ST lv1
ST lv1.1
HK1 dfl
HK2 bms
HK3 ag4
HK4 lv4
HK5 hyb

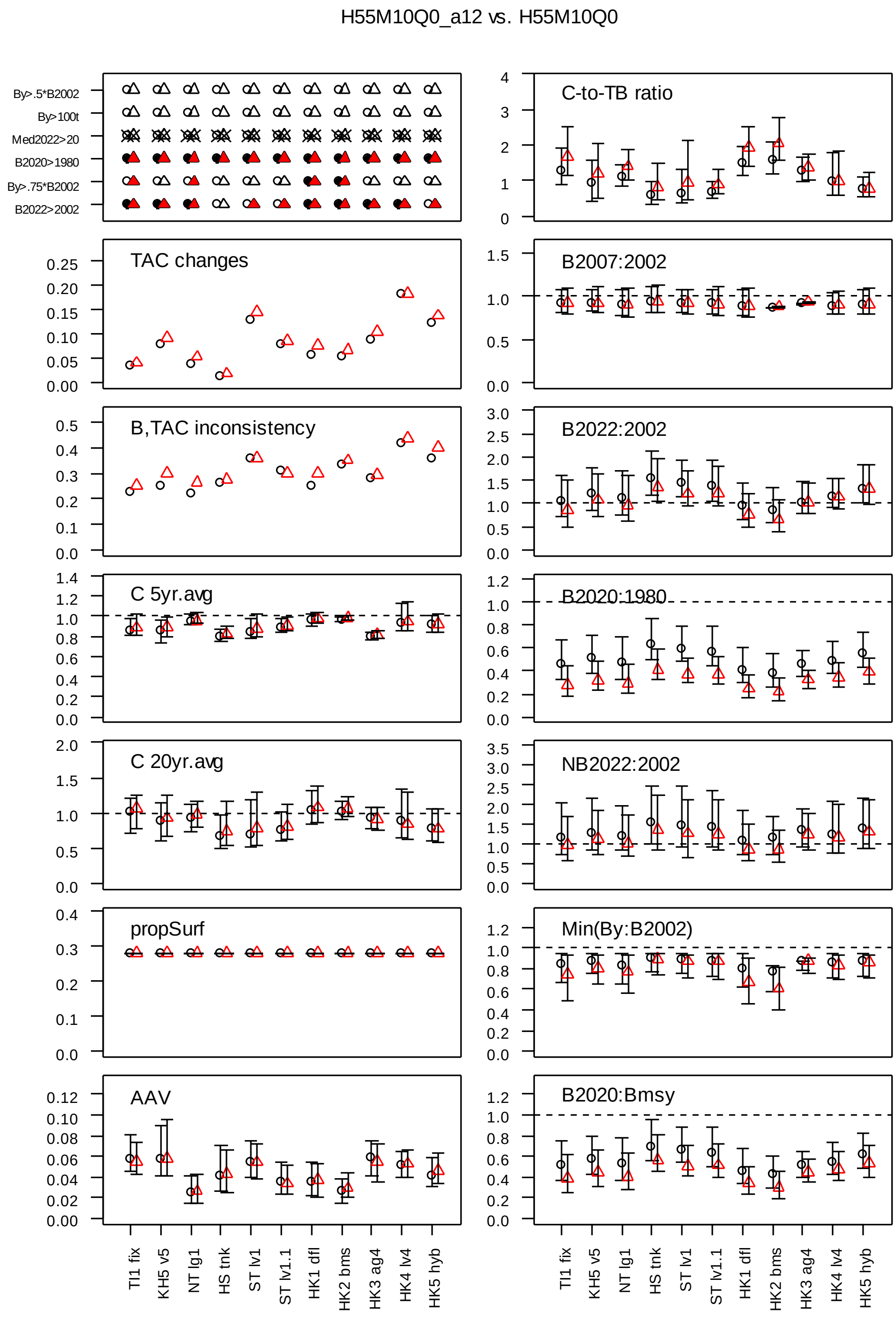
H55M10Q0_SC vs. H55M10Q0




H30M10Q0_a18 vs. H30M10Q0
By>.5*B2002
By>100t
Med2022>20
B2020>1980
By>.75*B2002
B2022>2002
C-to-TB ratio
TAC changes
B2007:2002
B,TAC inconsistency
B2022:2002
C 5yr.avg
B2020:1980
C 20yr.avg
NB2022:2002
propSurf
Min(By:B2002)
AAV
B2020:Bmsy
TI1 fix
KH5 v5
NT lg1
HS tnk
ST lv1
ST lv1.1
HK1 dfl
HK2 bms
HK3 ag4
HK4 lv4
HK5 hyb


H55M10Q0_a18 vs. H55M10Q0
By>.5*B2002
By>100t
Med2022>20
B2020>1980
By>.75*B2002
B2022>2002
C-to-TB ratio
TAC changes
B2007:2002
B,TAC inconsistency
B2022:2002
C 5yr.avg
B2020:1980
C 20yr.avg
NB2022:2002
propSurf
Min(By:B2002)
AAV
B2020:Bmsy
TI1 fix
KH5 v5
NT lg1
HS tnk
ST lv1
ST lv1.1
HK1 dfl
HK2 bms
HK3 ag4
HK4 lv4
HK5 hyb


H30M10Q0_a12 vs. H30M10Q0
By>.5*B2002
By>100t
Med2022>20
B2020>1980
By>.75*B2002
B2022>2002
C-to-TB ratio
0
2
4
6
8
10
TAC changes
0.00
0.05
0.10
0.15
B2007:2002
B,TAC inconsistency
B2022:2002
C 5yr.avg
B2020:1980
C 20yr.avg
NB2022:2002
propSurf
Min(By:B2002)
AAV
B2020:Bmsy
TI1 fix
KH5 v5
NT lg1
HS tnk
ST lv1
ST lv1.1
HK1 dfl
HK2 bms
HK3 ag4
HK4 lv4
HK5 hyb


H55M10Q0_a12 vs. H55M10Q0
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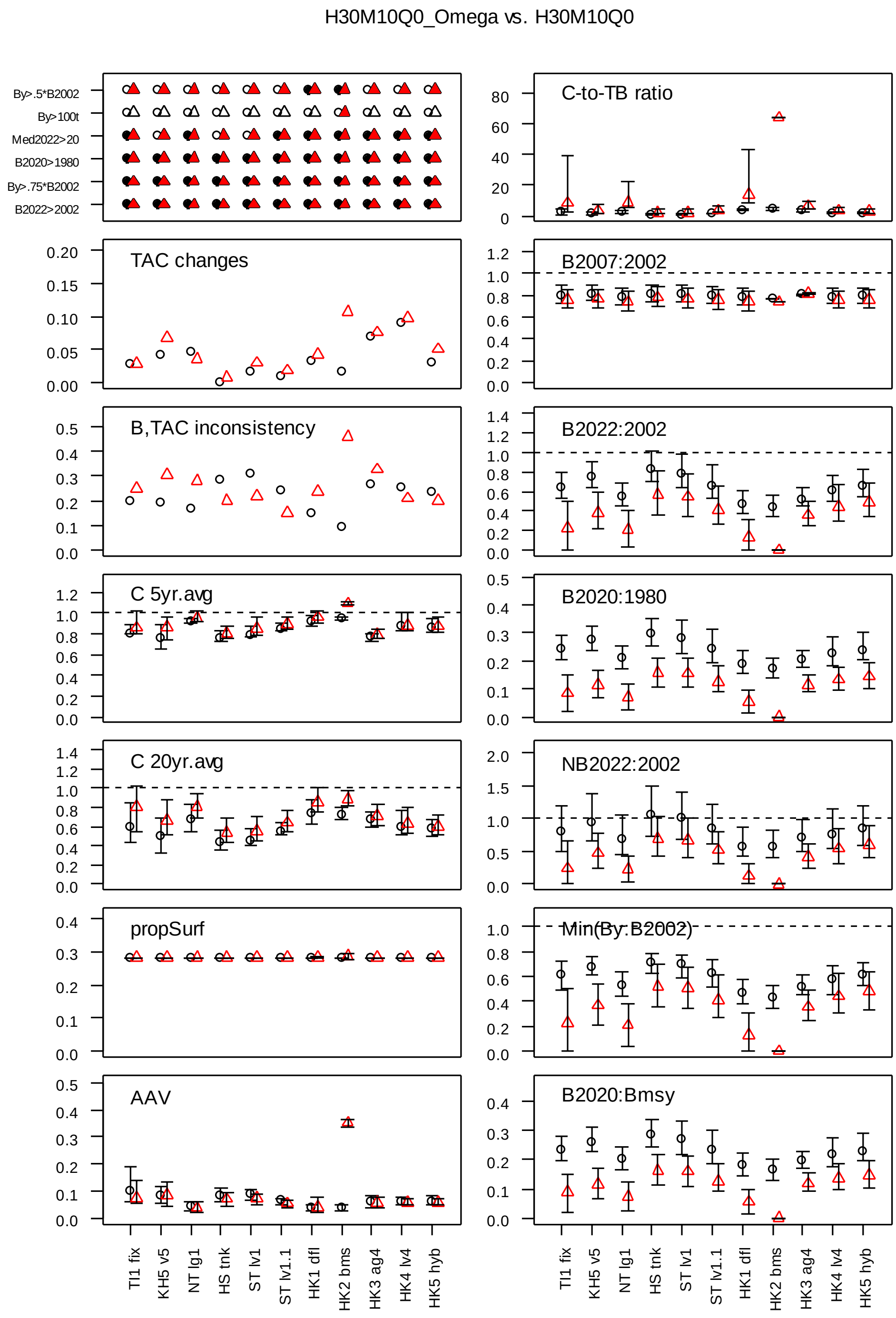
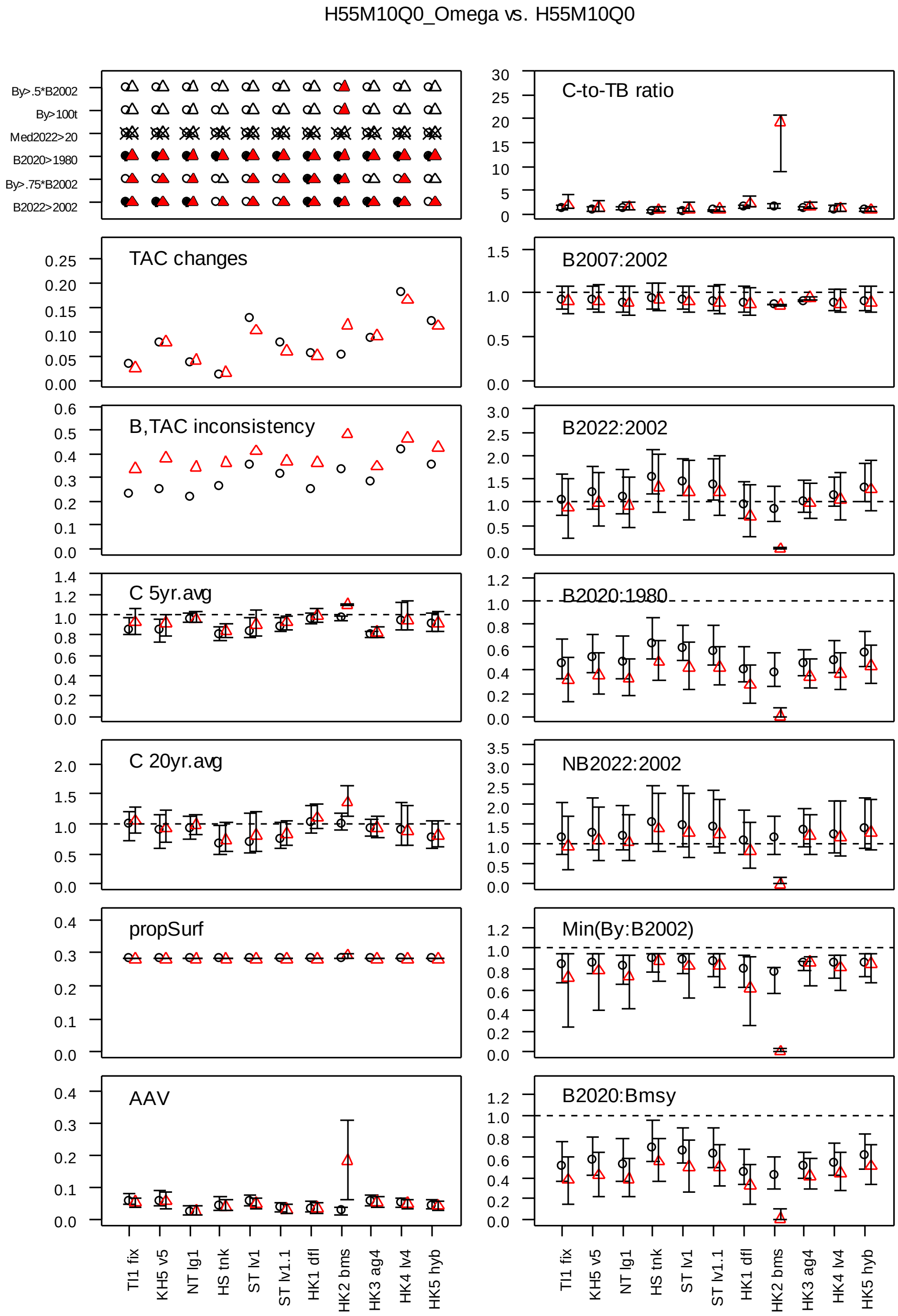
By>100t
Med2022>20
B2020>1980
By>.75*B2002
B2022>2002
C-to-TB ratio
TAC changes
B2007:2002
B,TAC inconsistency
B2022:2002
C 5yr.avg
B2020:1980
C 20yr.avg
NB2022:2002
propSurf
Min(By:B2002)
AAV
B2020:Bmsy
TI1 fix
KH5 v5
NT lg1
HS tnk
ST lv1
ST lv1.1
HK1 dfl
HK2 bms
HK3 ag4
HK4 lv4
HK5 hyb


H30M10Q0_Omega vs. H30M10Q0
By>.5*B2002
By>100t
Med2022>20
B2020>1980
By>.75*B2002
B2022>2002
C-to-TB ratio
TAC changes
B2007:2002
B,TAC inconsistency
B2022:2002
C 5yr.avg
B2020:1980
C 20yr.avg
NB2022:2002
propSurf
Min(By:B2002)
AAV
B2020:Bmsy
TI1 fix
KH5 v5
NT lg1
HS tnk
ST lv1
ST lv1.1
HK1 dfl
HK2 bms
HK3 ag4
HK4 lv4
HK5 hyb


H55M10Q0_Omega vs. H55M10Q0
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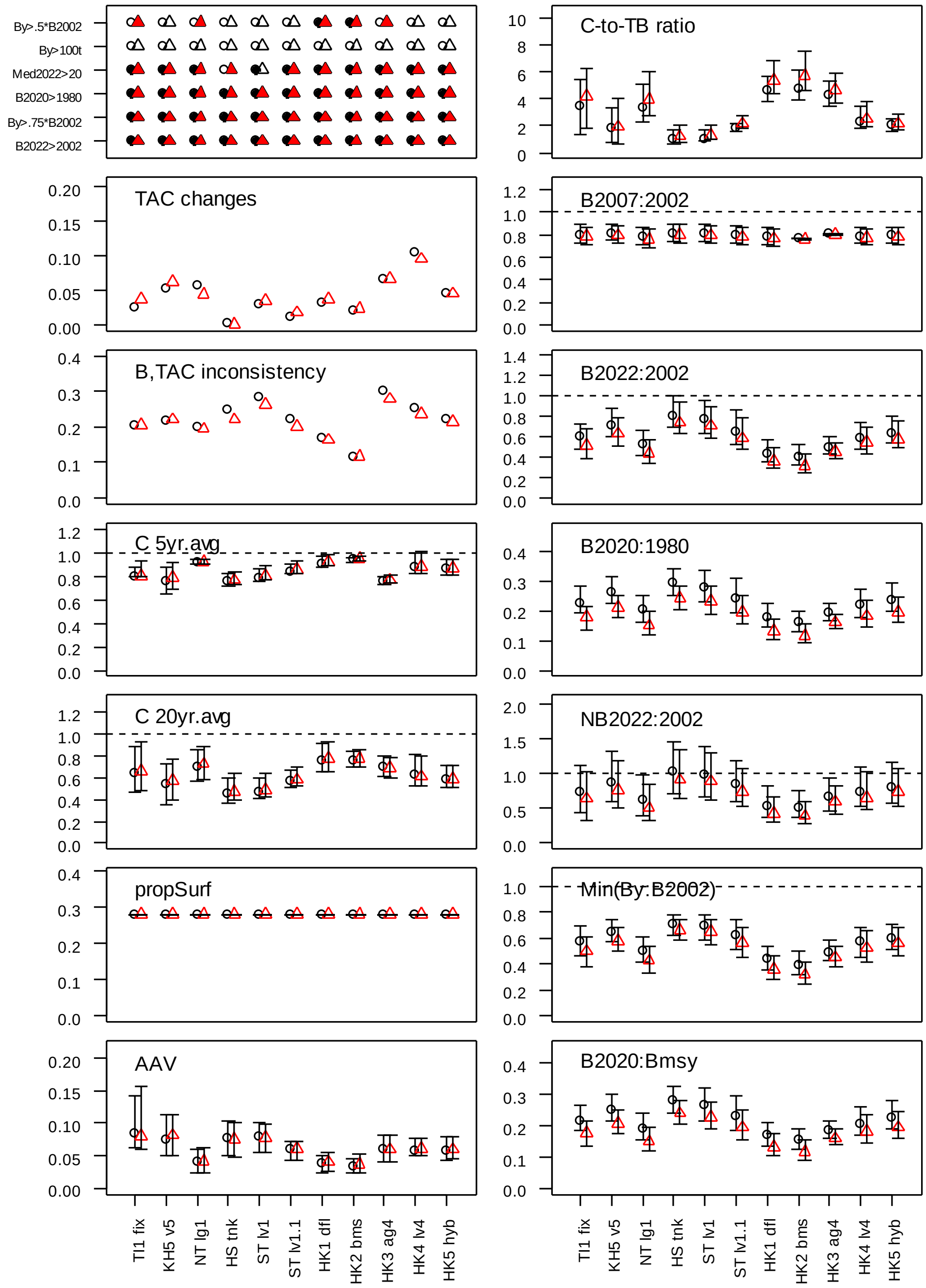
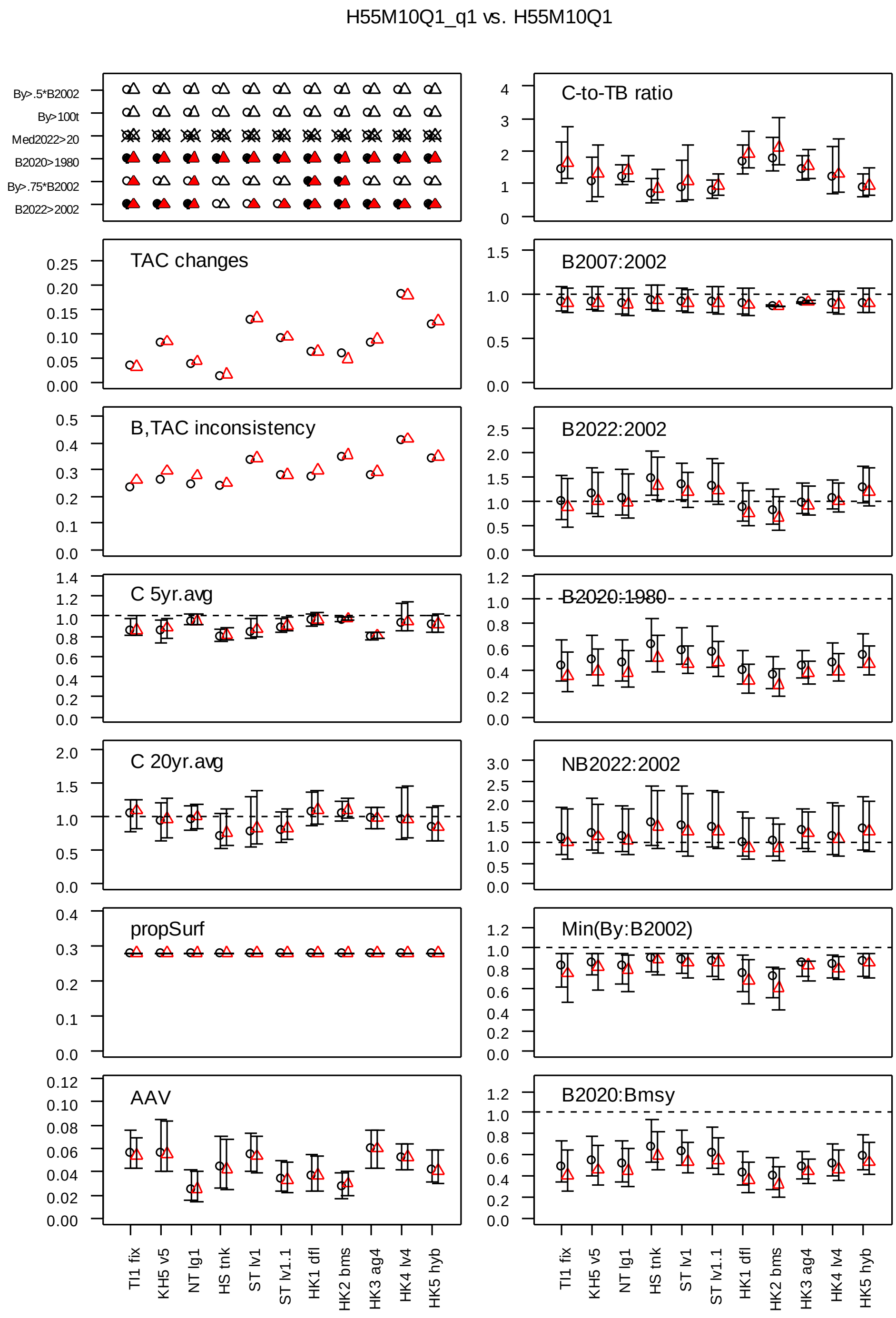
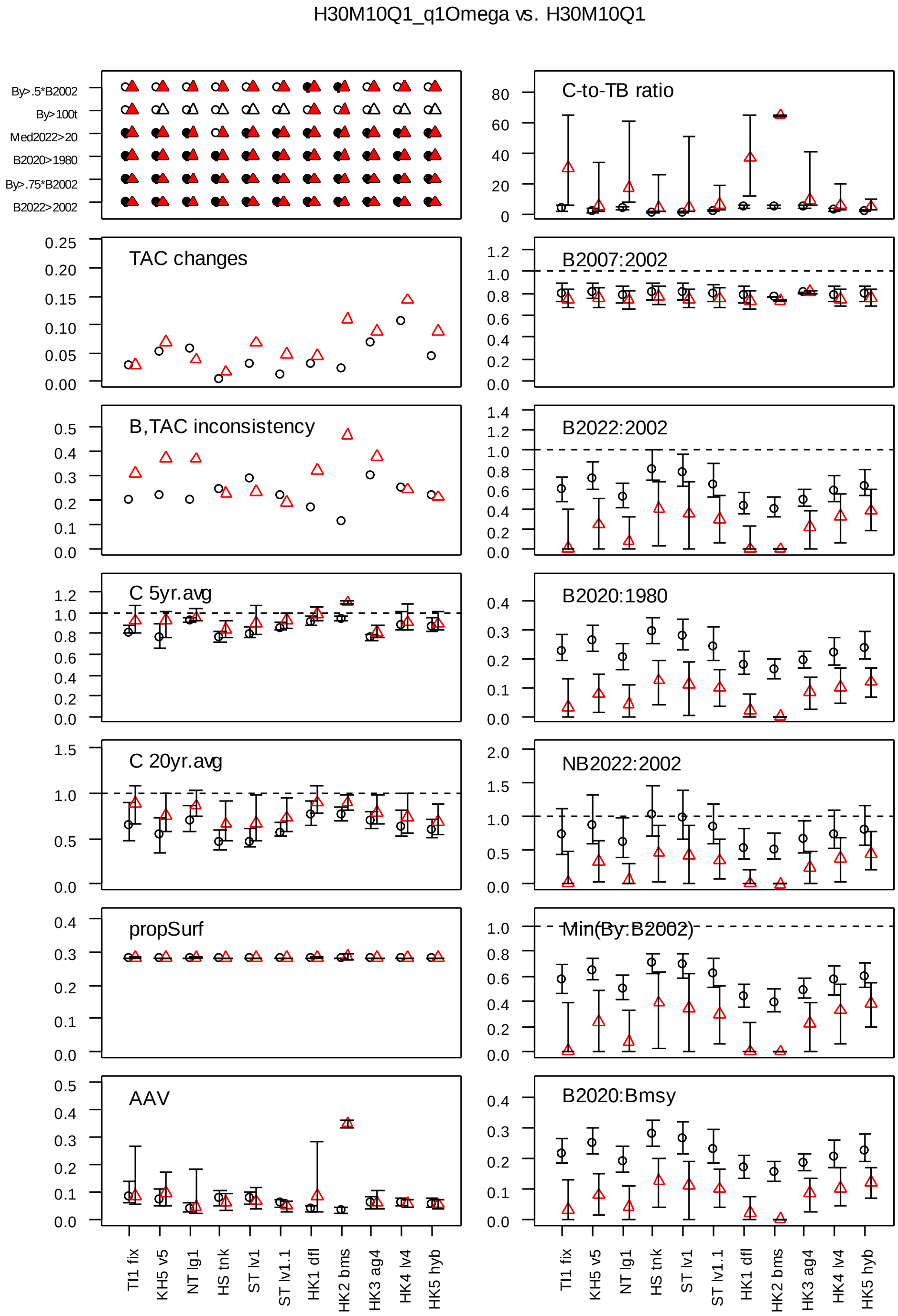
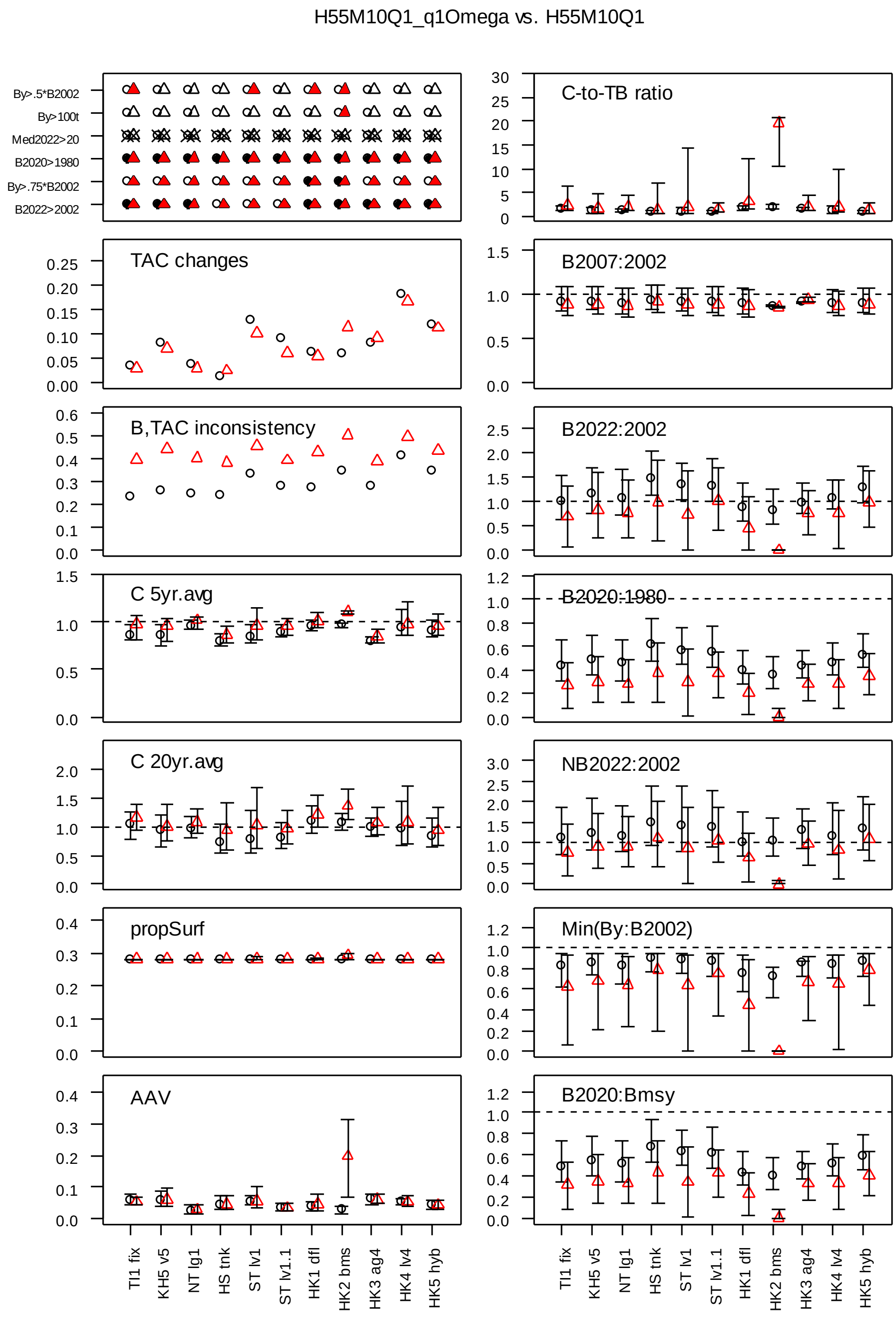
By>100t
Med2022>20
B2020>1980
By>.75*B2002
B2022>2002
C-to-TB ratio
TAC changes
B2007:2002
B,TAC inconsistency
B2022:2002
C 5yr.avg
B2020:1980
C 20yr.avg
NB2022:2002
propSurf
Min(By:B2002)
AAV
B2020:Bmsy
TI1 fix
KH5 v5
NT lg1
HS tnk
ST lv1
ST lv1.1
HK1 dfl
HK2 bms
HK3 ag4
HK4 lv4
HK5 hyb

H30M10Q1_q1 vs. H30M10Q1




H55M10Q1_q1 vs. H55M10Q1
By>.5*B2002
By>100t
Med2022>20
B2020>1980
By>.75*B2002
B2022>2002
C-to-TB ratio
TAC changes
B2007:2002
B,TAC inconsistency
B2022:2002
C 5yr.avg
B2020:1980
C 20yr.avg
NB2022:2002
propSurf
Min(By:B2002)
AAV
B2020:Bmsy
Tl1 fix
KH5 v5
NT lg1
HS tnk
ST lv1
ST lv1.1
HK1 dfl
HK2 bms
HK3 ag4
HK4 lv4
HK5 hyb


H30M10Q1_q1Omega vs. H30M10Q1
By>.5*B2002
By>100t
Med2022>20
B2020>1980
By>.75*B2002
B2022>2002
C-to-TB ratio
TAC changes
B2007:2002
B,TAC inconsistency
B2022:2002
C 5yr.avg
B2020:1980
C 20yr.avg
NB2022:2002
propSurf
Min(By:B2002)
AAV
B2020:Bmsy
TI1 fix
KH5 v5
NT lg1
HS tnk
ST lv1
ST lv1.1
HK1 dfl
HK2 bms
HK3 ag4
HK4 lv4
HK5 hyb


H55M10Q1_q1Omega vs. H55M10Q1
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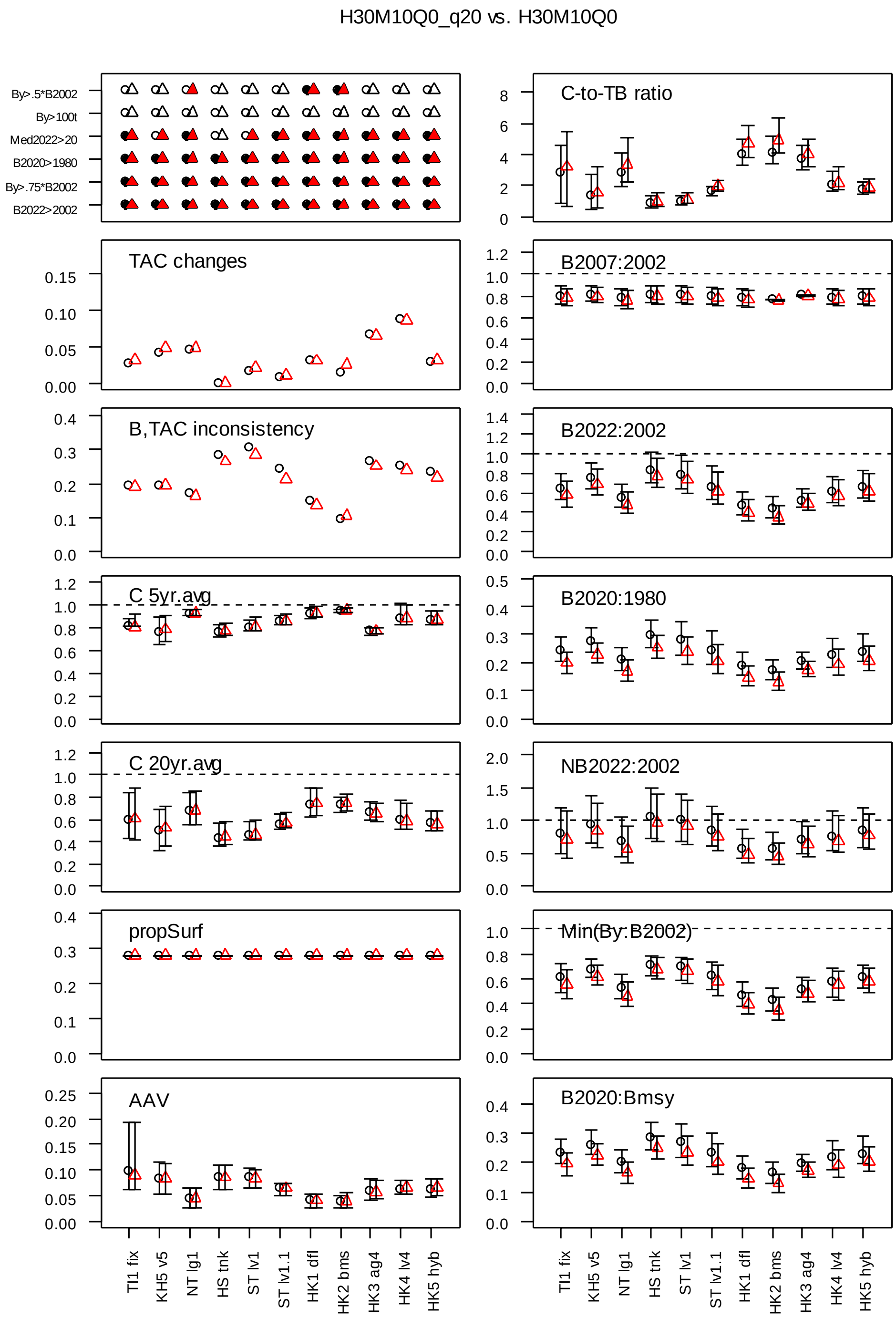
By>100t
Med2022>20
B2020>1980
By>.75*B2002
B2022>2002
C-to-TB ratio
TAC changes
B2007:2002
B,TAC inconsistency
B2022:2002
C 5yr.avg
B2020:1980
C 20yr.avg
NB2022:2002
propSurf
Min(By:B2002)
AAV
B2020:Bmsy
TI1 fix
KH5 v5
NT lg1
HS tnk
ST lv1
ST lv1.1
HK1 dfl
HK2 bms
HK3 ag4
HK4 lv4
HK5 hyb



H30M10Q0_q20 vs. H30M10Q0
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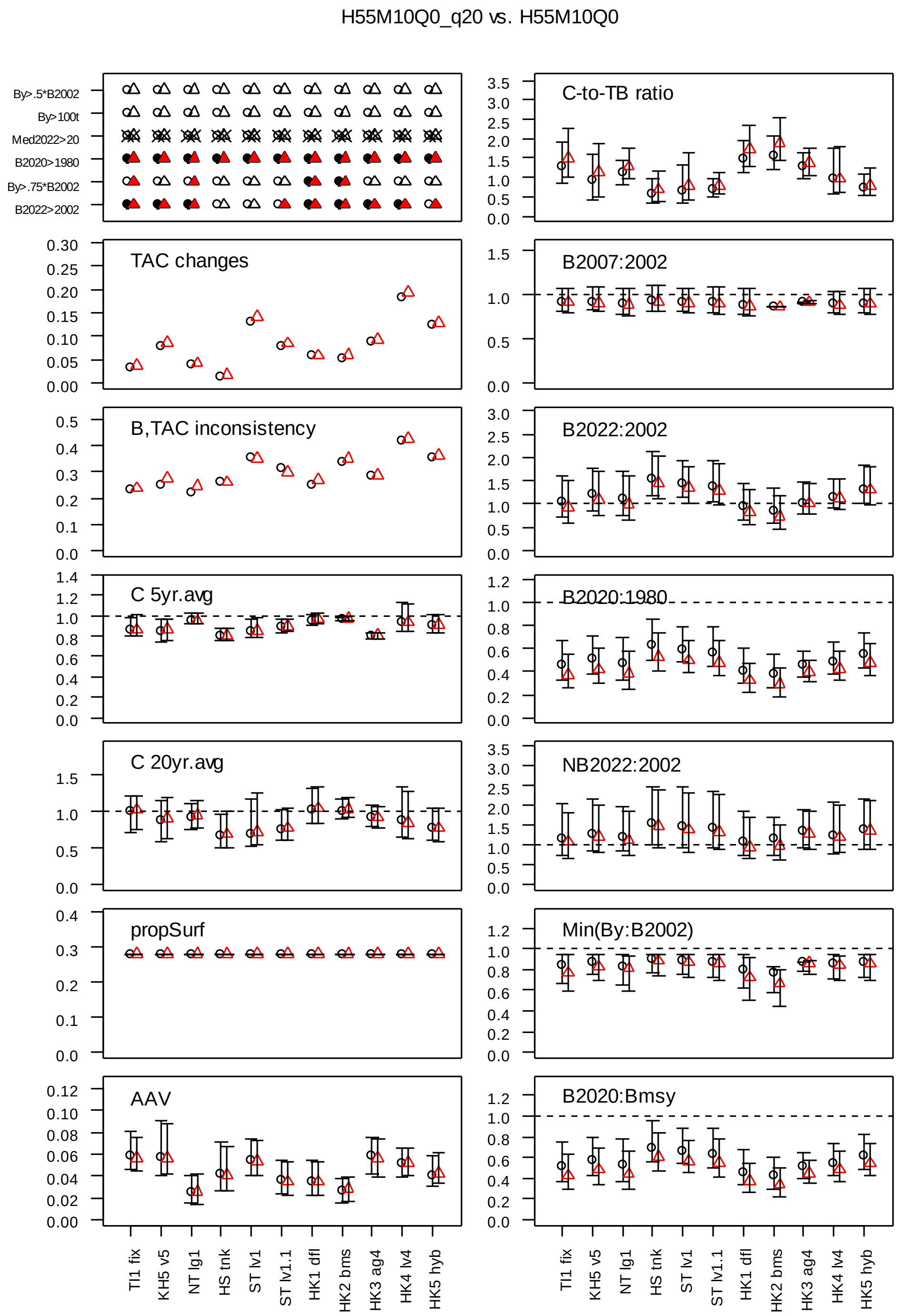
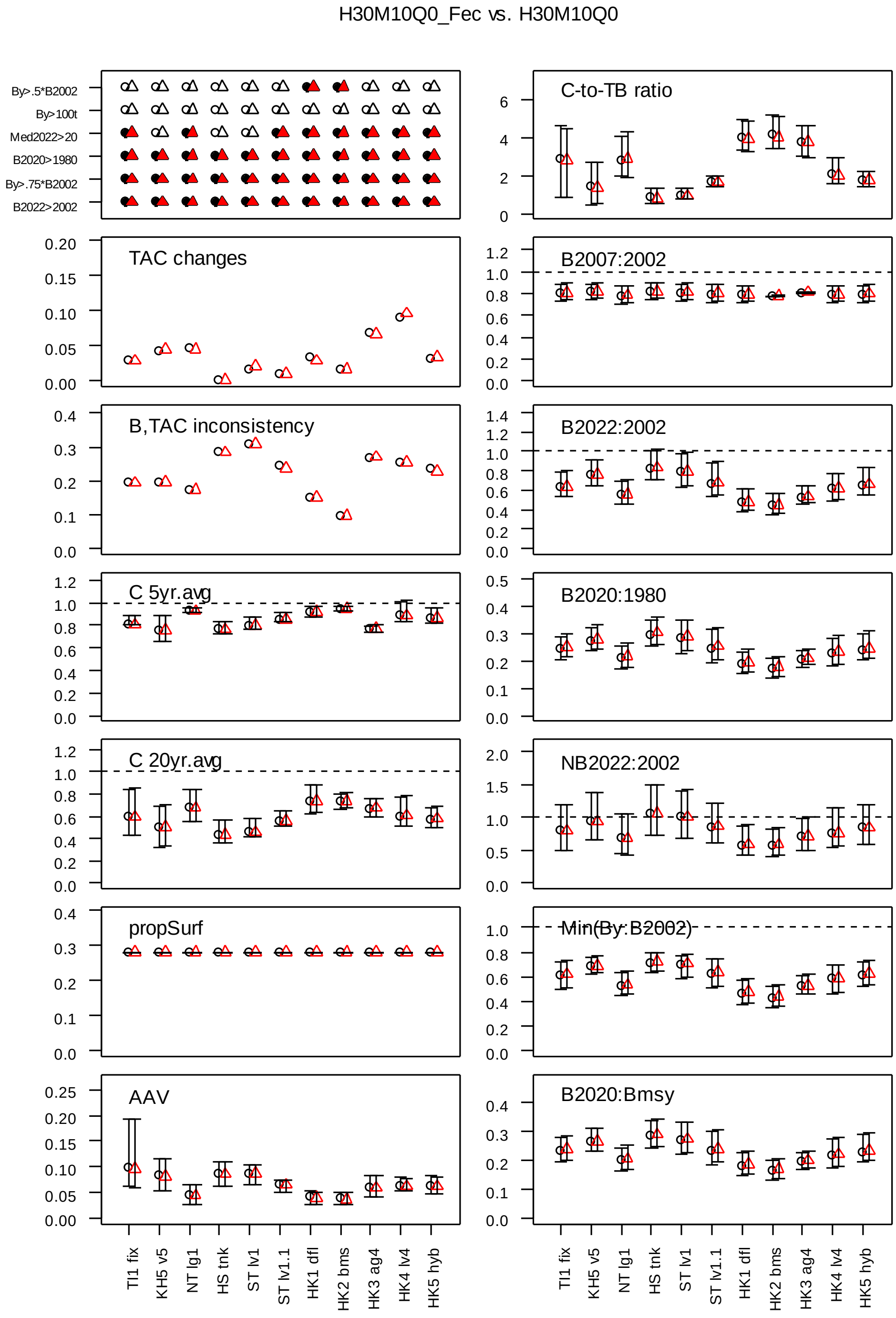
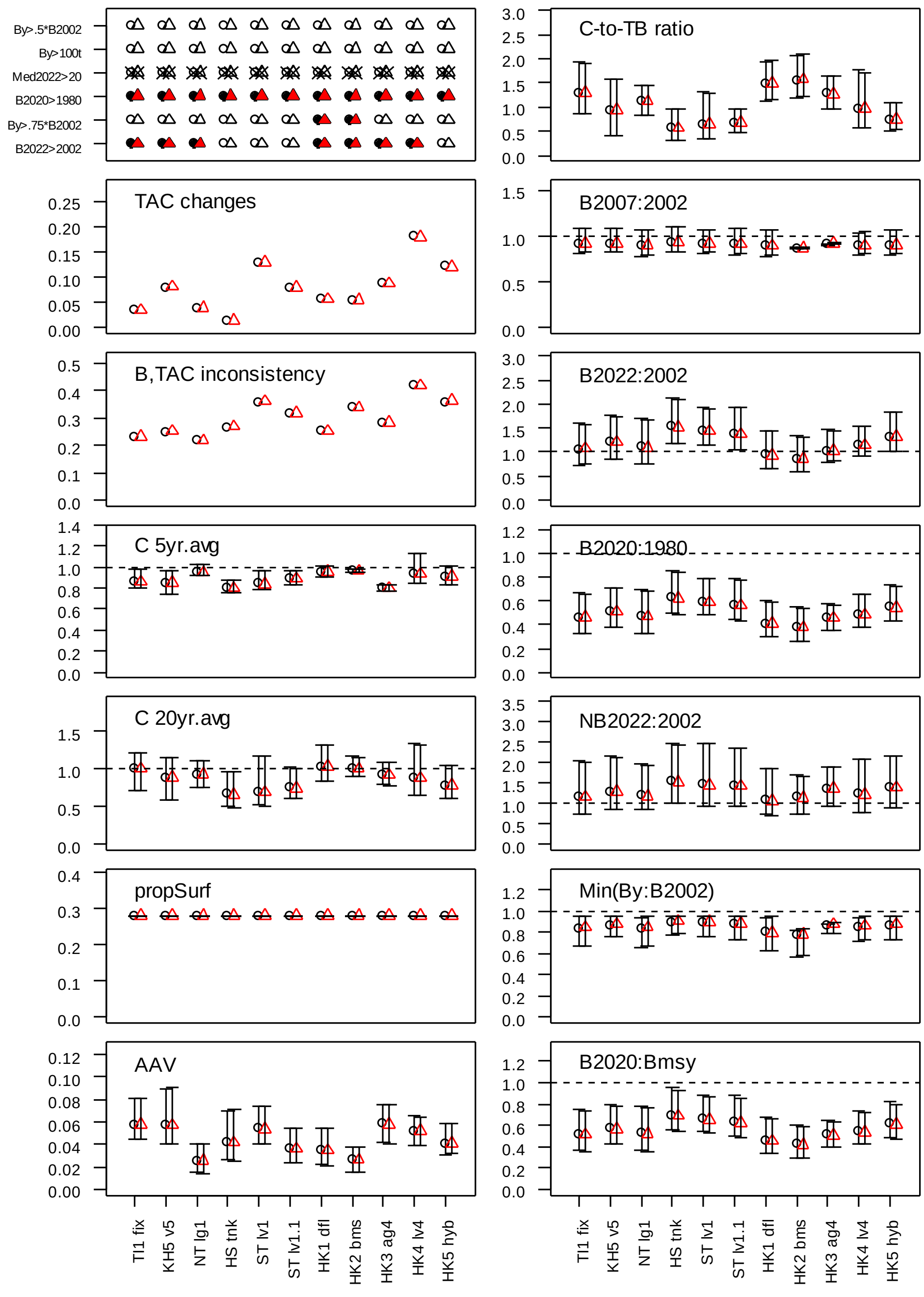
By>100t
Med2022>20
B2020>1980
By>.75*B2002
B2022>2002
C-to-TB ratio
TAC changes
B2007:2002
B,TAC inconsistency
B2022:2002
C 5yr.avg
B2020:1980
C 20yr.avg
NB2022:2002
propSurf
Min(By:B2002)
AAV
B2020:Bmsy
TI1 fix
KH5 v5
NT lg1
HS tnk
ST lv1
ST lv1.1
HK1 dfl
HK2 bms
HK3 ag4
HK4 lv4
HK5 hyb

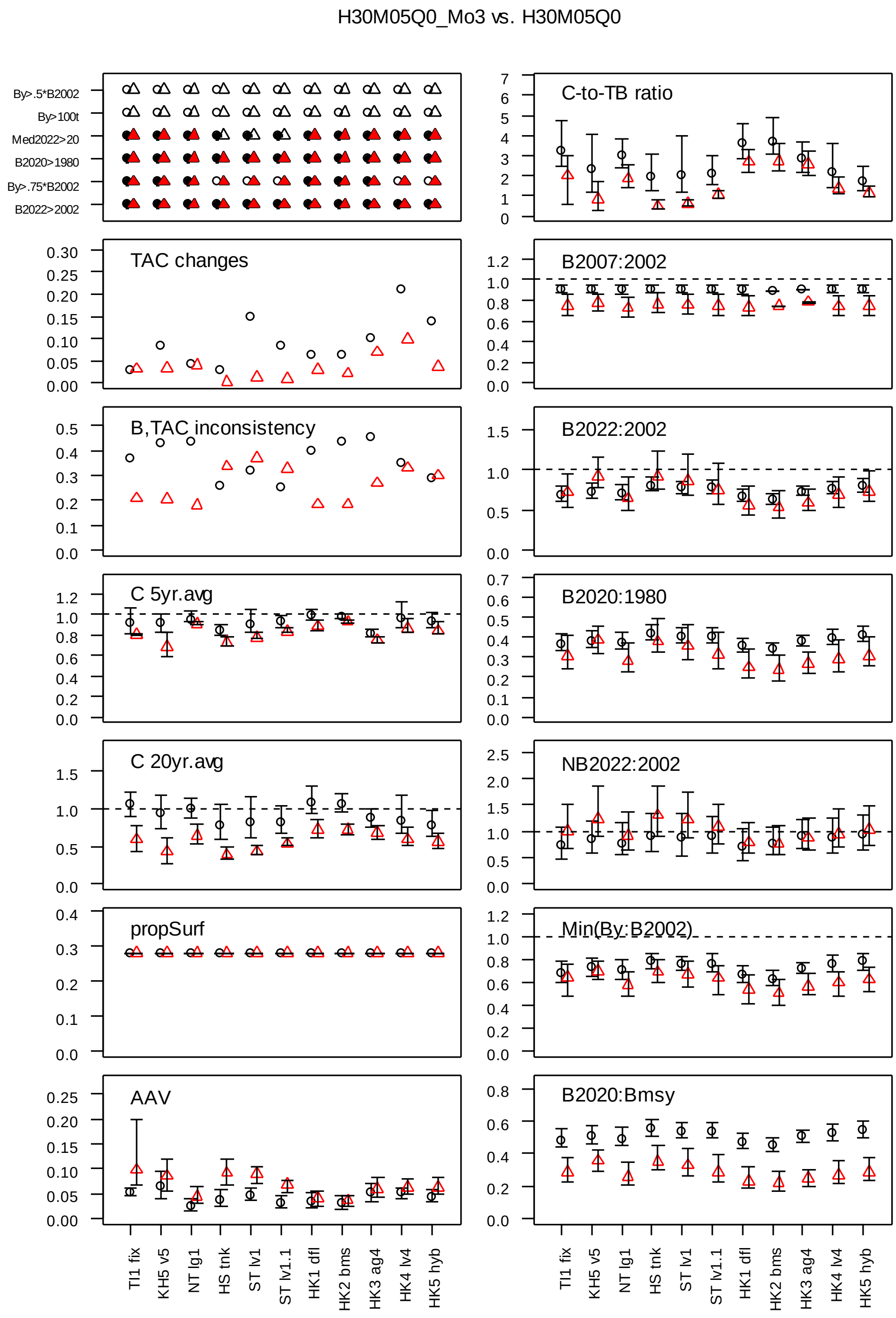

H55M10Q0_q20 vs. H55M10Q0
By>.5*B2002
By>100t
Med2022>20
B2020>1980
By>.75*B2002
B2022>2002
C-to-TB ratio
TAC changes
B2007:2002
B,TAC inconsistency
B2022:2002
C 5yr.avg
B2020:1980
C 20yr.avg
NB2022:2002
propSurf
Min(By:B2002)
AAV
B2020:Bmsy
TI1 fix
KH5 v5
NT lg1
HS tnk
ST lv1
ST lv1.1
HK1 dfl
HK2 bms
HK3 ag4
HK4 lv4
HK5 hyb


H30M10Q0_Fec vs. H30M10Q0
By>.5*B2002
By>100t
Med2022>20
B2020>1980
By>.75*B2002
B2022>2002
C-to-TB ratio
TAC changes
B2007:2002
B,TAC inconsistency
B2022:2002
C 5yr.avg
B2020:1980
C 20yr.avg
NB2022:2002
propSurf
Min(By:B2002)
AAV
B2020:Bmsy
TI1 fix
KH5 v5
NT lg1
HS tnk
ST lv1
ST lv1.1
HK1 dfl
HK2 bms
HK3 ag4
HK4 lv4
HK5 hyb

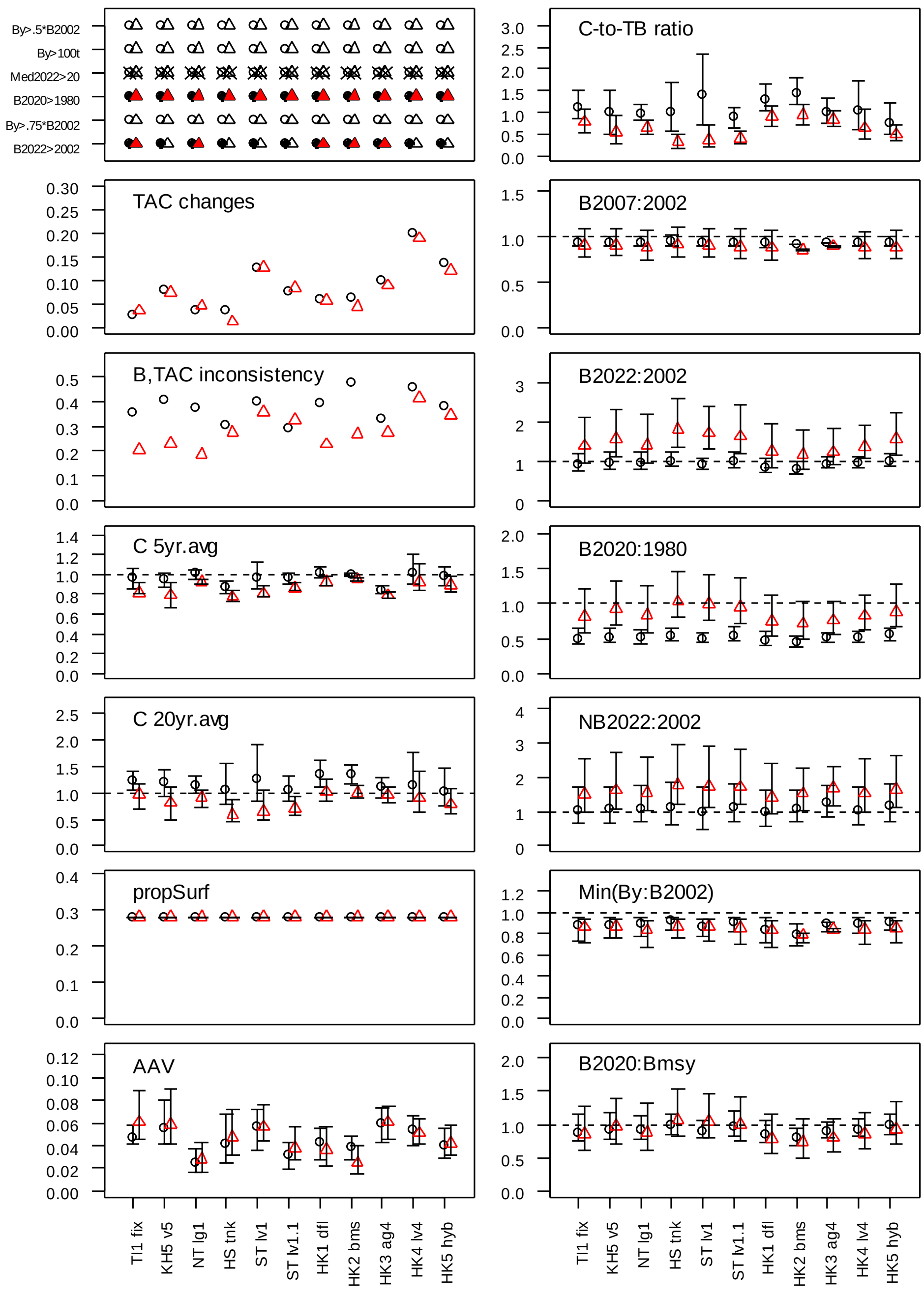
H55M10Q0_Fec vs. H55M10Q0

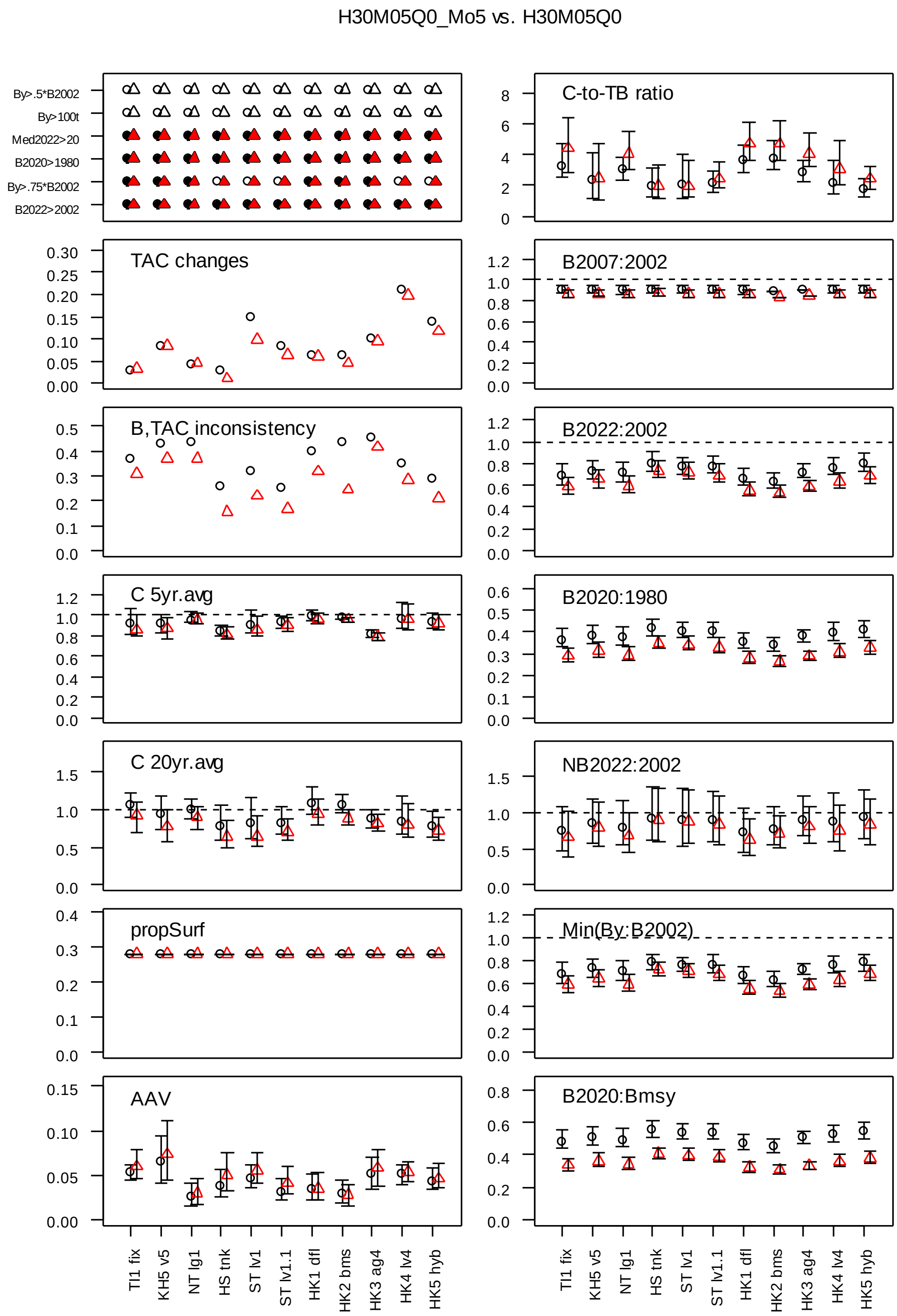


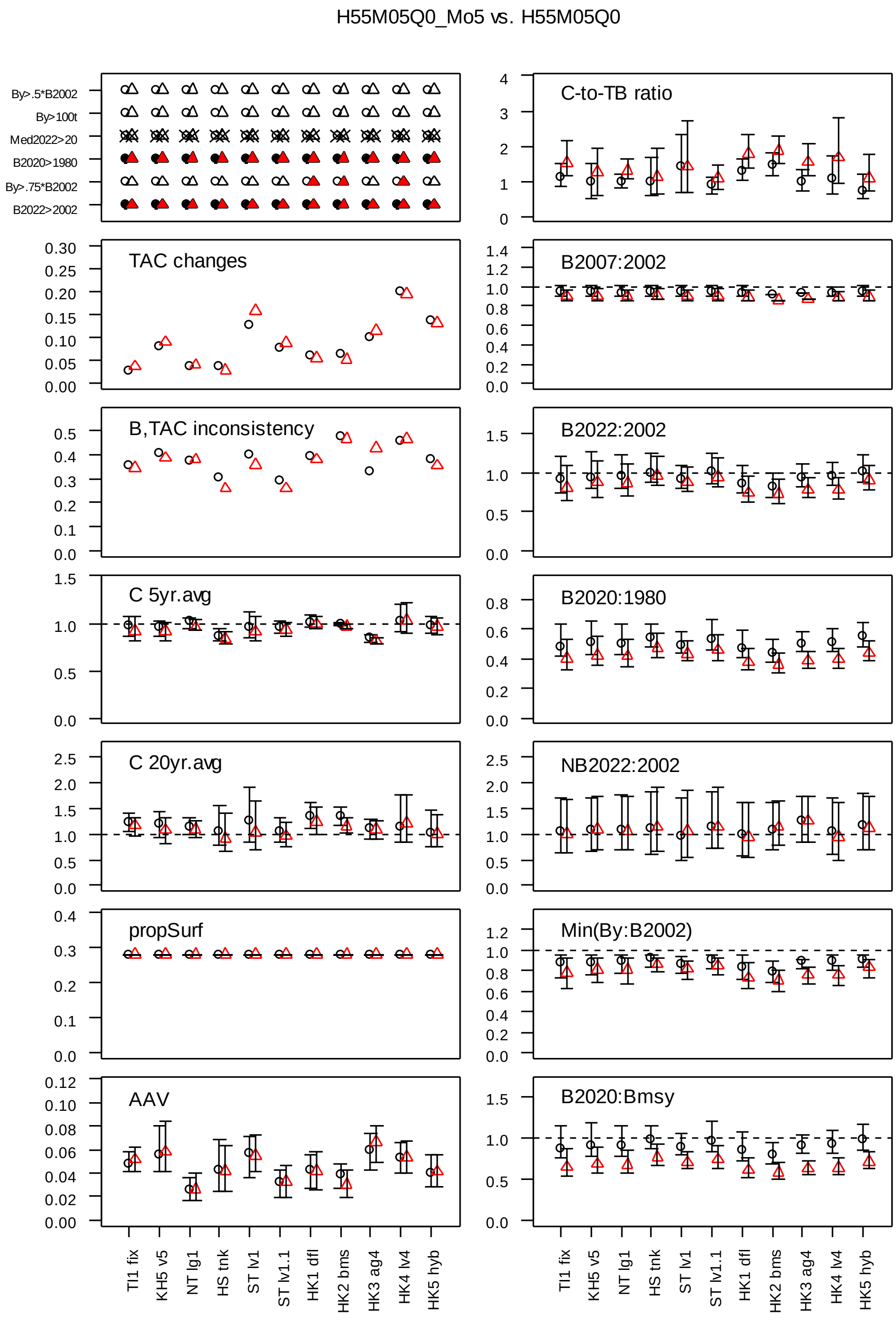
H30M05Q0_Mo3 vs. H30M05Q0



H55M05Q0_Mo3 vs. H55M05Q0




H30M05Q0_Mo5 vs. H30M05Q0
By>.5*B2002
By>100t
Med2022>20
B2020>1980
By>.75*B2002
B2022>2002
C-to-TB ratio
TAC changes
B2007:2002
B,TAC inconsistency
B2022:2002
C 5yr.avg
B2020:1980
C 20yr.avg
NB2022:2002
propSurf
Min(By:B2002)
AAV
B2020:Bmsy
TI1 fix
KH5 v5
NT lg1
HS tnk
ST lv1
ST lv1.1
HK1 dfl
HK2 bms
HK3 ag4
HK4 lv4
HK5 hyb


H55M05Q0_Mo5 vs. H55M05Q0
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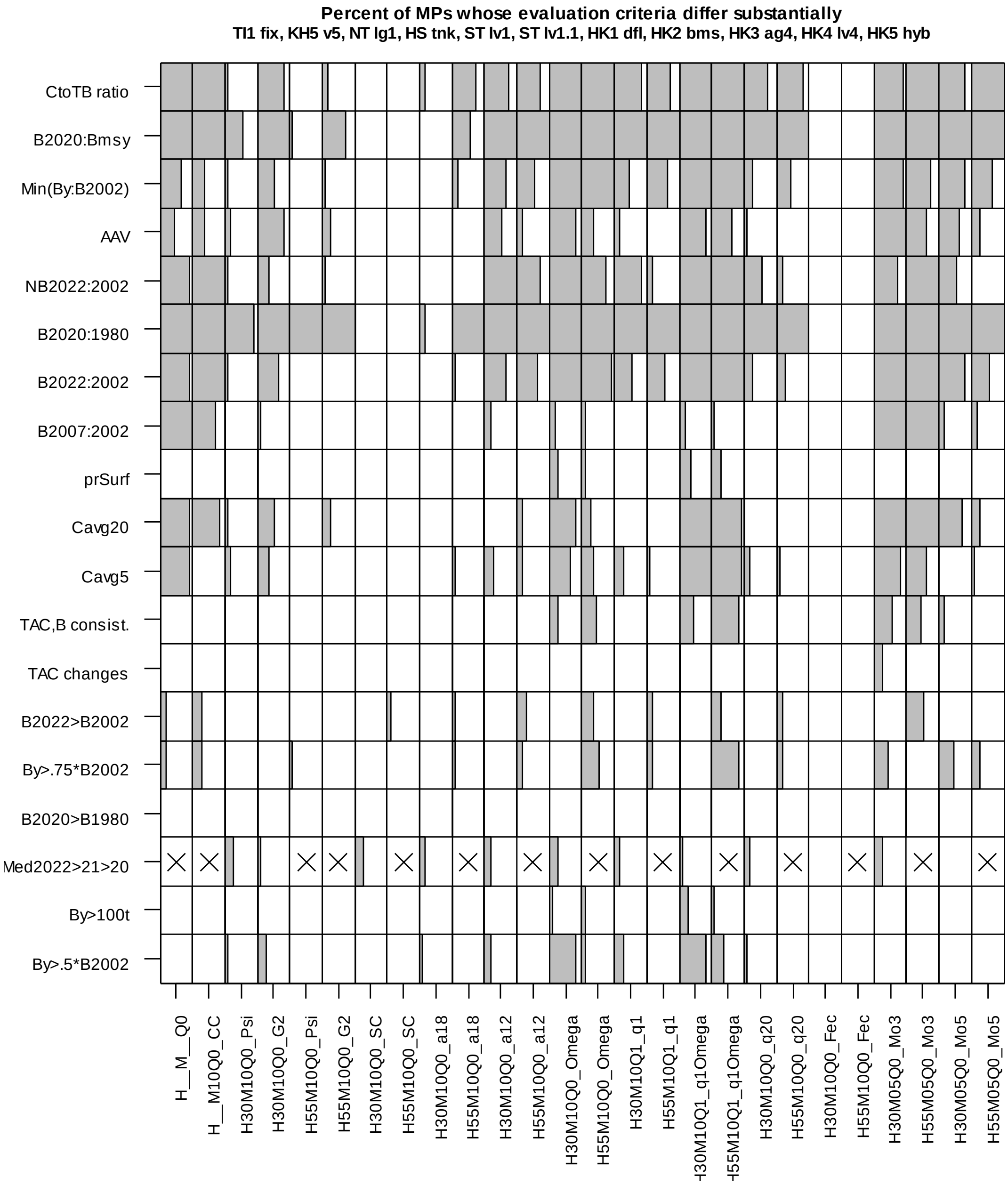
By>100t
Med2022>20
B2020>1980
By>.75*B2002
B2022>2002
C-to-TB ratio
TAC changes
B2007:2002
B,TAC inconsistency
B2022:2002
C 5yr.avg
B2020:1980
C 20yr.avg
NB2022:2002
propSurf
Min(By:B2002)
AAV
B2020:Bmsy
TI1 fix
KH5 v5
NT lg1
HS tnk
ST lv1
ST lv1.1
HK1 dfl
HK2 bms
HK3 ag4
HK4 lv4
HK5 hyb


Percent of MPs whose evaluation criteria differ substantially
TI1 fix, KH5 v5, NT lg1, HS tnk, ST lv1, ST lv1.1, HK1 dfl, HK2 bms, HK3 ag4, HK4 lv4, HK5 hyb
CtoTB ratio
B2020:Bmsy
Min(By:B2002)
AAV
NB2022:2002
B2020:1980
B2022:2002
B2007:2002
prSurf
Cavg20
Cavg5
TAC,B consist.
TAC changes
B2022>B2002
By>.75*B2002
B2020>B1980
Med2022>21>20
By>100t
By>.5*B2002
H__M__Q0
H__M10Q0_CC
H30M10Q0_Psi
H30M10Q0_G2
H55M10Q0_Psi
H55M10Q0_G2
H30M10Q0_SC
H55M10Q0_SC
H30M10Q0_a18
H55M10Q0_a18
H30M10Q0_a12
H55M10Q0_a12
H30M10Q0_Omega
H55M10Q0_Omega
H30M10Q1_q1
H55M10Q1_q1
H30M10Q1_q1Omega
H55M10Q1_q1Omega
H30M10Q0_q20
H55M10Q0_q20
H30M10Q0_Fec
H55M10Q0_Fec
H30M05Q0_Mo3
H55M05Q0_Mo3
H30M05Q0_Mo5
H55M05Q0_Mo5

Appendix 3. Outline of "TI1-fix v2 "

Hiroyuki Kurota & 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 of age 4+. This MP including parameter values is exactly the same as the MP "TI1-1-w2" at the second MP workshop (Hiramatsu et al., 2003). TAC is specified by:

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

where

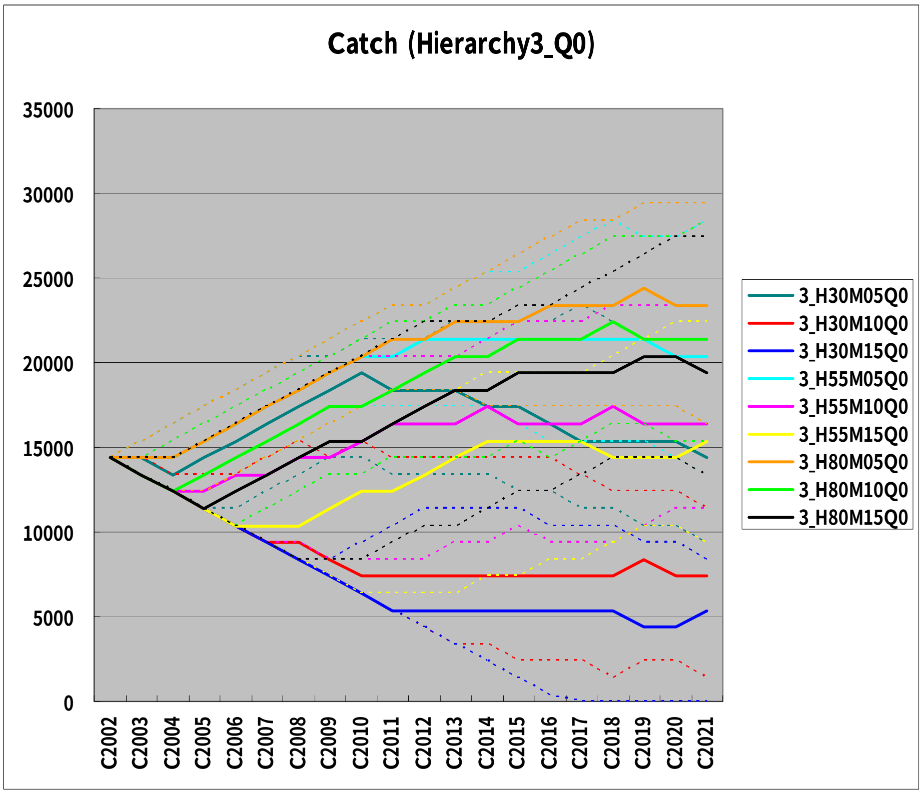
λ: the slope of the regression of ln($CPUE_{age4+}$) over 10 years (from y - 10 to y - 1),

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

2. Notes

Figure A3.1 showed results for the reference cases in the default. TACs decreased smoothly for two of the three scenarios with poor productivity and the spawning biomass almost stopped decreasing within the 20 year simulation period. However, inconsistency between catch and biomass trends was observed in the early simulation time for the H30M05 scenario and the spawning biomass continued to decrease over 20 years. TACs increased steadily without large oscillations for the scenarios with medium and high productivity, although TACs decreased for a few years in the early time. This MP also managed most of the robustness tests. However, significant decreases of the spawning biomass were observed in three scenarios (H30M10Q0_Omega, H30M10Q1_q1Omega, H30M05Q0_Mo5), because TACs did not decrease quickly.

When the control parameter a was too small, TACs changed almost every year in slight changes of CPUE trend. Also year-to-year variation of TACs was larger, as the other parameter c was larger (e.g. c = 2000). When periods for calculating CPUE trend were shortened to 5 years, the process and observation errors at hierarchy 3 prevented TACs from changing smoothly depending on productivity of scenarios. These results were also observed in the first-stage trials at the second MP workshop.



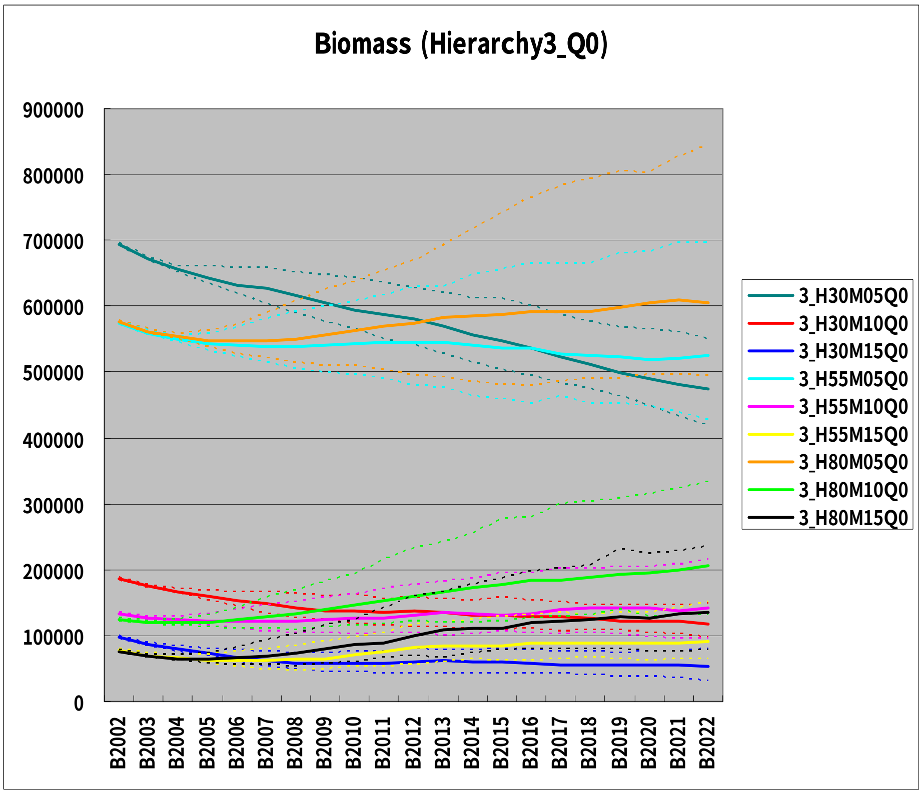


Figure A3.1. Results of the MP "TI1 v2".

Appendix 4. Outline of KH5-v5

Kazuhiko Hiramatsu

The structure of this MP is the same as the KH4 presented in the last MPWS2, except for the inclusion of the standard constraints for year to year changes in TACs (i.e. minimum and maximum change are 100 tons and 3000 tons, respectively).

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,

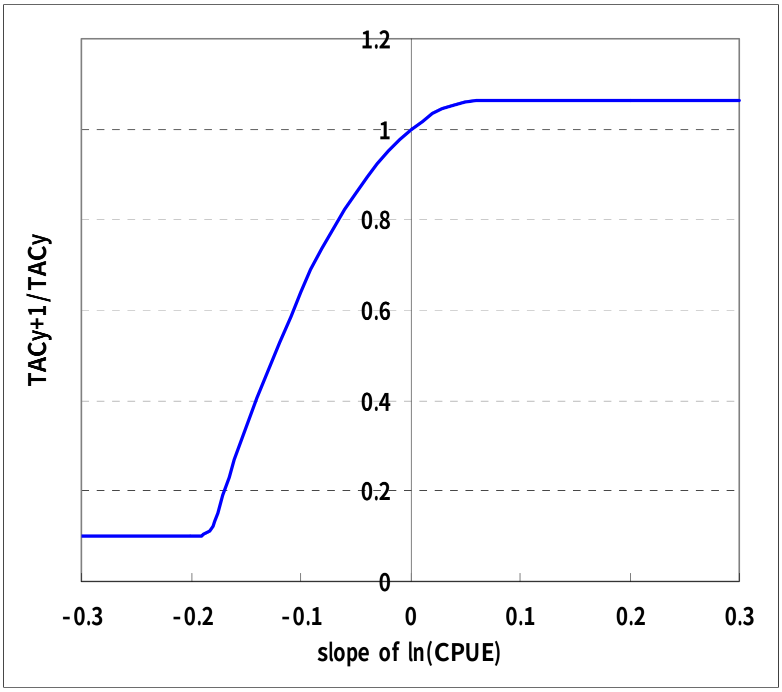
λ : the slope of the regression of ln(CPUE) versus time over the 10 years

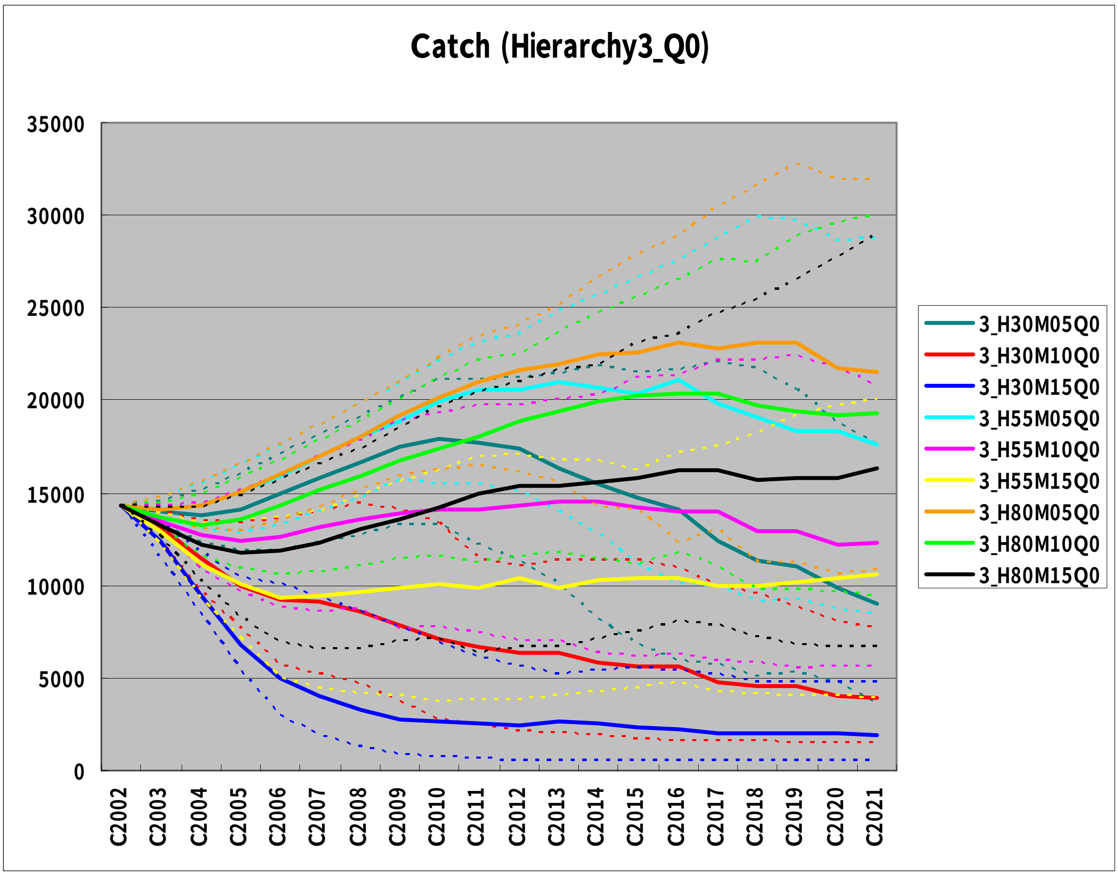
C_1、C_2、C_3 : control parameters (here $C_2 \leqq 0$)、

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 $\lambda < 0$.

The relation between λ and change in TAC and the trajectories of TAC and biomass are shown in following figures. Parameter values used in this MP are the same as the values used in KH4, i.e. $C_1=2$, $C_2=-16$, and $C_3=0.1$

The trends in TAC and biomass become relatively stable after 20 years, except for H3OM15Q0.


1.2
1
0.8
0.6
0.4
0.2
0
TACy+1/TACy
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
slope of ln(CPUE)


Catch (Hierarchy3_Q0)
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_H30M05Q0
3_H30M10Q0
3_H30M15Q0
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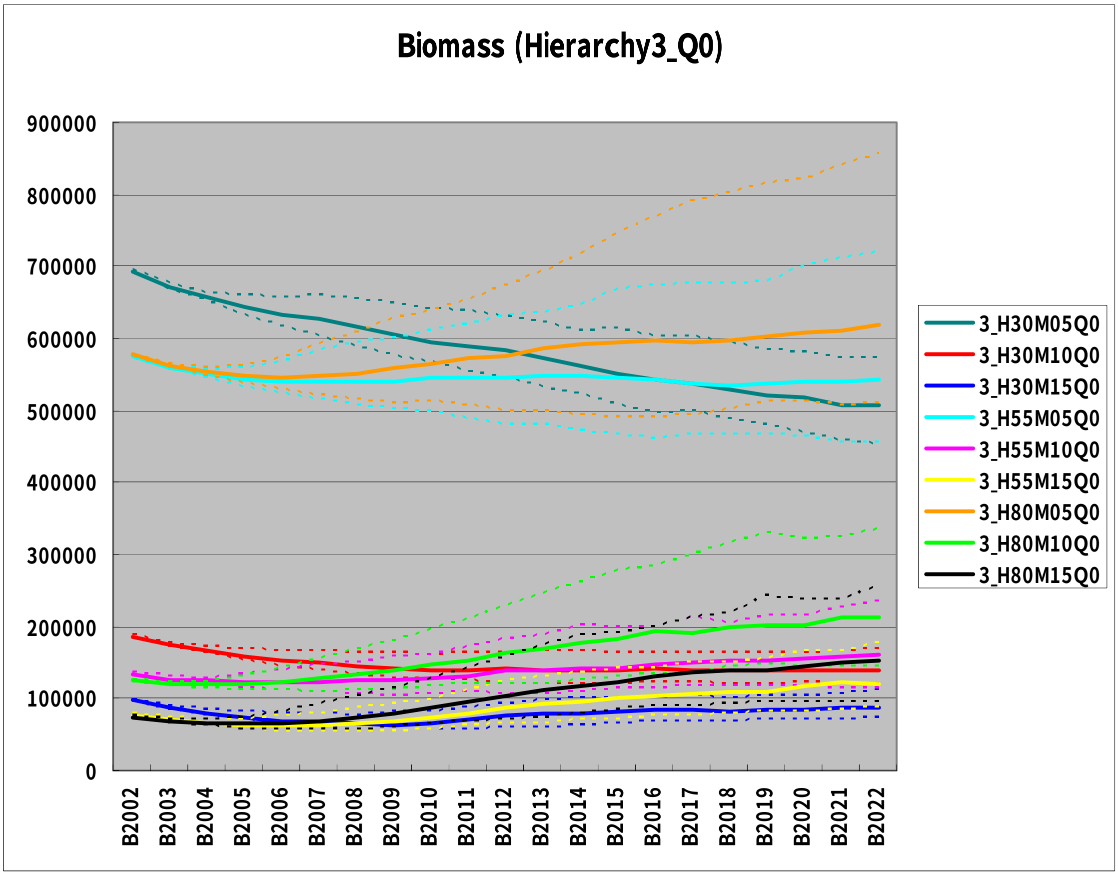
3_H80M10Q0
3_H80M15Q0


Biomass (Hierarchy3_Q0)
900000
800000
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_H30M05Q0
3_H30M10Q0
3_H30M15Q0
3_H55M05Q0
3_H55M10Q0
3_H55M15Q0
3_H80M05Q0
3_H80M10Q0
3_H80M15Q0

Appendix 5. 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). This MP was presented in the last MPWS2 and test results were updated for new scenarios. 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 specification 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

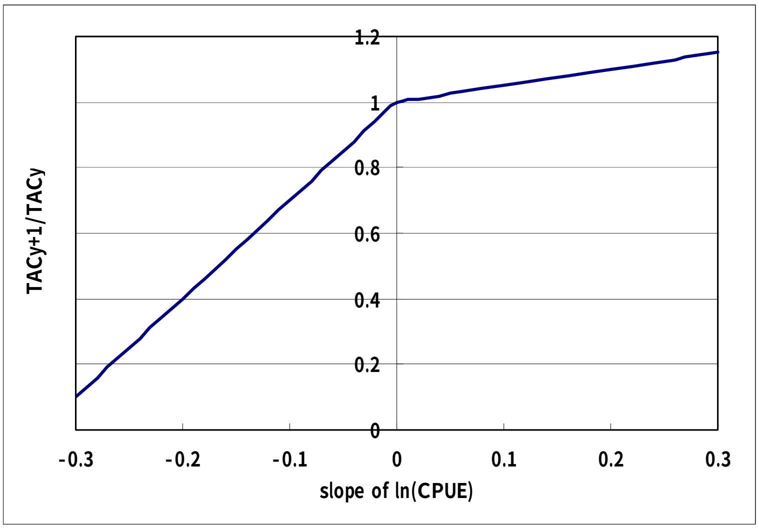
λ: the slope of the regression of ln(4+ CPUE) versus time over 10 years,

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. The effects of changes in the following values were examined.

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

Parameter values which gave good performance were: Time horizon=10, a=6, k=0.5, year lag=2. The following figure shows the graphical representation of CPUE-**λ** relationship for the parameter values determined above.

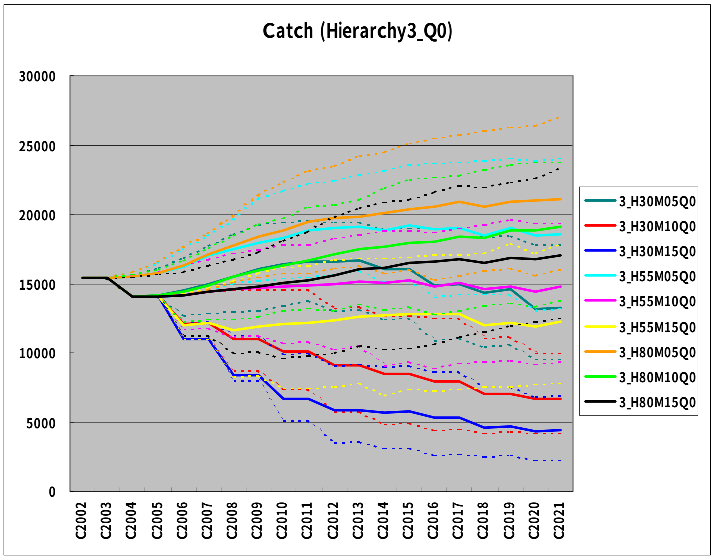


This MP adopts asymmetrical CPUE slope-TAC change relationship such that when the CPUE trend is positive TAC is increased slowly, while the trend is negative TAC is decreased rapidly.

2. Notes

Results of reference cases (hierarchy 3 and q0) are graphically presented in the following figures. Results of q0 scenarios are quite similar to ones of q1. Average dynamics of biomass reached stable state or turned to increasing after 20 years for most scenarios. Trends of TAC change were generally consistent with biomass trends. In a case where stock productivity is low (H30M05), the catch trend was not consistent with biomass dynamics (i. e., TAC increased while biomass continued to decline or vice versa).

In most of robustness tests, biomass trends turned to declining slowly, stopped decreasing, or turned to increasing depending on OM models (figures are not shown). Changes in catch consisted with the biomass trends. In some cases (e. g., H30M10, H30M05_Mo5), however, mean biomass trends continued to decline even when TAC was also continuously reduced. As well as reference cases, TAC changes were inconsistent with biomass dynamics in these cases.



Catch (Hierarchy3_Q0)
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_H30M05Q0
3_H30M10Q0
3_H30M15Q0
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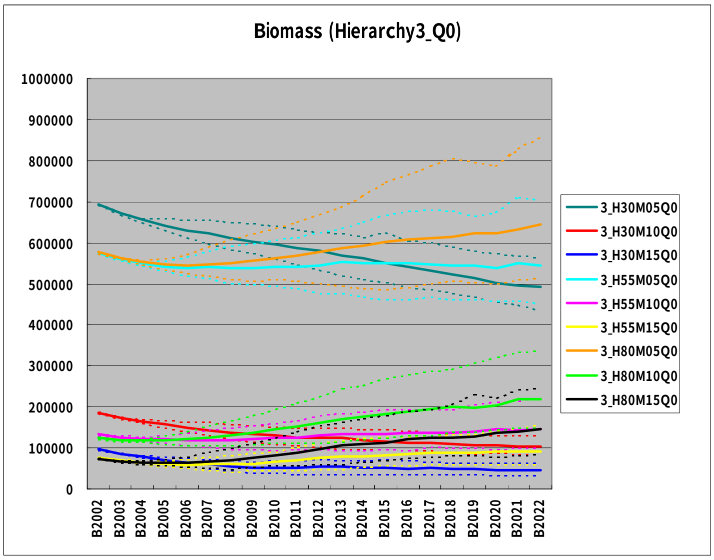
3_H80M15Q0



Biomass (Hierarchy3_Q0)
1000000
900000
800000
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_H30M05Q0
3_H30M10Q0
3_H30M15Q0
3_H55M05Q0
3_H55M10Q0
3_H55M15Q0
3_H80M05Q0
3_H80M10Q0
3_H80M15Q0

Appendix 6. Outline of "HK1-dfl v2"

Hiroyuki Kurota

1. Basic Idea

This MP is characterized by TAC control depending on CPUE trend of age 4+ and a fixed limit of TAC change. Formulation is exactly the same as that of the MP "HK1-1-w2" at the second MP workshop (Hiramatsu et al., 2003), although the default value of *k* is set as 1.0 instead of 5.0. 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 $\ln(CPUE_{age4+})$ over 10 years (from y - 10 to y - 1),

k, c: control parameters (k = 1, c = 2000 in the default case)

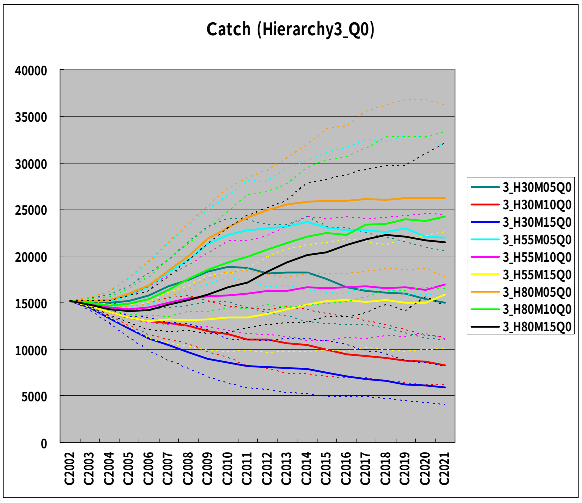
2. Notes

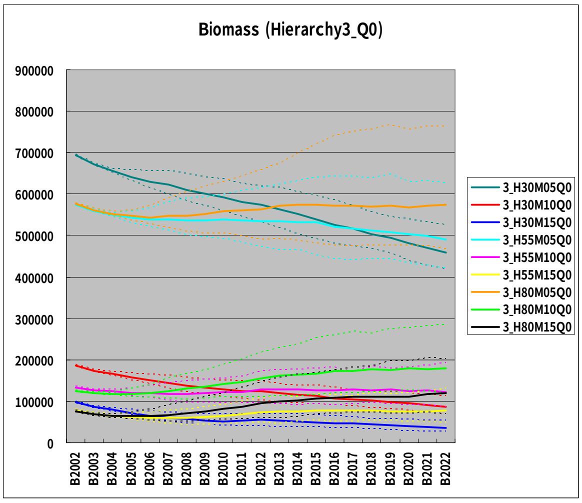
Figure A6.1 showed results for the reference cases and the robustness trials in the default case. In general, TACs changed smoothly depending on productivity of scenarios and the spawning biomass trend became more stable in the 20 year simulation period. However, inconsistency between catch and biomass trends was observed in the early time for the H30M05 and H55M05 scenarios, and the spawning biomass continued to decrease significantly for 20 years.

This MP managed some of the robustness tests. However, significant decreases of spawning biomass were observed in some scenarios, especially those with Omega and Mo5 options, because TACs increased in the early period even when the spawning biomass decreased.

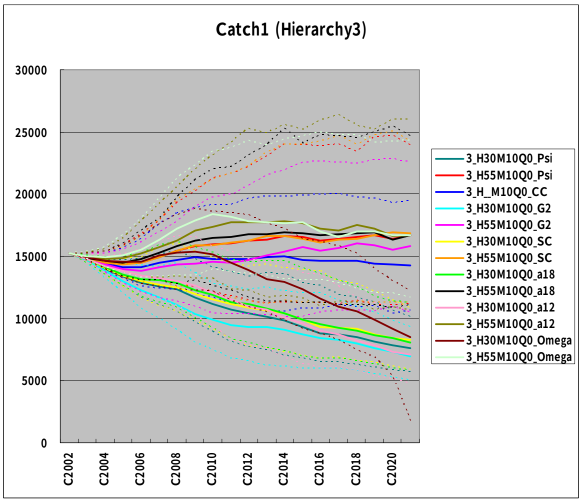
When *k* was large (*k* = 3), the MP stopped decline of spawning biomass in the low productive scenarios except H30M05, while year-to-year variation of TACs was larger. When periods for calculating CPUE trend were shortened to 5 years, process and observation errors at hierarchy 3 prevented TACs from changing quickly depending on productivity of each scenario. These results were also observed in the first-stage trials at the second MP workshop.

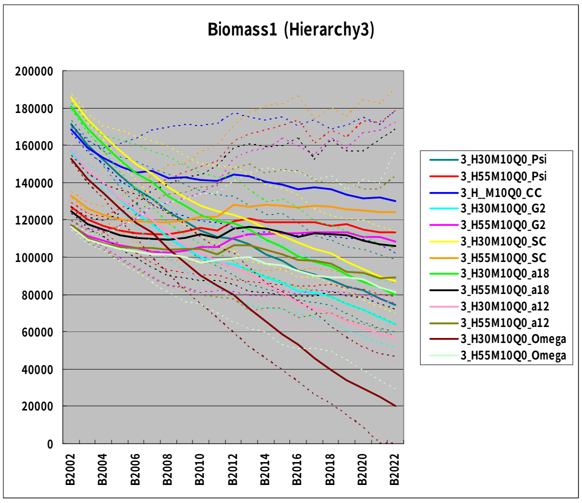
(a) Reference cases

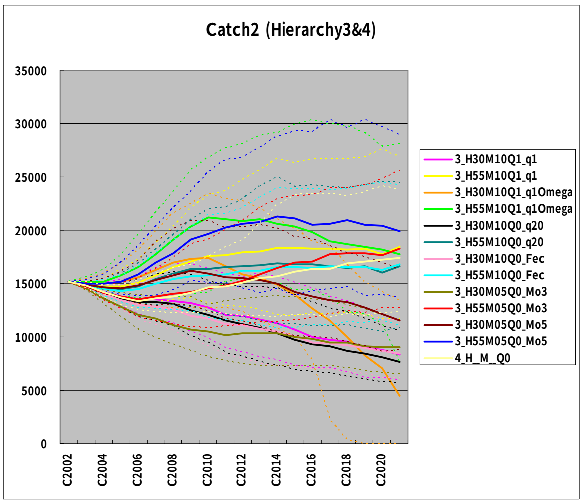




(b) Robustness tests







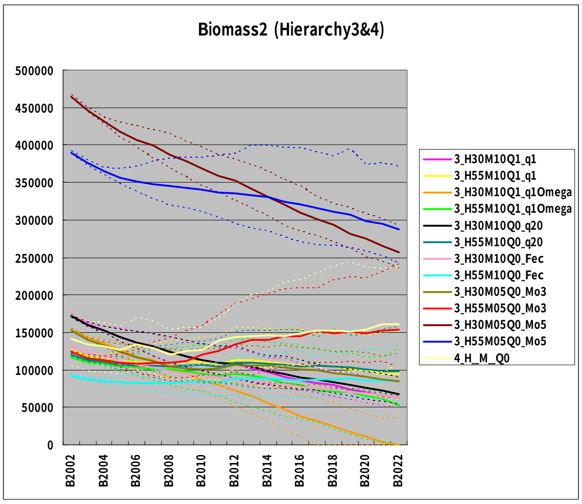


Figure A6.1. Results of the MP " HK1-dfl v2".

Appendix. 7. Outline of "HStnk" (HStanaka_v2 (Version2.0))

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,

α, β, γ : 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)

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

The following input parameters assumed in this analysis were almost same as those used in the document of CCSBT-MP/0304/11. These are as follows:

$$\alpha = 1.0,\ \beta = 0.2,\ \gamma = 0.5,\ T = 10,\ L = 10,\ CPUE_{2022}^{\text{target}} = 0.65 \qquad (3)$$

We hardly changed the program (i.e. TPL-file) from the 2nd MP workshop to this time except for the annual TAC limitation (i.e. maximum and minimum TAC changes are 3000 and 100 tonnage, respectively).

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

$$g(CPUE) = \frac{1}{1 + \exp\{-k(\lambda^{T} - t)\}} - 1 \qquad (4)$$

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

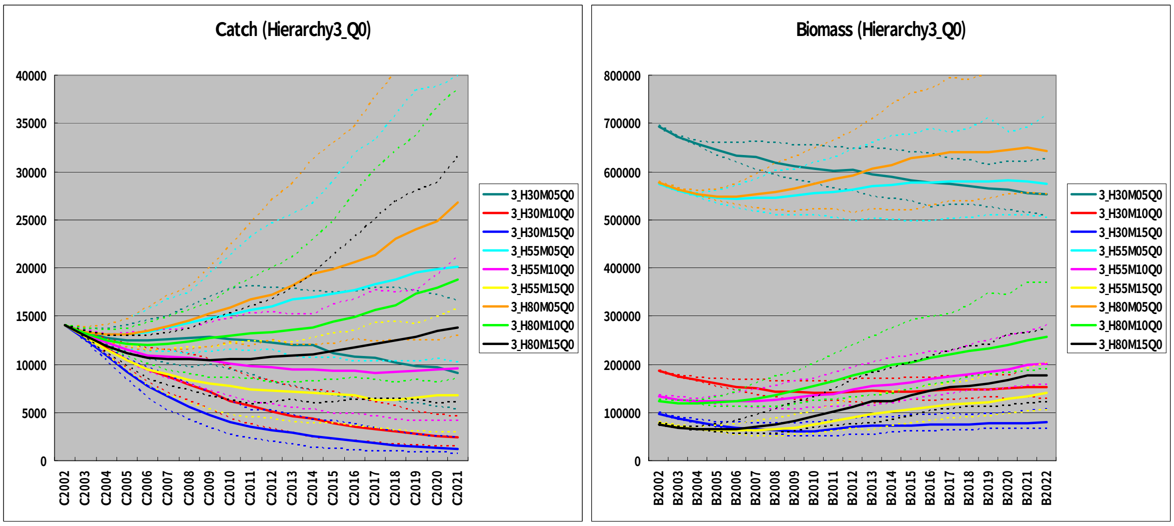
$$level(CPUE_{y+1}) = level(CPUE_{y}) + \frac{CPUE_{2022}^{\text{target}} - CPUE_{y}}{22}$$
$$\left(or\ level(CPUE_{y+1}) = level(CPUE_{y}) + \frac{CPUE_{2022}^{\text{target}} - CPUE_{y}}{2022 - (y+1)} \right) \qquad (5)$$

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, these 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 H30M10 and H30M15 in the reference case is a little increased because of using the non-symmetrical TAC control rule. Although it is difficult to set the adequate level of target CPUE, the assumption in this case (target CPUE in 2022 is 0.65.) seems to be quite good. If the adequate value is set as a target CPUE, then we can obtain the stable results (i.e. CPUE and SSB trends etc.) from the Tanaka's feedback method.

(a) Reference cases



(b) Robustness tests

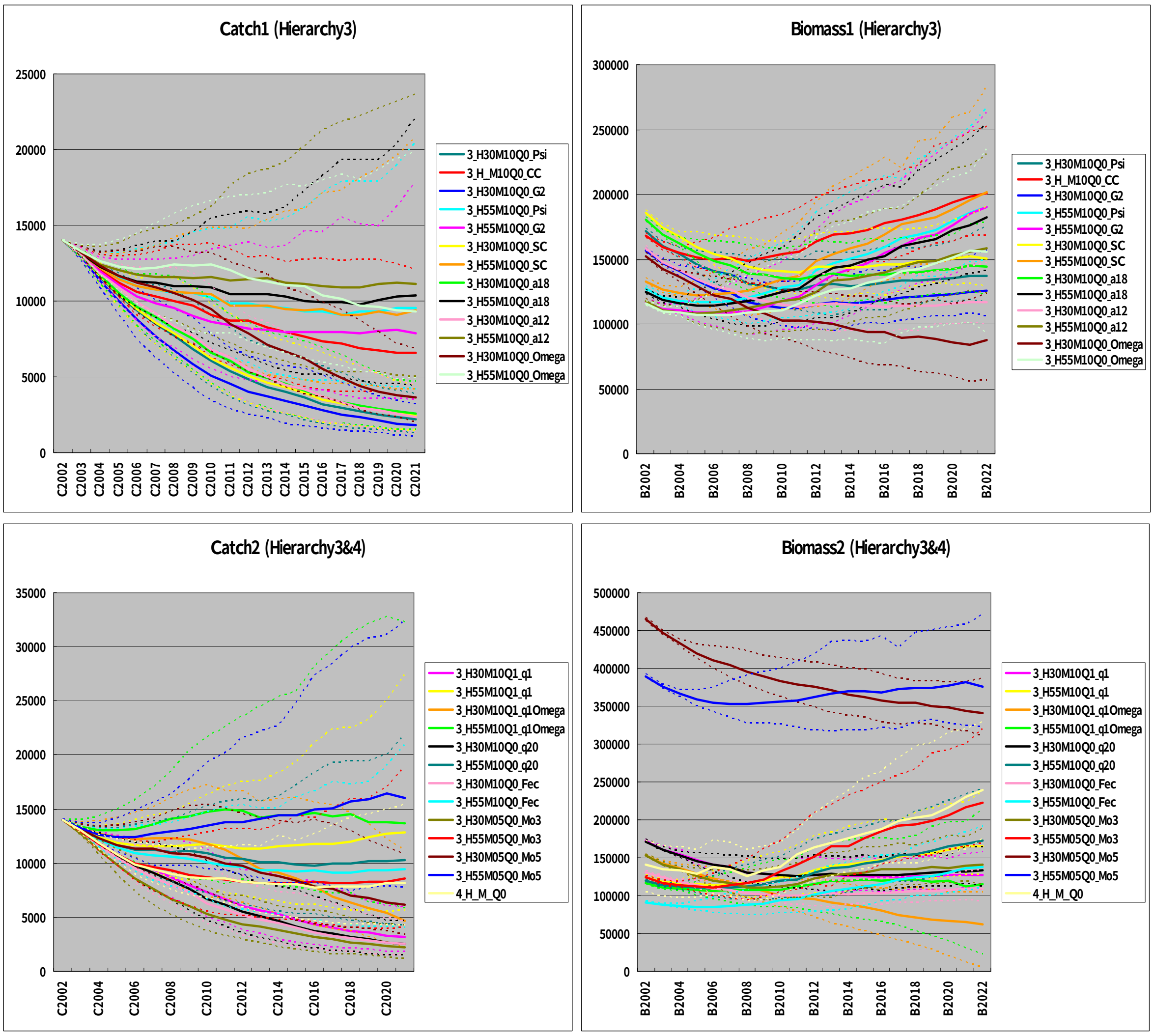


Figure A7.1. Results of the MP "”HStnk” (HStanaka_v2).

Appendix 8. Outline of "HK2-bms v1"

Hiroyuki Kurota, Norio Takahashi and Sachiko Tsuji

1. Basic Idea

Most of previous MPs were based on CPUE in numbers. CPUE in numbers might be easier to fluctuate to uncertainties such as variability of recruitment than CPUE in biomass. Thus, MP based on CPUE trend in biomass is explored to develop more robust MP to uncertainties. Formulation is the same as that of "HK1-1-w2" (Hiramatsu et al., 2003) and "HK1-dfl v2". The only difference is that used CPUE is based on biomass, not numbers. Past CPUE in biomass is calculated conveniently from the median CPUE in number and average body weight of age 4+. 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$_{age4+}$ in biomass) over 10 years (from y - 10 to y - 1),

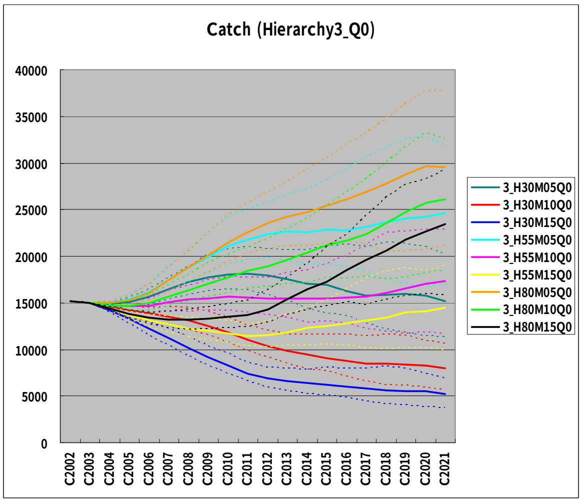
k, c: control parameters (k = 1, c = 2000 in the default case)

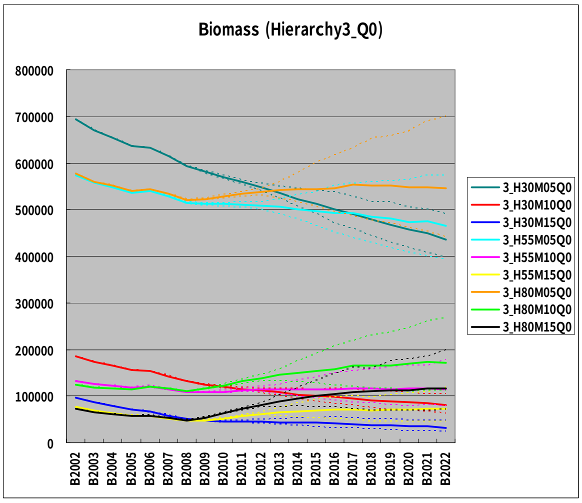
2. Notes

Figure A8.1 showed results in the default case for the reference cases and the robustness trials. Trajectory of catch in the reference cases did not show significant differences from results in using CPUE in numbers, although TACs continued to increase under the productive scenarios. However, this MP did not manage at all the robustness tests with the omega option and stock collapsed quickly.

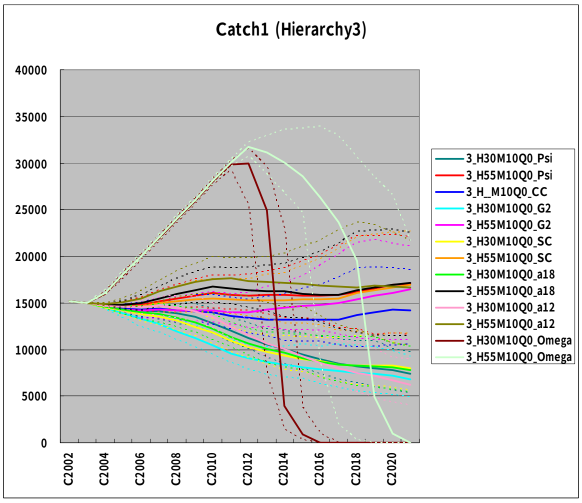
Figure A8.2 showed changes of CPUE in numbers and biomass under the current catch (15380t). They indicated that CPUE in biomass looked a little more stable than CPUE in numbers. In other words, it is insensitive to changes of stock conditions. This is because this MP was not able to manage scenarios with omega options, which was difficult to detect stock decline.

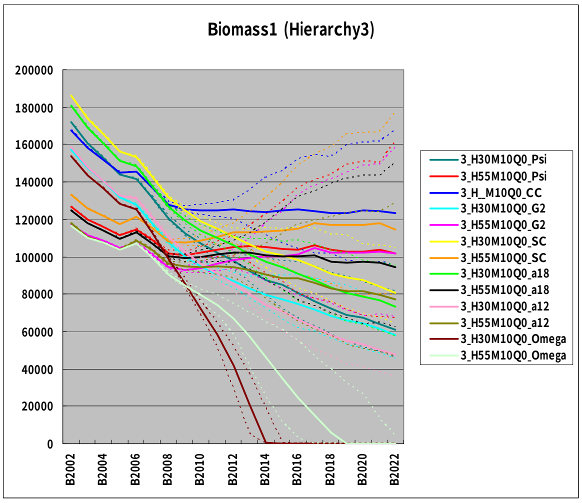
(a) Reference cases

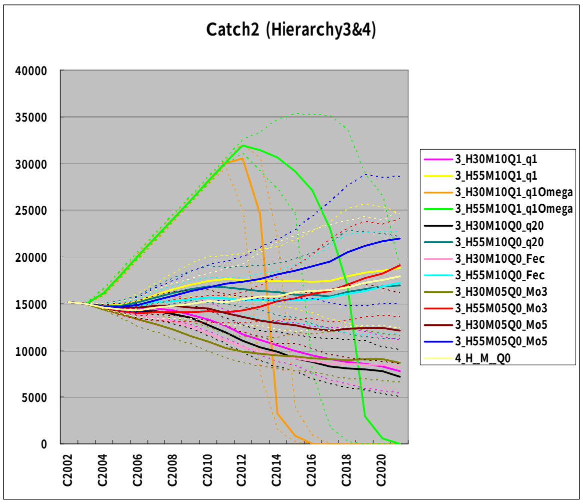




(b) Robustness tests







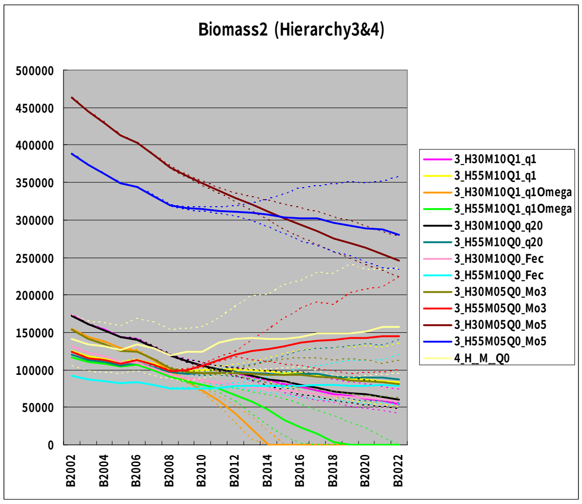


Figure A8.1. Results of the MP " HK2-bms v1".

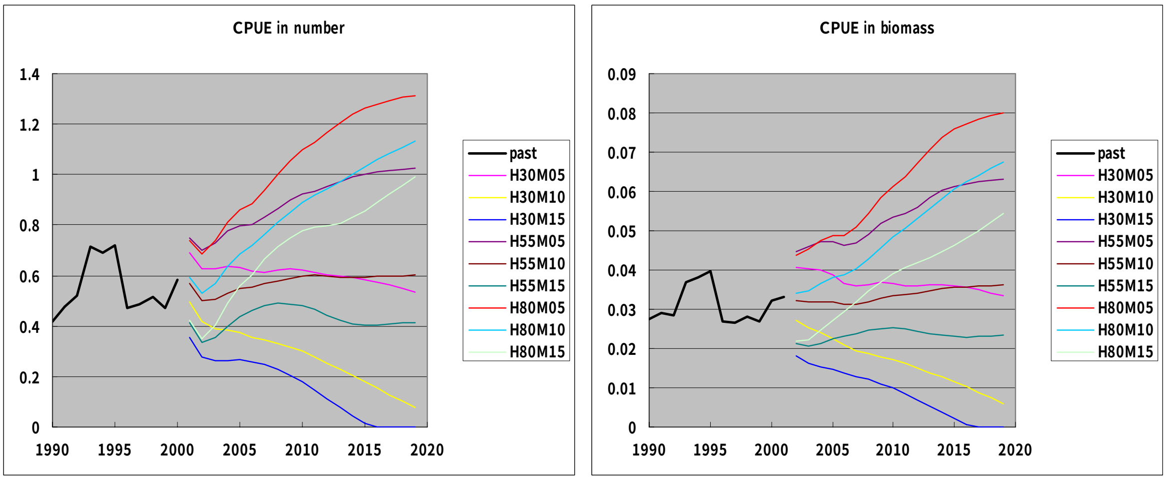


Figure A8.2. CPUE changes under the current catch (left: in number, right: in biomass).

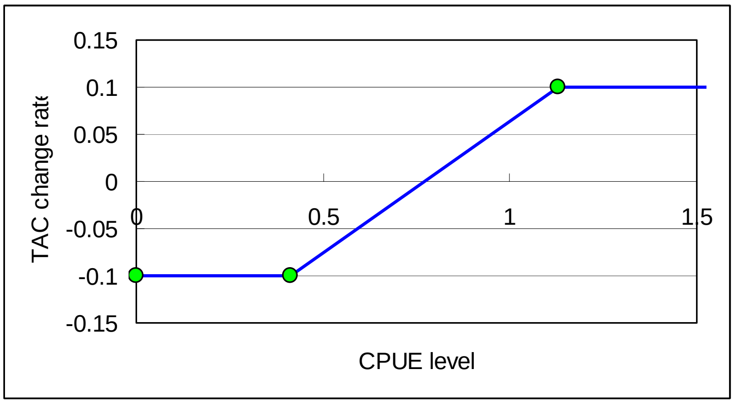
Appendix 9. Outline of “STlv1 v1”

Norio Takahashi

1. Basic Idea

This rule-based MP determines TAC corresponding to CPUE level. The relationship between 4+ CPUE level and the rate of TAC change is predefined as a function. TAC is changed by the rate determined from this function to which the current CPUE level applies.

The function of CPUE level-TAC change rate relationship used is represented in the following figure.



Two inflection points of the function correspond to CPUE of historically lowest level (0.4146) and 1980 level (1.1299), respectively.

TAC specification is:

$$TAC_{y+1} = TAC_y \times (1 + r)$$

where r is the rate of TAC change determined from the function above, applying the most recent 4+ CPUE available. TAC is rounded down by the unit of 100 tons.

Various transformations of this MP were examined and one which gave a good performance was empirically selected (MP explained above). The transformations explored include combinations of the following elements:

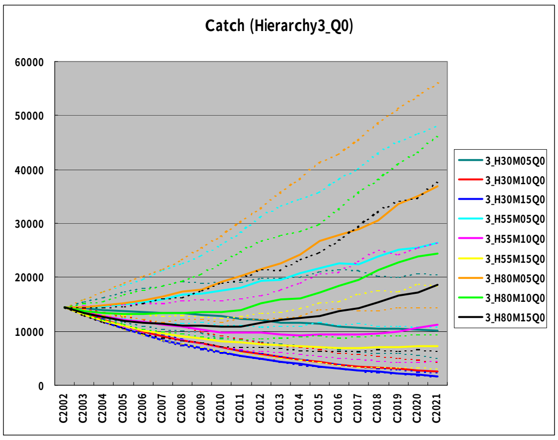
1) TAC change rates of 2, 3, 5, 8, 10, or 20%
2) If the current CPUE is less than the historically lowest level, then TAC is reduced by x%; if the current CPUE is greater than 1980 level, then TAC is increased by y%; TAC change rates between these 2 CPUE levels are determined by a linear interpolation.

3) If the current CPUE is less than the historically lowest level, then TAC is reduced by x%; if the current CPUE is equal to the recent CPUE level (0.5064, average of 1996-2000), then TAC is unchanged; if the current CPUE is greater than 1980 level, then TAC is increased by y%; TAC change rates between these 3 CPUE levels are determined by a linear interpolation.
4) The most recent CPUE or an average of CPUEs over the most recent 10 years is applied to set TAC

2. Notes

Results of reference and robustness scenarios (hierarchy 3) are graphically presented in the following figures. Results of q0 scenarios are quite similar to ones of q1 in reference cases. Mean biomass dynamics reached one of the following states after 20 years depending on scenarios: 1) stable; 2) turned to declining slowly; 3) stopped decreasing; or 4) turned to increasing. Trends of TAC change were consistent with stock dynamics (i. e., TAC increased when biomass continued to increase or vice versa).

In some cases where stock continued to declining slowly after 20 years (e.g., H30M10Q1_q1Omega), this MP could stop decline of biomass when looking at time horizon of 50 years (figures are not shown). However, in other cases where TAC rapidly increased corresponding to continuous stock increase (e. g., H55M10Q1_q1Omega), stock eventually collapsed due to large increase of TAC during 50 years.


Catch (Hierarchy3_Q0)
3_H30M05Q0
3_H30M10Q0
3_H30M15Q0
3_H55M05Q0
3_H55M10Q0
3_H55M15Q0
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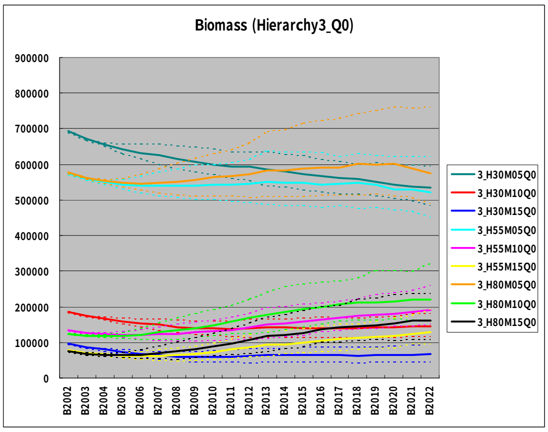
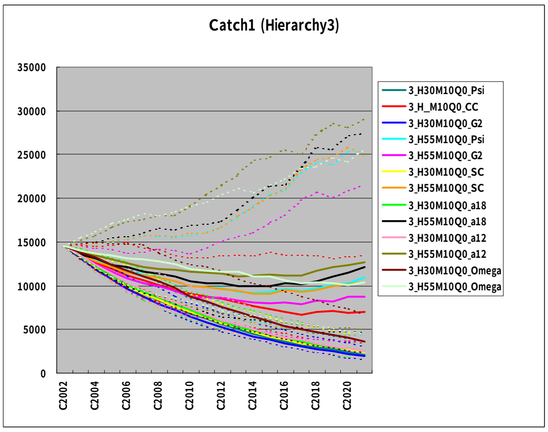
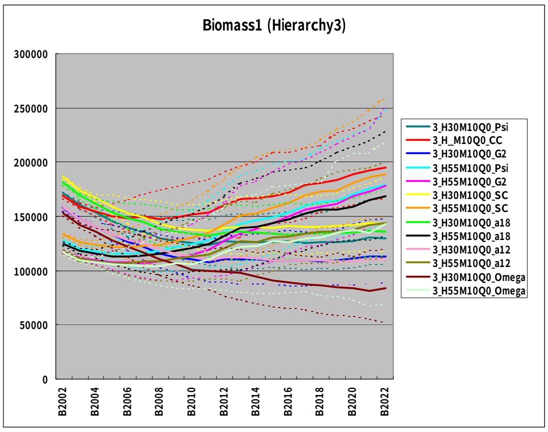
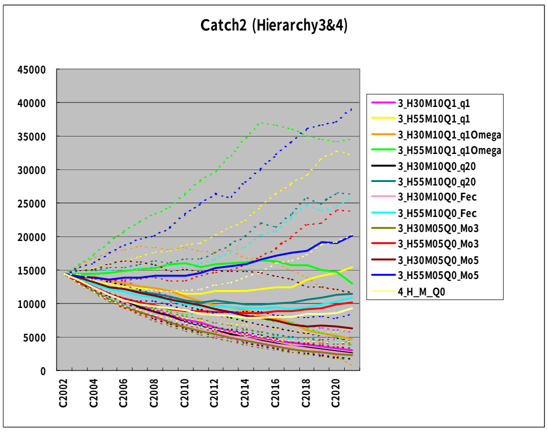
3_H80M15Q0


Biomass (Hierarchy3_Q0)
3_H30M05Q0
3_H30M10Q0
3_H30M15Q0
3_H55M05Q0
3_H55M10Q0
3_H55M15Q0
3_H80M05Q0
3_H80M10Q0
3_H80M15Q0


Catch1 (Hierarchy3)
3_H30M10Q0_Psi
3_H_M10Q0_CC
3_H30M10Q0_G2
3_H55M10Q0_Psi
3_H55M10Q0_G2
3_H30M10Q0_SC
3_H55M10Q0_SC
3_H30M10Q0_a18
3_H55M10Q0_a18
3_H30M10Q0_a12
3_H55M10Q0_a12
3_H30M10Q0_Omega
3_H55M10Q0_Omega


Biomass1 (Hierarchy3)
3_H30M10Q0_Psi
3_H_M10Q0_CC
3_H30M10Q0_G2
3_H55M10Q0_Psi
3_H55M10Q0_G2
3_H30M10Q0_SC
3_H55M10Q0_SC
3_H30M10Q0_a18
3_H55M10Q0_a18
3_H30M10Q0_a12
3_H55M10Q0_a12
3_H30M10Q0_Omega
3_H55M10Q0_Omega


Catch2 (Hierarchy3&4)
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3_H55M10Q1_q1
3_H30M10Q1_q1Omega
3_H55M10Q1_q1Omega
3_H30M10Q0_q20
3_H55M10Q0_q20
3_H30M10Q0_Fec
3_H55M10Q0_Fec
3_H30M05Q0_Mo3
3_H55M05Q0_Mo3
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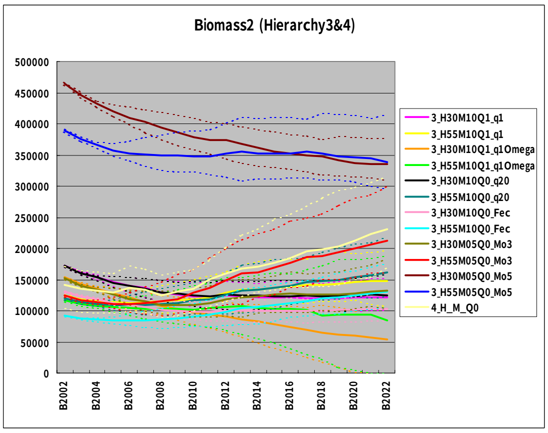
3_H55M05Q0_Mo5
4_H_M_Q0


Biomass2 (Hierarchy3&4)
3_H30M10Q1_q1
3_H55M10Q1_q1
3_H30M10Q1_q1Omega
3_H55M10Q1_q1Omega
3_H30M10Q0_q20
3_H55M10Q0_q20
3_H30M10Q0_Fec
3_H55M10Q0_Fec
3_H30M05Q0_Mo3
3_H55M05Q0_Mo3
3_H30M05Q0_Mo5
3_H55M05Q0_Mo5
4_H_M_Q0

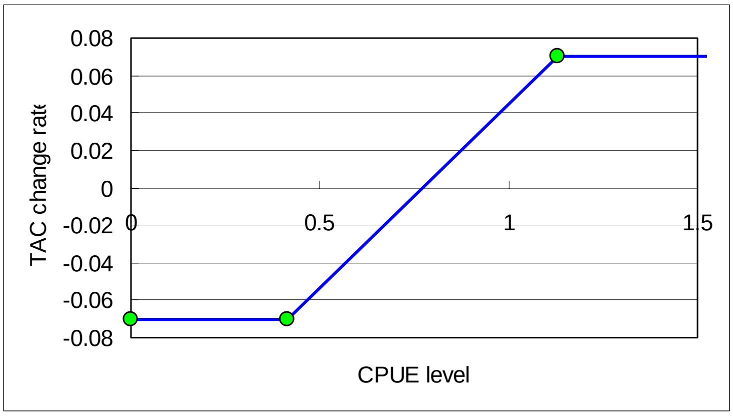
Appendix 10. Outline of “STlv1.1 v1”

Norio Takahashi

1. Basic Idea

This rule-based MP determines TAC corresponding to either 4+ CPUE level or CPUE slope. TAC is firstly specified using CPUE level and slope separately in the MP, and then final TAC is set as a minimum of TAC specified by the either ways. Details of TAC specifications by CPUE level and slope are explained as follows.

As well as “STlv1 v1” MP, the relationship between 4+ CPUE level and the rate of TAC change is predefined as a function. The relationship is represented in the following figure.



Two inflection points of the function correspond to CPUE of historically lowest level (0.4146) and 1980 level (1.1299), respectively.

TAC specification of using CPUE level is:

$$TAC_{y+1} = TAC_y \times (1 + r)$$

where r is the rate of TAC change determined from the function above, applying the most recent 4+ CPUE available.

TAC specification by CPUE slope 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(4+ CPUE) versus time over 10 years,

a、 k: parameters (a=1, k=0.8 in this case)

Final TAC is set as a minimum of TAC values specified using CPUE level or slope. TAC is rounded down by the unit of 100 tons.

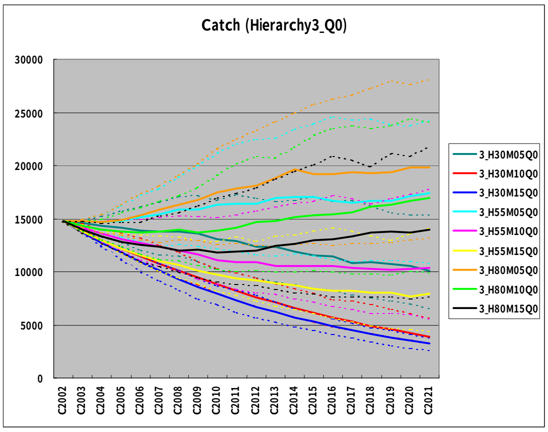
Various transformations and parameter values of this MP were examined and one which gave a good performance was empirically selected (MP explained above). The transformations and parameters explored include combinations of the following elements:

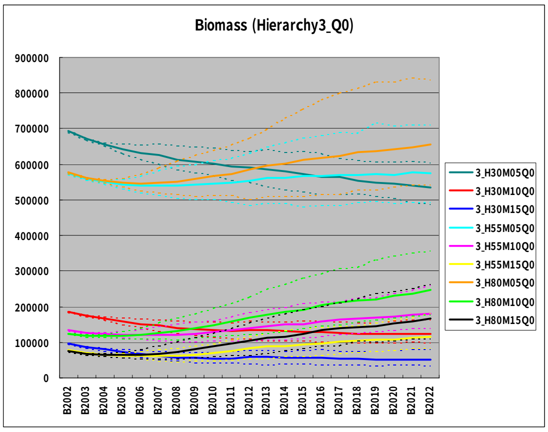
5) TAC change rates of 5, 7, 8, or 10%
6) If the current CPUE is less than the historically lowest level, then TAC is reduced by x%; if the current CPUE is greater than 1980 level, then TAC is increased by y%; TAC change rates between these 2 CPUE levels are determined by a linear interpolation.
7) If the current CPUE is less than the historically lowest level, then TAC is reduced by x%; if the current CPUE is equal to the recent CPUE level (0.5064, average of 1996-2000), then TAC is unchanged; if the current CPUE is greater than 1980 level, then TAC is increased by y%; TAC change rates between these 3 CPUE levels are determined by a linear interpolation.
8) k = 0.5, 0.8, 1.0, 1.5, or 2.0
9) a = 1.0, 3.0, or 6.0

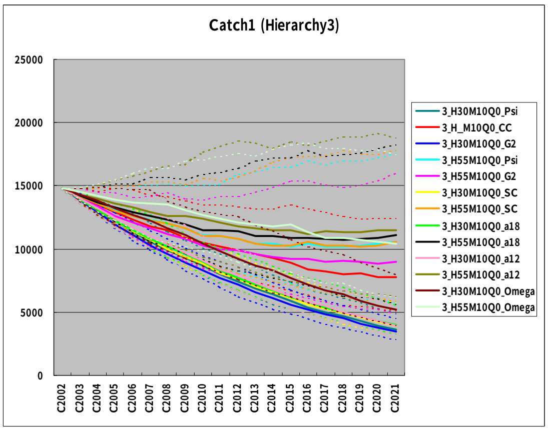
2. Notes

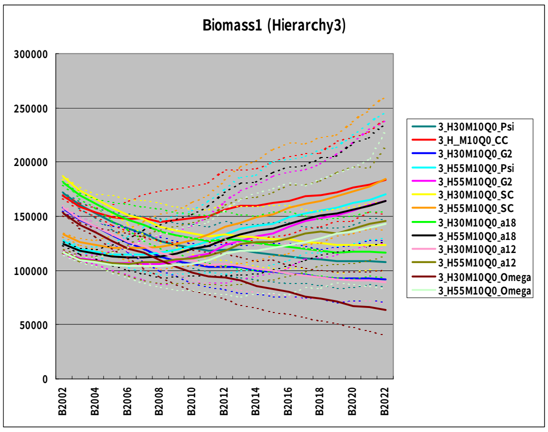
Results of reference and robustness scenarios (hierarchy 3) are graphically presented in the following figures. Results of q0 scenarios are quite similar to ones of q1 in reference cases. Average stock dynamics reached one of the following states after 20 years depending on scenarios: 1) stable; 2) turned to declining slowly; 3) stopped decreasing; or 4) turned to increasing. Trends of TAC change were consistent with stock dynamics (i. e., TAC increased when stock continued to increase or vice versa).

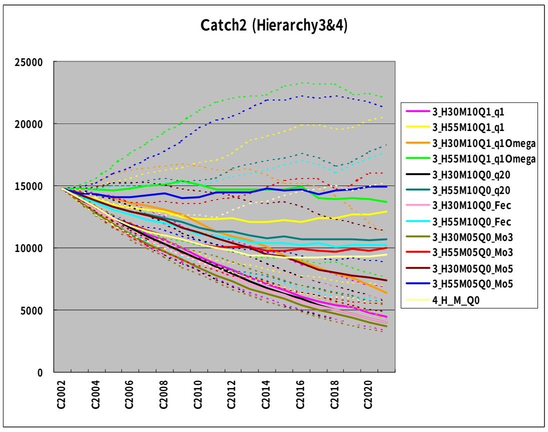
In some cases where stock continued to declining slowly after 20 years (e.g., H30M10Q1_q1Omega), this MP could stop decline of biomass when looking at time horizon of 50 years (figures are not shown). Furthermore this MP did not lead to stock collapse due to large TAC increase during 50 years in cases where TAC rapidly increased corresponding to continuous stock increase (e. g., H55M10Q1_q1Omega).

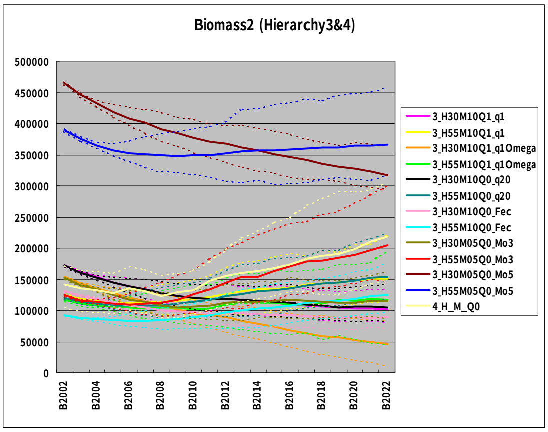

Catch (Hierarchy3_Q0)
30000
25000
20000
15000
10000
5000
0
C2002 C2003 C2004 C2005 C2006 C2007 C2008 C2009 C2010 C2011 C2012 C2013 C2014 C2015 C2016 C2017 C2018 C2019 C2020 C2021
3_H30M05Q0
3_H30M10Q0
3_H30M15Q0
3_H55M05Q0
3_H55M10Q0
3_H55M15Q0
3_H80M05Q0
3_H80M10Q0
3_H80M15Q0


Biomass (Hierarchy3_Q0)
900000
800000
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_H30M05Q0
3_H30M10Q0
3_H30M15Q0
3_H55M05Q0
3_H55M10Q0
3_H55M15Q0
3_H80M05Q0
3_H80M10Q0
3_H80M15Q0


Catch1 (Hierarchy3)
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_H30M10Q0_Psi
3_H_M10Q0_CC
3_H30M10Q0_G2
3_H55M10Q0_Psi
3_H55M10Q0_G2
3_H30M10Q0_SC
3_H55M10Q0_SC
3_H30M10Q0_a18
3_H55M10Q0_a18
3_H30M10Q0_a12
3_H55M10Q0_a12
3_H30M10Q0_Omega
3_H55M10Q0_Omega


Biomass1 (Hierarchy3)
300000
250000
200000
150000
100000
50000
0
B2002 B2004 B2006 B2008 B2010 B2012 B2014 B2016 B2018 B2020 B2022
3_H30M10Q0_Psi
3_H_M10Q0_CC
3_H30M10Q0_G2
3_H55M10Q0_Psi
3_H55M10Q0_G2
3_H30M10Q0_SC
3_H55M10Q0_SC
3_H30M10Q0_a18
3_H55M10Q0_a18
3_H30M10Q0_a12
3_H55M10Q0_a12
3_H30M10Q0_Omega
3_H55M10Q0_Omega


Catch2 (Hierarchy3&4)
25000
20000
15000
10000
5000
0
C2002 C2004 C2006 C2008 C2010 C2012 C2014 C2016 C2018 C2020
3_H30M10Q1_q1
3_H55M10Q1_q1
3_H30M10Q1_q1Omega
3_H55M10Q1_q1Omega
3_H30M10Q0_q20
3_H55M10Q0_q20
3_H30M10Q0_Fec
3_H55M10Q0_Fec
3_H30M05Q0_Mo3
3_H55M05Q0_Mo3
3_H30M05Q0_Mo5
3_H55M05Q0_Mo5
4_H_M_Q0


Biomass2 (Hierarchy3&4)
500000
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
B2002 B2004 B2006 B2008 B2010 B2012 B2014 B2016 B2018 B2020 B2022
3_H30M10Q1_q1
3_H55M10Q1_q1
3_H30M10Q1_q1Omega
3_H55M10Q1_q1Omega
3_H30M10Q0_q20
3_H55M10Q0_q20
3_H30M10Q0_Fec
3_H55M10Q0_Fec
3_H30M05Q0_Mo3
3_H55M05Q0_Mo3
3_H30M05Q0_Mo5
3_H55M05Q0_Mo5
4_H_M_Q0

Appendix 11. Outline of "HK3-ag4 v1"

Hiroyuki Kurota and Norio Takahashi

1. Basic Idea

Fishery management based on amount of recruitment could be useful in SBT fishery targeting mainly juvenile fish. CPUE of age 4 in numbers ($CPUE_{age4}$) is assumed to be an index of recruitment out of information available in the projection. Nominal $CPUE_{age4}$ of Japanese longline is used as the past data before 2000 (Figure A11.1) and $CPUE_{age4}$ is calculated from CPUE of age 4+ and age-composition data of LL1 provided in the file "sbtOMdata" in the projection.

$$CPUE_{age4} = \frac{catch_{age4}}{catch_{age4+}} \times CPUE_{age4+}$$

TAC is determined by the $CPUE_{age4}$ trend as follows:

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

where

λ: the slope of the regression of ln($CPUE_{age4}$) over 10 years (from y - 10 to y - 1),

k, c: control parameters (k = 1, c = 2000 in the default case)

The model fomulation and parameter values are the same as those in the MP "HK1-dfl v2" except for age ranges of used CPUE.

2. Notes

Figure A11.2 showed results for the reference cases and the robustness trials in the default. TACs decreased in the first several years in the all scenarios and then increased in the productive scenarios and decreased in the poor scenarios in general, though they increased slightly after around 2010. However, inconsistency between catch and biomass trends was observed in the H30M05 scenario, which were also found in the MP "HK1-dfl v2" based on $CPUE_{age4+}$ trend. Biomass decline did not stop in H30 scenarios including robustness trials. This MP based on CPUE trend of age 4 did not show higher performance than that based on CPUE trend of age 4+. This is probably because CPUE of age 4 is too easy to fluctuate in order to detect stock conditions.

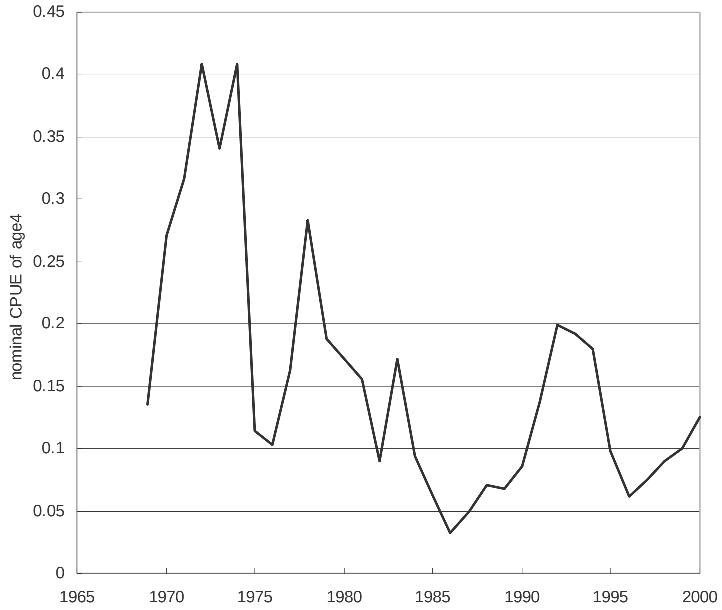
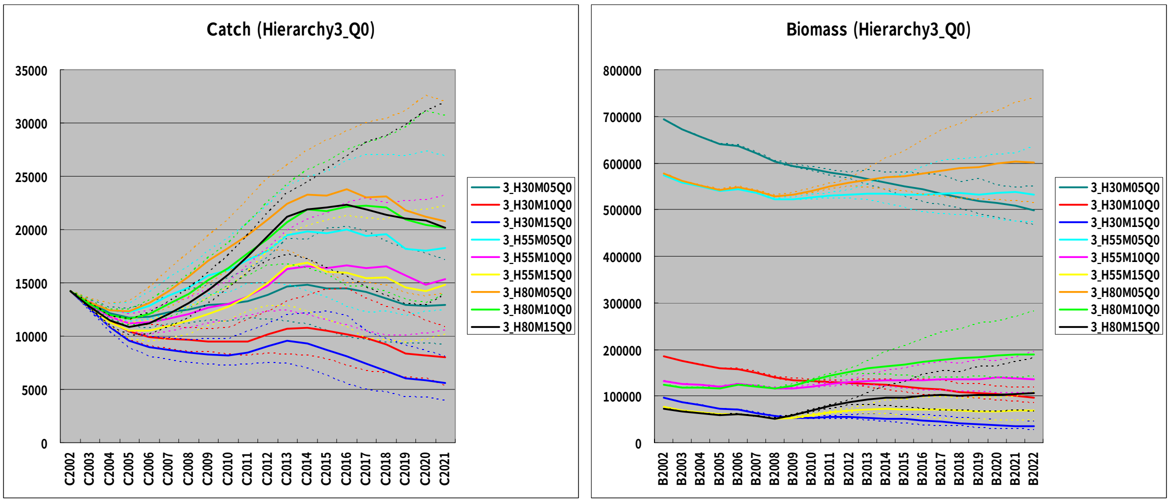


Figure A11.1. Past nominal CPUE of age 4 used in this MP.

(a) Reference cases



(b) Robustness tests

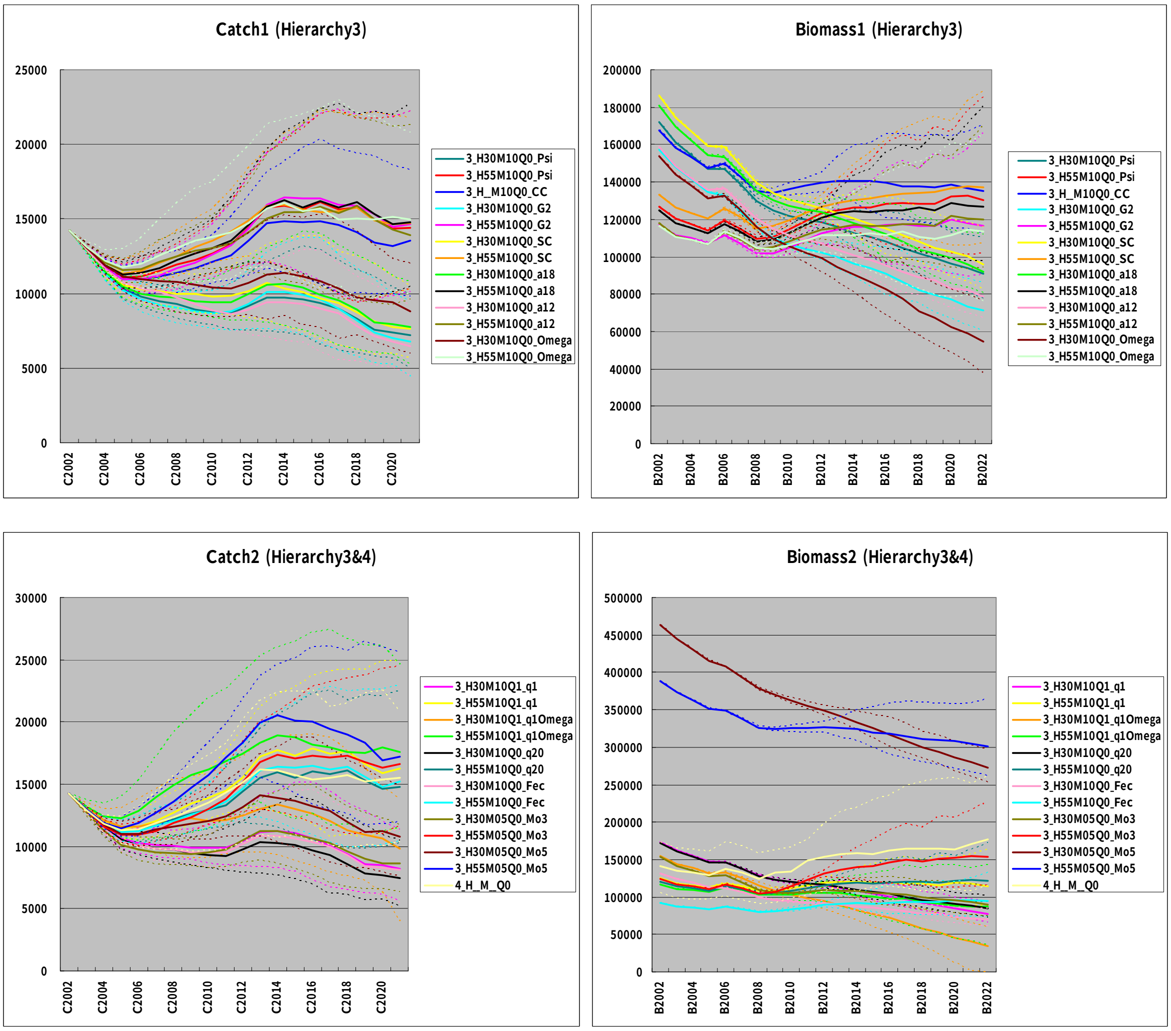


Figure A11.2. Results of the MP " HK3-ag4 v1"

Appendix 12. Outline of "HK4-lv4 v1"

Hiroyuki Kurota

1. Basic Idea

CPUE of age 4 in numbers ($CPUE_{age4}$) is assumed to be an index of recruitment. Changes in TAC are determined by the CPUE level of the previous year, not CPUE trend over 10 years. The calculating method of $CPUE_{age4}$ is similar to that in the MP "HK3-ag4 v1". TAC is specified by:

$$TAC_{y+1} = TAC_y \times \left(1 + f(CPUE_{age4,\, y-1})\right)$$

$$f(CPUE_{age4,\, y-1}) = \begin{cases} m_{\max} & if \quad CPUE_{age4,\, y-1} > l_{\max} \\ a \times CPUE_{age4,\, y-1} + b & if \quad l_{\min} \le CPUE_{age4,\, y-1} \le l_{\max} \\ m_{\min} & if \quad CPUE_{age4,\, y-1} < l_{\min} \end{cases}$$

where

m_{max}, m_{min}, l_{max}, l_{min}, a, b: control parameters (m_{max} = 0.1, m_{min} = -0.1, a = 1.21, b = -0.16, l_{max} = 0.214, l_{min} = 0.048 in the default case)

Figure A12.1 shows a relation between $CPUE_{age4}$ and TAC change. Average nominal $CPUE_{age4}$ in 1985-1987 (l_{min}, minimum in the past) and $CPUE_{age4}$ in 1978-1980 (l_{max}) are set as a reference level of $CPUE_{age4}$ at a lower (m_{min}) and upper (m_{max}) limit of TAC change, respectively. Linear relation is assumed between the reference levels.

2. Notes

Figures A12.2 showed results for the reference cases and the robustness trials in the default case. TACs changed reasonably depending on productivity of scenerios. The spawning biomass almost became stable within the 20 year simulation period. Inconsistency between catch and biomass trends was not observed in the early simulation time for the H30M05 and H55M05 scenarios, which were often found in MPs based on CPUE trend. The robustness tests including those with omega and Mo5 options were managed. These are because recruitments depend on steepness straightforward. Thus, this MP looked better than previous ones based on CPUE trend judging from our target.

However, when simulation period was set as 50 years, stock collapse were occured after 2030 under the high productive scenarios (Figure A12.3). This is because decline of spawning biomass did not result in TAC reduction without time lag. It took some time for $CPUE_{age4}$ level to become lower than a critical level, where change in TAC was zero, while $CPUE_{age4}$ trend was negative. It indicates that it is important to check MP behaviors for more than 20 years.

When l_{max} was set higher (0.386, average in 1972-1974), the MP became more conservative and TACs were lower than the current level in all reference scenarios through the simulation periods. When m_{max} and m_{min} was larger (ex. 0.2, -0.2, respectively), TACs fluctuated more often and it looked worse than the default case.

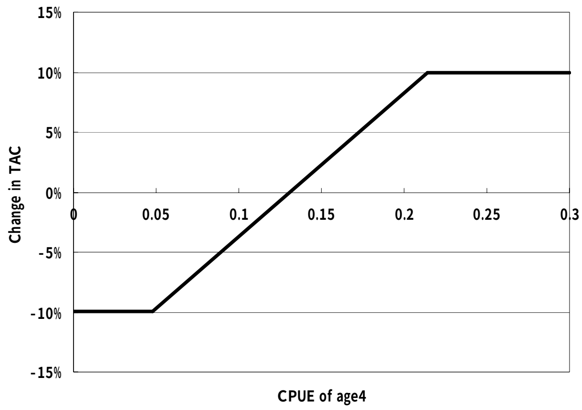
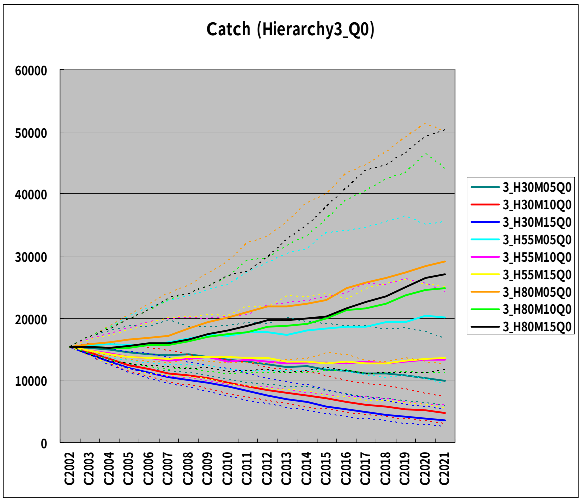
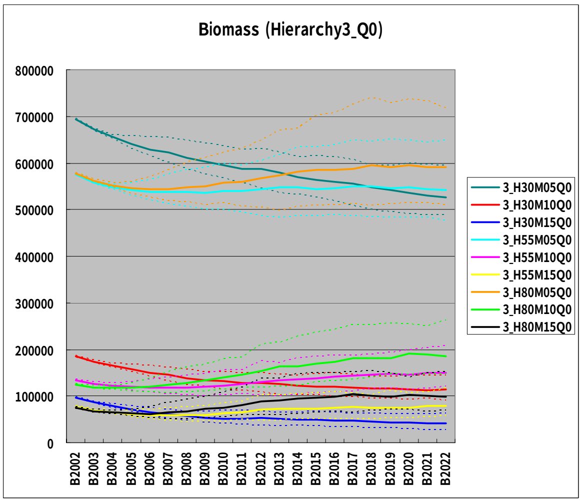


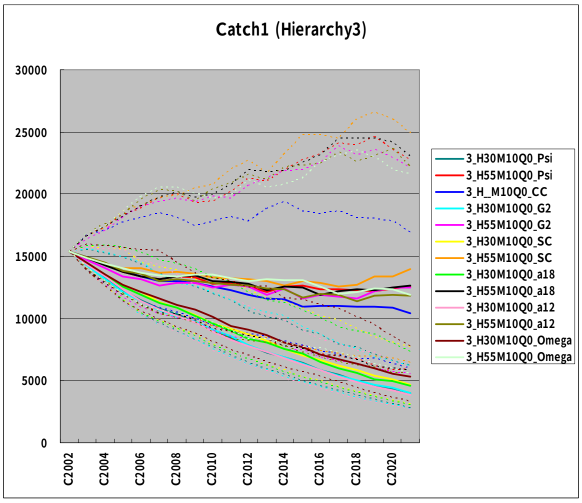
Figure A12.1. Relation between CPUE level of age 4 and change in TAC.

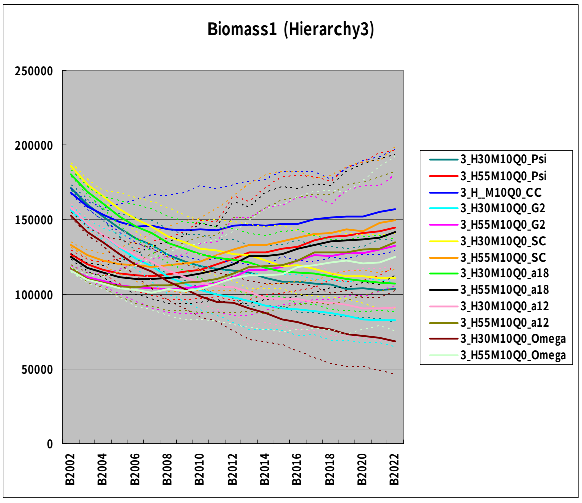
(a) Reference cases

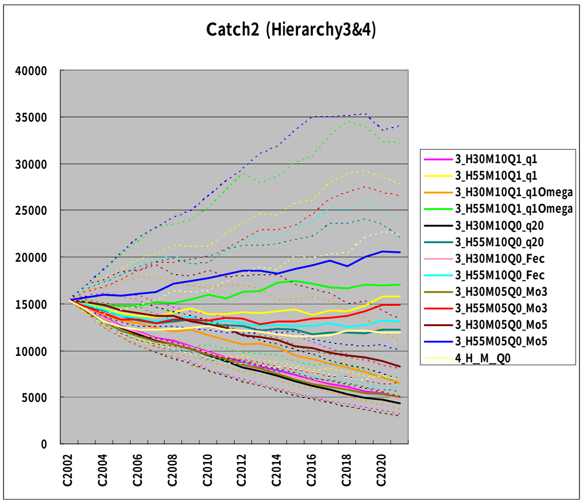




(b) Robustness tests







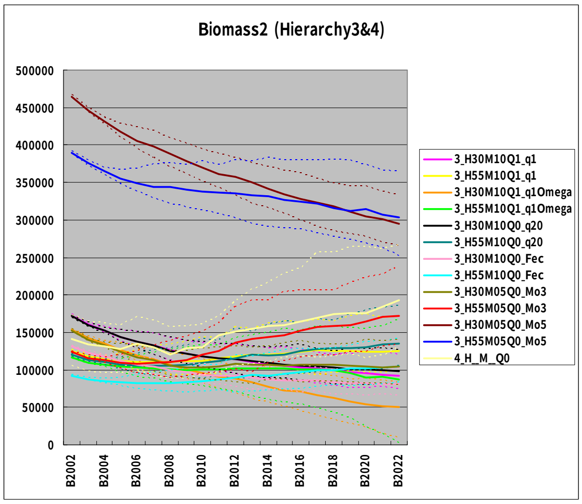


Figure A12.2. Results of the MP " HK4-lv4 v1"

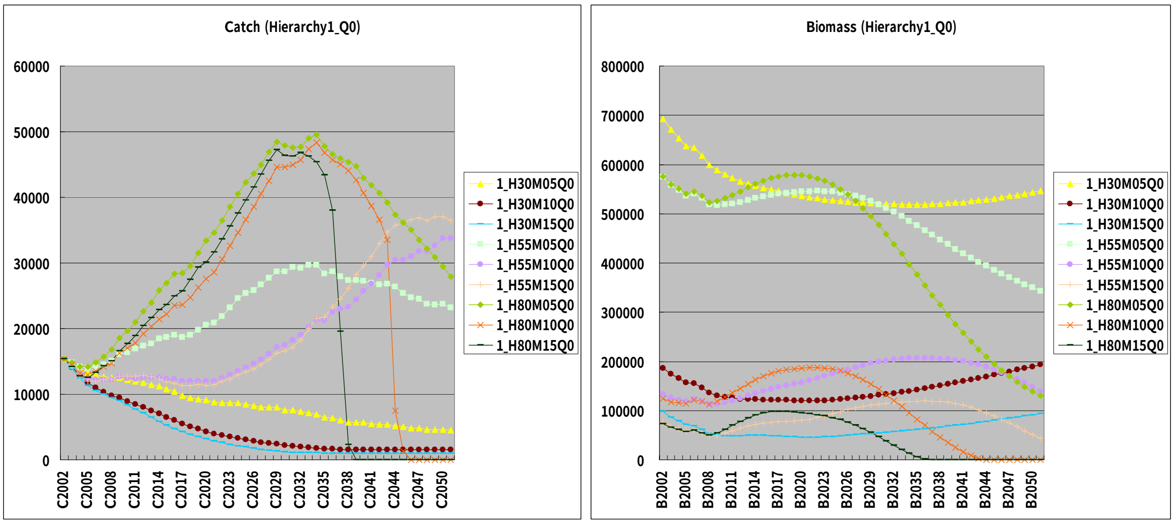


Figure A12.3. Trajectory of catch and biomass for 50 years.

Appendix 13. Outline of "HK5-hyb v1"

Hiroyuki Kurota

1. Basic Idea

SBT are long-lived fish and fisheries target fish of different age ranges by different fleets. It might be better to use plenty of information of stock condition covering different age ranges to determine TACs robustly. This is a hybrid MP of the "HK1-dfl v2" and the "HK4-ag4 v1". TACs are determined by CPUE trend of age 4+ and CPUE level of age 4. It is also a characteristic of this MP to adapt the lower of TACs determined by the two different methods. TAC is specified by:

$$TAC_{y+1} = \min\left(TAC_{y+1}^{trend\,4+},\ TAC_{y+1}^{level\,4}\right)$$

$$TAC_{y+1}^{trend\,4+} = \begin{cases} TAC_y + c & if \quad \lambda > \dfrac{c}{k \times TAC_y} \\ TAC_y \times (1 + k\lambda) & if \quad \lambda \le \left|\dfrac{c}{k \times TAC_y}\right| \\ TAC_y - c & if \quad \lambda < -\dfrac{c}{k \times TAC_y} \end{cases}$$

where

λ: the slope of the regression of ln($CPUE_{age4+}$) over 10 years (from y - 10 to y - 1),

k, c: control parameters (k = 1, c = 2000 in the default case)

$$TAC_{y+1}^{level\,4} = TAC_y \times \left(1 + f(CPUE_{age4,\,y-1})\right)$$

$$f(CPUE_{age4,\,y-1}) = \begin{cases} m_{\max} & if \quad CPUE_{age4,\,y-1} > l_{\max} \\ a \times CPUE_{age4,\,y-1} + b & if \quad l_{\min} \le CPUE_{age4,\,y-1} \le l_{\max} \\ m_{\min} & if \quad CPUE_{age4,\,y-1} < l_{\min} \end{cases}$$

where

m_{max}, m_{min}, l_{max}, l_{min}, a, b: control parameters (m_{max} = 0.1, m_{min} = -0.1, a = 1.21, b = -0.16, l_{max} = 0.214, l_{min} = 0.048 in the default case)

2. Notes

Figure A13.1 showed results for the reference cases and the robustness trials in the default case. TACs changed reasonably depending on productivity of scenarios. The spawning biomass almost became stable within the 20 year simulation period. Inconsistency between catch and biomass trends was not observed for the H30M05 and H55M05 scenarios, which were often found in MPs based on CPUE trend. The robustness tests including those with omega and Mo5 options were also managed better than the "HK1-dfl v2" and the "HK4-ag4 v1". This MP is very reasonable judging from our target, because it prevents stock collapse in low productive scenarios without sacrificing large catch under high productive scenarios.

When simulation period was set as 50 years, TACs did not increase extremely and stock collapse were not occured under the high productive scenarios, and the spawning biomass continued to increase under all reference cases (Figure A13.2). Figure A13.3 showed an example of changes of CPUE and TACs calculated by the two methods under the H80M05Q0 scenario (hierarchy 1). First, TACs decreased due to low recruitment level and then increased by both high CPUE indices of age 4+ and age 4. Finally, TAC increase stopped because CPUE trend of age 4+ was near zero. This MP controlled TACs more safely, because it was able to check resource conditions at the two age ranges.

This MP accepted the lower of the two TACs determined by the diferent methods. I also explored another way to integrate the two components:

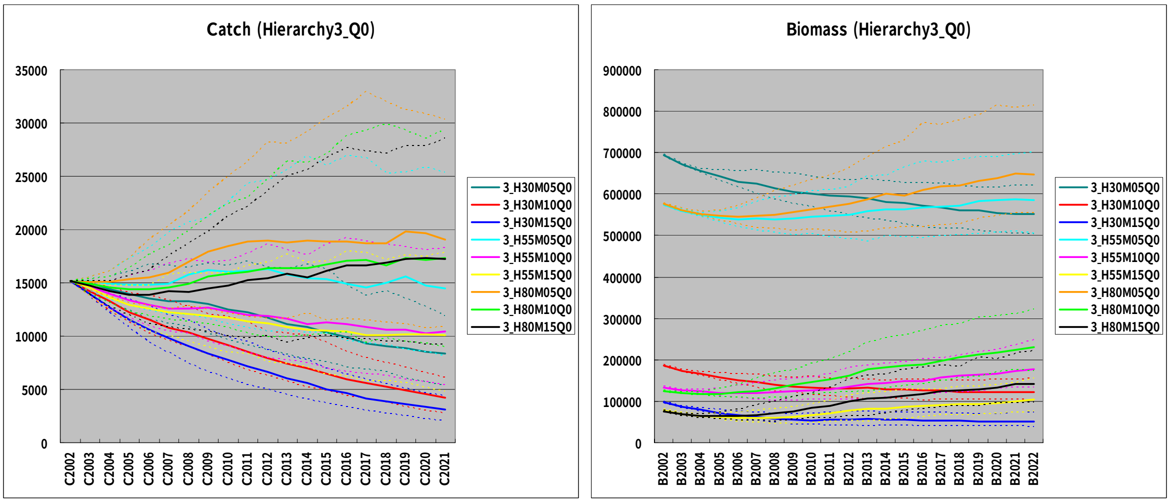
$$TAC_{y+1} = \omega\, TAC_{y+1}^{trend\,4+} + (1-\omega)\, TAC_{y+1}^{level\,4}$$

where

ω: weighting parameter

When ω was small, this composite did not manage the high productive scenarios and the stock collapsed, because TAC determined by the CPUE level of age 4 pulled up the total too highly. On the other hand, when ω was large, catch trends were not consistent with biomass trends for the H30M05 and H55M05 scenarios. Therefore, in this case, the MP which accepts the minimum TAC is considered better than the MP which adds the two TACs in that it can manage all scenarios reasonably, although it might be more conservative.

(a) Reference cases



(b) Robustness tests

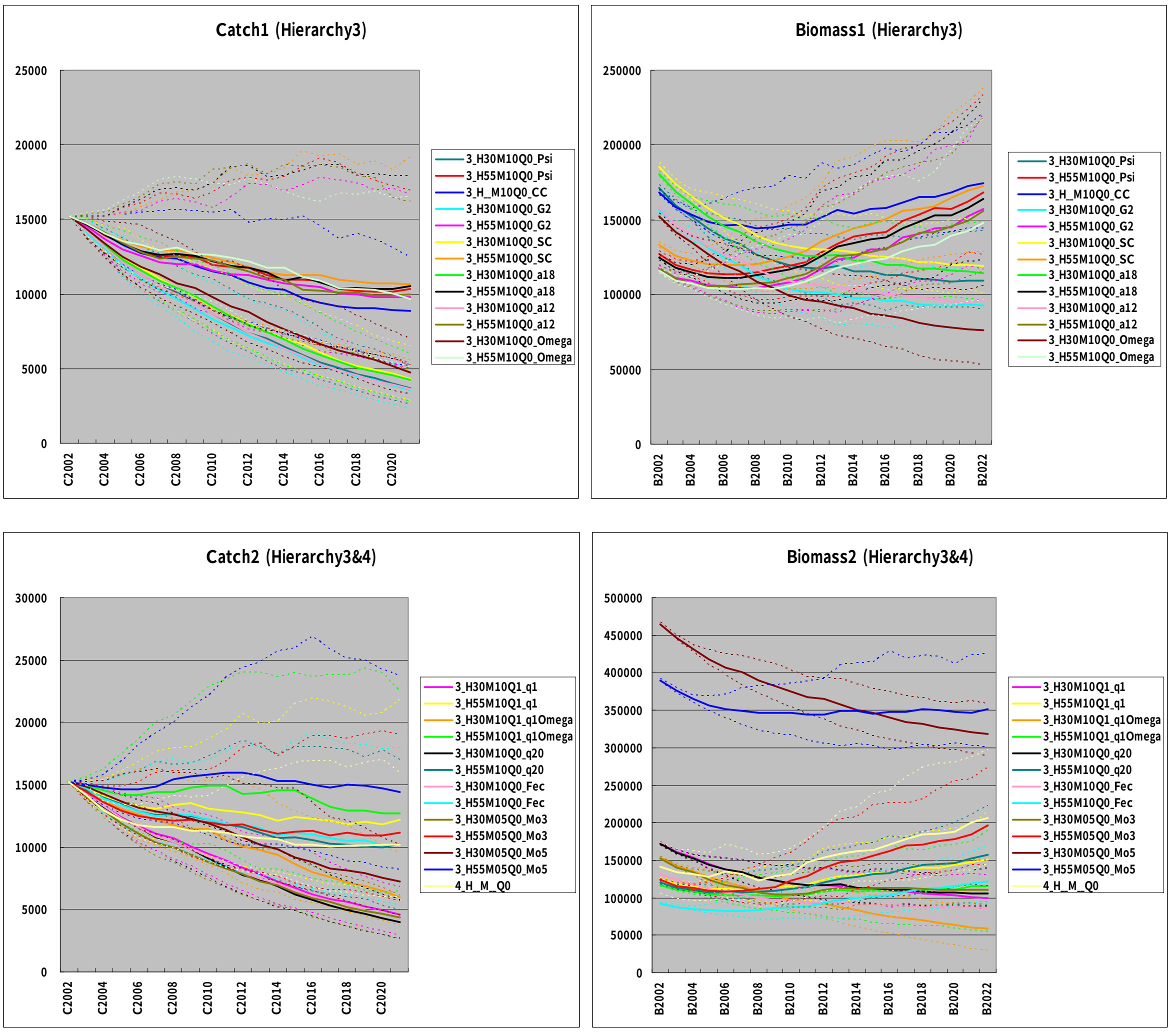


Figure A13.1. Results of the MP " HK5-hyb v1"

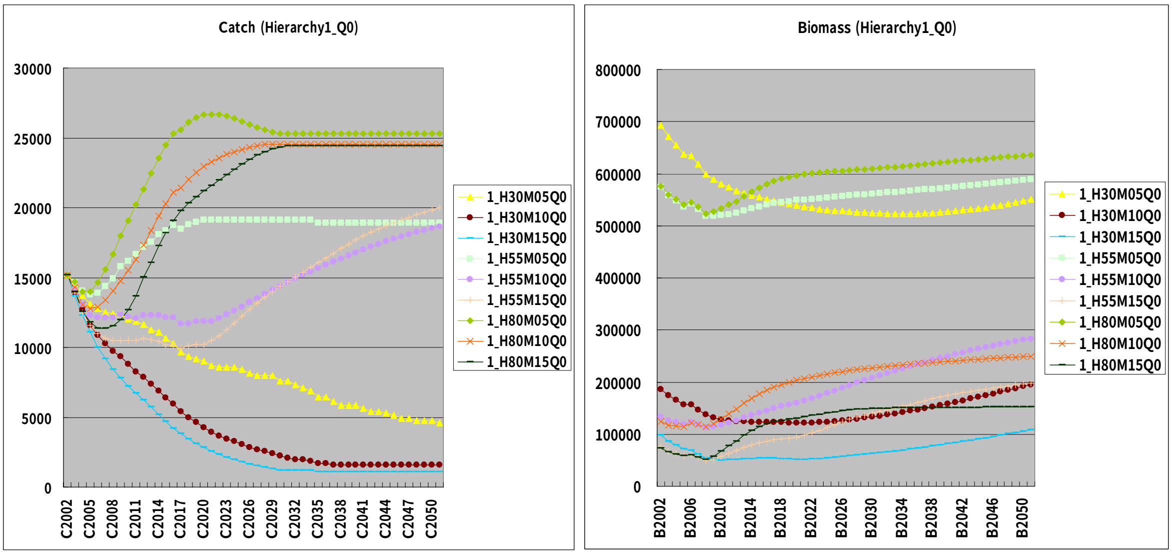


Figure A13.2. Trajectory of catch and biomass for 50 years.

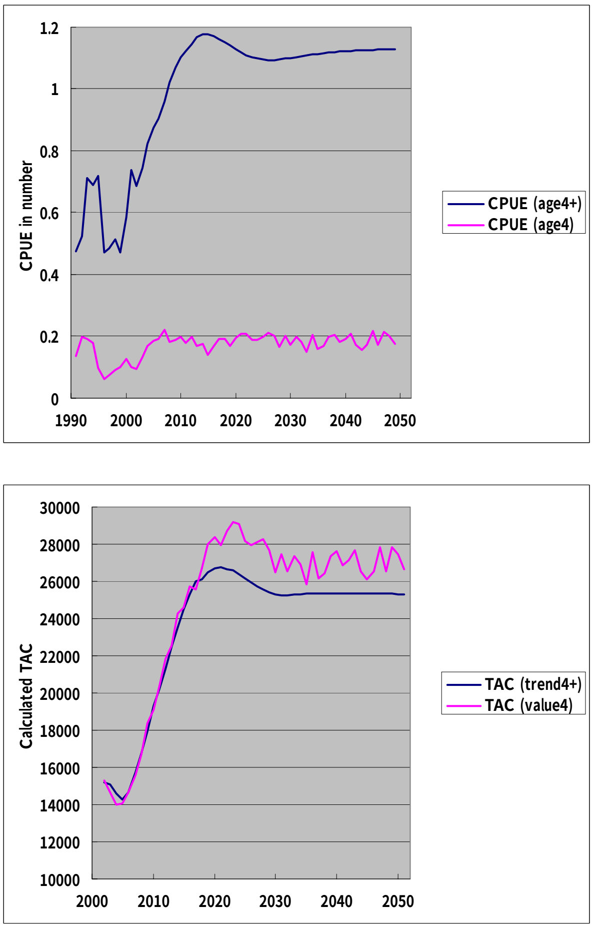


Figure A13.3. (a) CPUE of age 4+ and age 4 in the H80M05Q0 scenario and (b) TACs calculated by the two methods, of which the lower is accepted.