Further improvement and performance evaluation of a candidate management procedure (“NT4”) for southern bluefin tuna

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Abstract: This document provides results of further improvement and performance evaluation of a candidate management procedure (CMP) for southern bluefin tuna. A CMP considered is simple empirical one, called “NT4”. NT4 utilizes CPUE, estimates from gene-tagging, and a close-kin mark recapture parent-offspring pairs (POP) index.

Basic characteristics of NT4 are: i) until the tuning year of achieving the stock level target, NT4 suppresses increase of TAC, and after the tuning year, it tries to increase TAC as possible; ii) if recruitment level becomes declining to a very low level, then NT4 reduces TAC accordingly to avoid decrease of the stock. Comparisons of results between the reference set and associated robustness tests (“reclow5”, “as2016”, “cpuew0”, “reclow5as2016”, and “reclow5cpuew0”) are presented. Projected median trends of both TAC and relative total reproductive output (TRO) are different between the reference set and “reclow5” (and its combinations with “as2016” or “cpuew0”) reflecting reaction to low recruitment.

ミナミマグロのための管理方式候補（“NT4”）の更なる改良と性能評価

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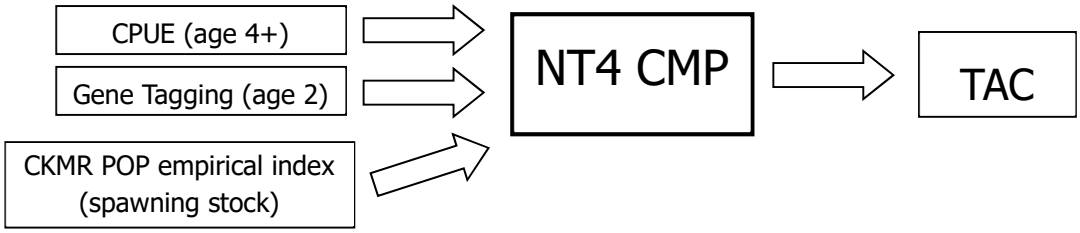
要旨：この文書ではミナミマグロのための管理方式候補（CMP）の更なる改良と性能評価の結果を提供する。考えた CMP は単純で経験的なものであり、“NT4”と呼ばれる。NT4 は CPUE、遺伝標識からの推定値、および近縁遺伝標識再捕親子ペア（POP）指数を利用している。NT4 の基本的特徴は以下；i) 資源水準目標を達成するチューニング年までは、NT4 は TAC の増加を抑え、チューニング年以降は可能な限り TAC を増やそうとする；ii) もし加入水準が非常に低水準まで低下した場合には、それに応じて NT4 は資源の減少を回避するために TAC を削減させる。リファレンスセットとそれに関連する頑健性試験（“reclow5”, “as2016”, “cpuew0”, “reclow5as2016”, “reclow5cpuew0”）との結果の比較を示す。TAC と相対総再生産出力（TRO）両者の予測された中央値のトレンドは、低加入への反応を反映して、リファレンスセットと“reclow5”（および “as2016”あるいは“cpuew0”とのその組み合わせ）とで異なっていた。

1. Introduction

Due to cessation of the CCSBT scientific aerial survey (AS) after 2017 for both budgetary and logistic reasons, to set TAC for the 2021-2023 fishing season in 2020, the CCSBT decided to develop a new management procedure (MP) which utilizes, in addition to longline CPUE index, recruitment estimates (age 2 fish abundance) obtained from the gene-tagging project (GT) and/or spawning stock indices from the close-kin mark recapture project (CKMR) in place of the current MP by 2019 (CCSBT 2017). At the Extended Scientific Committee for the 23rd meeting of the Scientific Committee (ESC23), results of development and performance evaluation of a simple empirical candidate MP (CMP), "NT4", were presented (Takahashi 2018). This document provides results of further improvement and performance evaluation of NT4.

2. Description of the CMP ("NT4")



"NT4" CMP uses the following three indicators as inputs to evaluate the stock trend/level, and then specifies the next year's TAC:

(1) CPUE age 4+ series - Use as an indicator of change in the spawning stock biomass trend (the slope of log(CPUE age 4+) over the most recent t_{CPUE} years);

(2) Gene Tagging (GT) age 2 abundance estimate – Use as an indicator of the recruitment level (the most recent $t_{GTlimit}$ years average) of whether this level is below the prespecified lowest recruitment level (as the lowest limit);

(3) CKMR POP empirical index (Hillary et al. 2016) – Use as an indicator of the spawning stock level (the most recent t_{POP} years average) of whether this level is below or above the prespecified target spawning stock level.

Equations of TAC calculation are:

For CPUE-based TAC,

If year y ≤ (2035 or 2040)[1], then use

$$TAC_{y+1}^{CPUE} = \begin{cases} TAC_y(1 + k1_{CPUE}S1_{CPUE}) & S1_{CPUE} < 0 \\ TAC_y(1 + k2_{CPUE}S1_{CPUE}) & S1_{CPUE} \geq 0 \end{cases} \quad \text{eq. 1}$$

Else if year y > (2035 or 2040) and $\mu_{POP} \leq I_{target}^{POP}$, then use the same equations as eq. 1

Else if year y > (2035 or 2040) and $\mu_{POP} > I_{target}^{POP}$, then use

$$TAC_{y+1}^{CPUE} = \begin{cases} TAC_y(1 + k3_{CPUE}S2_{CPUE}) & S2_{CPUE} < 0 \\ TAC_y(1 + k4_{CPUE}S2_{CPUE}) & S2_{CPUE} \geq 0 \end{cases} \quad \text{eq. 2}$$

TAC_y: TAC for year *y*
TAC_{y+1}^{CPUE}: TAC calculated using log(CPUE (age 4+)) slope for *y*+1
μ_{POP}: the average POP index over the most recent t_{POP} years
I_{target}^{POP}: the prespecified target spawning stock level
$S1_{CPUE}$: the slope of log(CPUE age 4+) over the most recent $t1_{CPUE\_slope}$ years
$S2_{CPUE}$: the slope of log(CPUE age 4+) over the most recent $t2_{CPUE\_slope}$ years
$k1_{CPUE}$: a parameter for TAC calculation using log(CPUE (age 4+)) slope when $S1_{CPUE} < 0$
$k2_{CPUE}$: a parameter for TAC calculation using log(CPUE (age 4+)) slope when $S1_{CPUE} \geq 0$
$k3_{CPUE}$: a parameter for TAC calculation using log(CPUE (age 4+)) slope when $S2_{CPUE} < 0$
$k4_{CPUE}$: a parameter for TAC calculation using log(CPUE (age 4+)) slope when $S2_{CPUE} \geq 0$

[1] Year 2035 is used when the tuning target is 30%TRO by 2035, 2040 is applied when the target is 35%TRO by 2040.

For TAC based on GT age 2 abundance estimate,

$$TAC_{y+1}^{GTlimit} = \begin{cases} TAC_y k_{GT}^{limit} \left(\frac{\mu_{GT}}{N_{age2}^{limit}}\right)^2 & \mu_{GT} < N_{age2}^{limit} \\ Not\ used & \mu_{GT} \geq N_{age2}^{limit} \end{cases} \quad \text{eq. 3}$$

$TAC_{y+1}^{GTlimit}$: TAC calculated using the GT age 2 abundance estimate level
k_{GT}^{limit}: a gain parameter for TAC calculation using the GT age 2 abundance estimate level
μ_{GT}: the average GT age 2 abundance estimate over the most recent t_{GTlimt} years
N_{age2}^{limit}: the prespecified lowest limit of age 2 abundance below which TAC is reduced

Final TAC is specified as

$$TAC_{y+1} = \begin{cases} minimum\left(TAC_{y+1}^{GTlimit}, TAC_{y+1}^{CPUE}\right) & \mu_{GT} < N_{age2}^{limit} \\ TAC_{y+1}^{CPUE} & \mu_{GT} \geq N_{age2}^{limit} \end{cases} \quad \text{eq. 4}$$

3. Tuning of the CMP

At the ESC23, the meeting agreed that, in further development of CMPs for the presentation to the 10th Operating Model and Management Procedure Technical Meeting (OMMP10), developers would continue to focus on the two combinations of target level and tuning year: i) 30% of the initial total reproductive output (TRO_0) by 2035 (0.30 by 2035); and ii) 35% of TRO_0 by 2040 (0.35 by 2040) (CCSBT 2018). As previously done, NT4 was tuned to these two combinations providing a 50% probability of reaching the tuning points with a maximum TAC changes of 3000 t. The tunings were done based on the reference set operating model (OM) ("base18_UAM1.grid"). Then, associated robustness tests scenarios agreed at the ESC23 ("reclow5", "as2016", "cpuew0", "reclow5as2016", and "reclow5cpuew0"; see Table 2 in CCSBT 2018) were run using the same tuning parameter values as the reference set case. Briefly, "reclow5", "as2016", and "cpuew0" respectively correspond to cases where: reduce future recruitment by 50% during the first 5 years; remove the high 2016 aerial survey data point; Variable Square (VS) CPUE interpretation is assumed.

4. Results

Values for the input parameters of NT4 used in simulation tests were summarized in Table 1. Tunings were done allowing the error range between -0.005 and +0.005 for the tuning probability (i.e., 0.495-0.505 when the tuning probability is 0.5). Results (trajectories of TAC and relative

total reproductive output, TRO) for the 0.30 by 2035 tuning based on the reference set (base18_UAM1) are shown in Fig. 1a (TAC) and 1b (relative TRO). Results of associated robustness tests are also shown in Fig. 1a and 1b along with the reference set case. Similarly, figures for the 0.35 by 2040 tuning are shown in Fig. 2a and 2b. Performance statistics graphs are shown in Fig. 3 (0.30 by 2035) and 4 (0.35 by 2040).

Major findings from the tunings (for the reference set) and robustness tests are summarized below (these summaries are all explained with respect to median behaviors of TAC and relative TRO trends):

- Basic characteristics of NT4 are: i) until the tuning year of achieving the stock level target (2035 or 2040), NT4 suppresses increase of TAC, and after the tuning year, it tries to increase TAC as possible corresponding to increase of the stock (Figs. 1ab and 2ab); ii) if recruitment level becomes declining to a very low level similar to the historical lowest level, then NT4 reduces TAC accordingly to avoid decrease of the stock (Figs. 1ab and 2ab).
- When testing NT4 under "reclow5" robustness scenario and its combinations with "as2016" or "cpuew0" scenarios ("reclow5as2016" or "reclow5cpuew0"), NT4 reduces TAC accordingly reacting to the low recruitment to keep TRO increase (Figs. 1ab and 2ab). Probability intervals of TAC under these scenarios become wider than that for the reference set.
- When testing NT4 under "as2016" robustness scenario, median behaviors of both TAC and relative TRO were similar to the reference set (Figs. 1ab and 2ab). However, the probability of reaching the tuning point under "as2016" became less than 50% for the reference set.
- When testing NT4 under "cpuew0" robustness scenario, it results in more pessimistic situation where TAC is not increased (is substantially reduced in some cases) reacting to low productive stock to avoid decline of TRO than under "reclow5" (Figs. 1ab and 2ab).
- Incorporating a minimum TAC change of 500 t improved P(2up/1down) performance statistics without any impact on other statistics (Figs. 3 and 4). For the reference set, values of P(2up/1down) are < 0.03 (0.30 by 2035 tuning) and < 0.005 (0.35 by 2040 tuning).

Acknowledgements

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5. References

CCSBT (2017) Report of the Twenty Second Meeting of the Scientific Committee. 2 September 2017. Yogyakarta, Indonesia

CCSBT (2018) Report of the Twenty Third Meeting of the Scientific Committee. 8 September 2018. San Sebastian, Spain

Hillary R, Preece A, Davies C (2016) Methods for data generation in projections. CCSBT-ESC/1609/BGD06 (*Previously* CCSBT-OMMP/1609/07)

Takahashi N (2018) Further improvement and performance evaluation of management procedure candidate. CCSBT-ESC/1809/34

Table 1. Values for the input parameters of NT4

	maxTACchange_%TRO_0	
input parameter	3000_30	3000_35
I_{target}^{POP}	2500000	2500000
t_{POP}	3	3
$k1_{CPUE}$ (tuned)	0.20	0.20
$k2_{CPUE}$ (tuned)	1.21	0.65
$t1_{CPUE}$	10	10
$k3_{CPUE}$ (tuned)	0.10	0.10
$k4_{CPUE}$ (tuned)	3.00	3.00
$t2_{CPUE}$	10	10
k_{GT}^{limit} (tuned)	0.75	0.75
t_{GTlimt}	2	2
N_{age2}^{limit}	840000	840000
maximum TAC (capping)	32000	32000
minimum TAC change	500	500

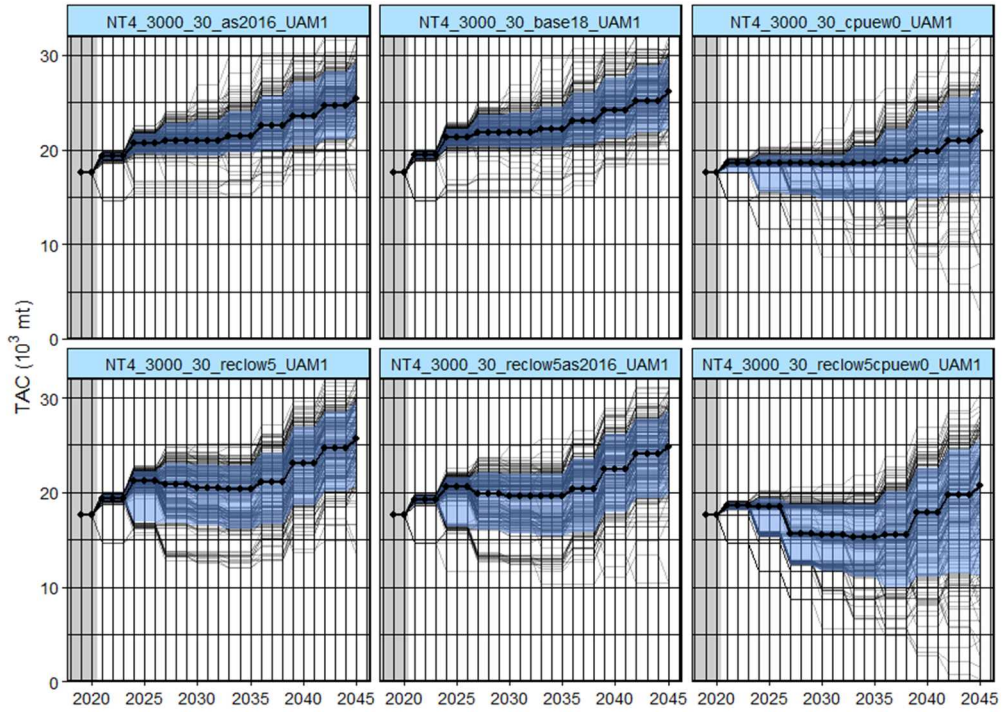

Fig. 1a. Trajectories of TAC for the 0.30 by 2035 tuning based on the reference set (base18_UAM1) and associated robustness tests ("as2016", "reclow5", "cpuew0", "reclow5as2016", and "reclow5cpuew0").

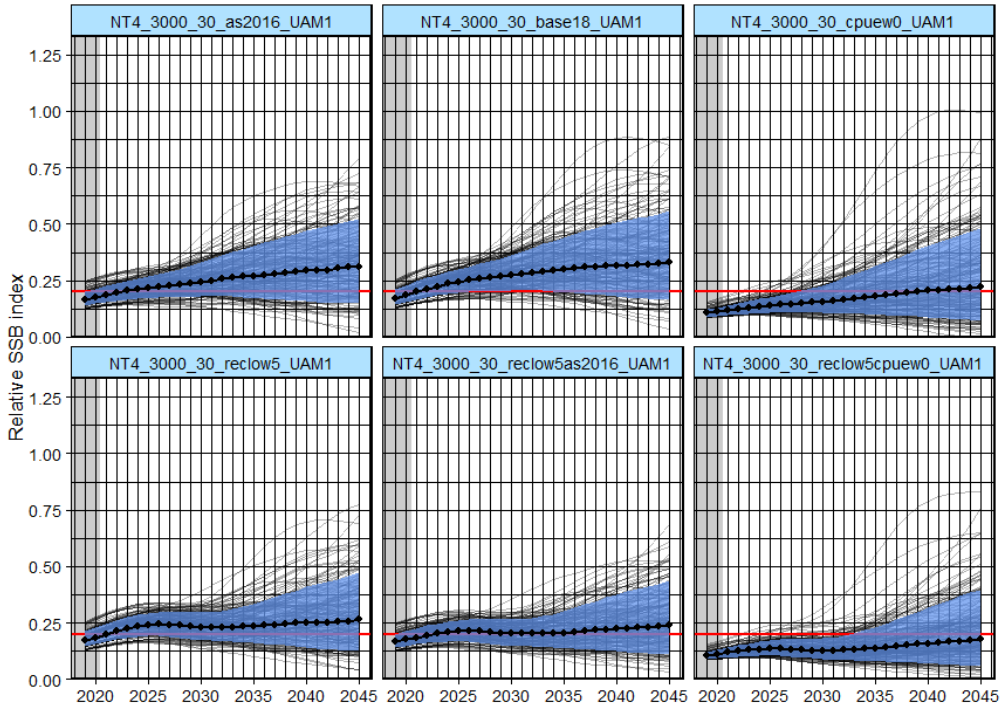

Fig. 1b. Trajectories of relative TRO for the 0.30 by 2035 tuning based on the reference set (base18_UAM1) and associated robustness tests ("as2016", "reclow5", "cpuew0", "reclow5as2016", and "reclow5cpuew0").

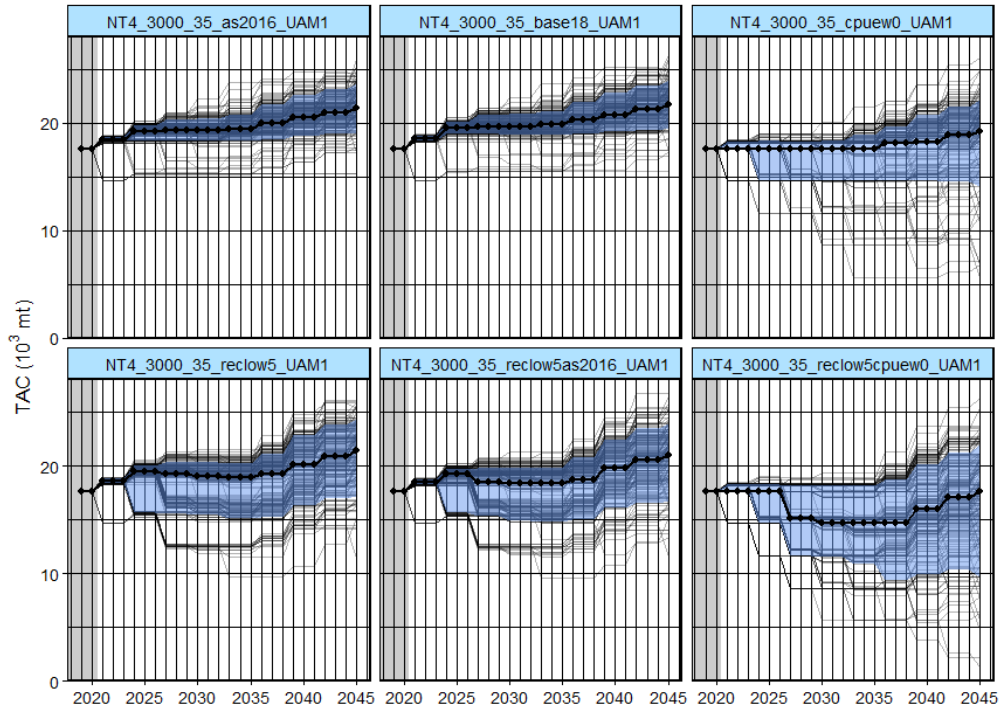

Fig. 2a. Trajectories of TAC for the 0.35 by 2040 tuning based on the reference set (base18_UAM1) and associated robustness tests ("as2016", "reclow5", "cpuew0", "reclow5as2016", and "reclow5cpuew0").

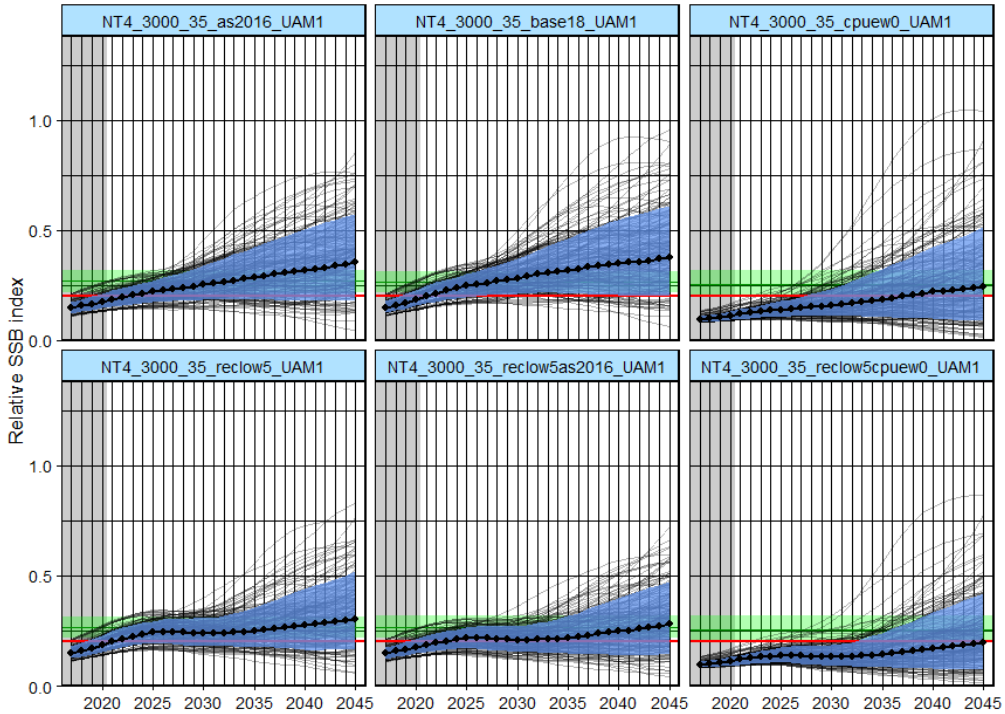

Fig. 2b. Trajectories of relative TRO for the 0.35 by 2040 tuning based on the reference set (base18_UAM1) and associated robustness tests ("as2016", "reclow5", "cpuew0", "reclow5as2016", and "reclow5cpuew0").

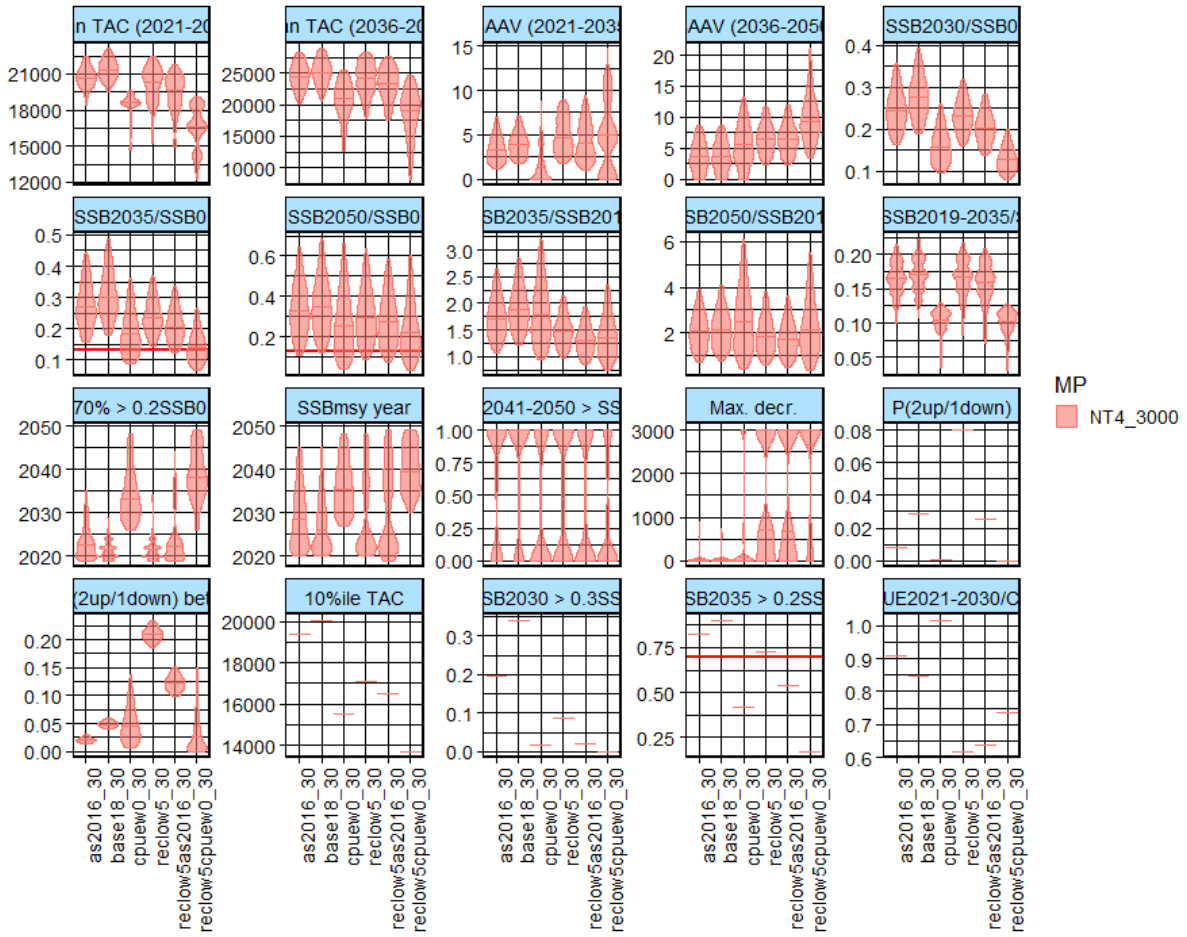

Fig. 3. Performance statistics graphs for the 0.30 by 2035 tuning.

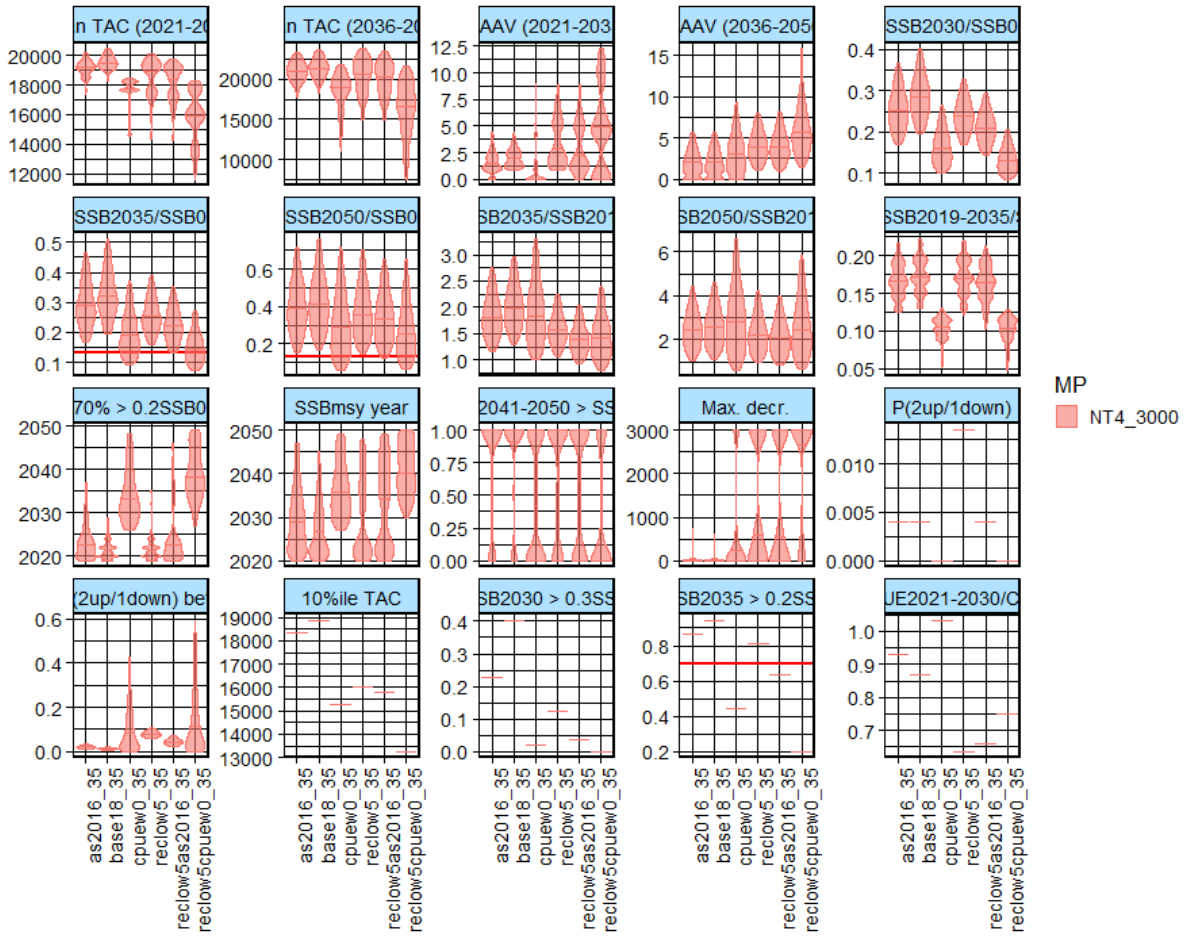

Fig. 4. Performance statistics graphs for the 0.35 by 2040 tuning.