Further improvement and performance evaluation of management procedure candidate

Norio TAKAHASHI

National Research Institute of Fisheries Science
National Research Institute of Far Seas Fisheries

Japan Fisheries Research and Education Agency

Abstract : This document provides results of further development and performance evaluation of a new 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. 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 drastically reduces TAC to avoid decrease of the stock. Comparisons of results between the reference set and some selected robustness tests ("reclow5", "cpueupq", "cpueom75", "as2016", and "cpuehcv") are presented. Projected median trends of both TAC and total reproductive output (TRO) are more or less similar between the reference set and the selected robustness tests except that the trend of TAC (reducing) under "reclow5" is different from the reference set case reflecting reaction to low recruitment. Although it depends on the robustness tests, probability intervals of TAC and TRO are wider than those for the reference set.

管理方式候補の更なる改良と性能評価

高橋紀夫

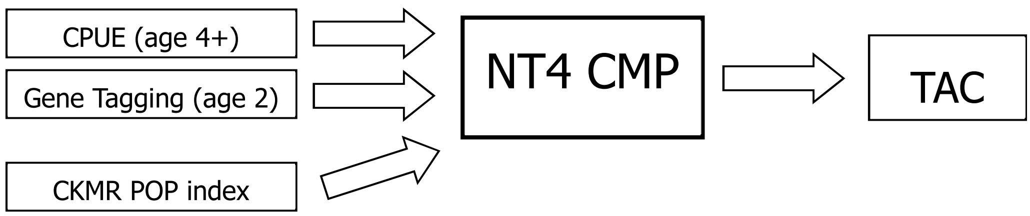
水産研究・教育機構 中央水産研究所・国際水産資源研究所

要旨：この文書ではミナミマグロのための新たな管理方式候補（CMP）の更なる開発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減少した場合には、NT4 は資源の減少を回避するために大幅に TAC を減少させる。リファレンスセットといくつかの選択された頑健性試験（"reclow5", "cpueupq", "cpueom75", "as2016", "cpuehcv"）との結果の比較を示す。TAC と総再生産出力（TRO）両者の予測された中央値のトレンドは、リファレンスセットと選択された頑健性試験とで大体似ていた。例外として、低加入への反応を反映して、"reclow5"の下での TAC のトレンド（減少する）がリファレンスセットの場合と異なっていた。頑健性試験によるが、TAC と TRO の確率区間はリファレンスセットのものより広くなる。

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 9th Operating Model and Management Procedure technical meeting (OMMP9), preliminary results of development and performance evaluation of simple empirical "NT1" and "NT2" candidate MPs (CMPs) were presented (Takahashi 2018). This document provides results of further improvement and performance evaluation of "NT4" CMP, based on experience of evaluating the former "NT1" and "NT2" CMPs.

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 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

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

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

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

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 OMMP9, the meeting agreed that, in refining CMPs for the presentation to the Extended Scientific Committee (ESC23), developers would focus on two combinations of target level and tuning year: i) 30% of the initial total reproductive output (TRO_0) by 2035; and ii) 35% of TRO_0 by 2040 (CCSBT 2018). For the ESC23, 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) ("base16.grid"). Then, robustness tests scenarios agreed at the OMMP9 (Table 2 in CCSBT 2018) were run using the same tuning parameter values as the reference set case.

4. Results

Values for the tuning 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 (e.g., 0.495-0.505 when the tuning probability is 0.5). Tuning results (trajectories of TAC and spawning stock size in total reproductive output, TRO) for NT4 based on the reference set are shown in Fig. 1. Results of selected robustness tests are shown in Figs. 2 to 6. Comparisons of the results between the reference set ("base16") and the selected robustness tests are shown in Figs. 7 and 8.

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 TRO trends):

- 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 (Fig. 1); ii) if recruitment level becomes declining to a very low level similar to the historical lowest level, then NT4 drastically reduces TAC to avoid decrease of the stock (Fig. 2).

- When testing NT4 under "reclow5" robustness scenario (Reduced future recruitment by 50% during the first 5 years), NT4 urgently reduces TAC reacting to the low recruitment to keep TRO increase (Figs. 2, 7, and 8). Probability intervals of TAC under this scenario become much wider than that for the reference set (Figs. 1 and 2).

- When testing NT4 under "cpueupq" robustness scenario (CPUE q increased by 25% permanent in 2008), median trends of both TAC and TRO are similar to those of the reference set, but the lower probability interval of TAC becomes wider than that for the reference set (Fig. 1, 3, 7, and 8).

- When testing NT4 under "cpueom75" robustness scenario (Power function for stock-CPUE relationship with power = 0.75), median trends of both TAC and TRO are similar to the reference set (Fig. 1, 4, 7, and 8).

- When testing NT4 under "as2016" robustness scenario (Remove the 2016 aerial survey data point), median behaviors of both TAC and TRO were similar to the reference set, but the lower probability interval of TAC becomes wider than that for the reference set (Fig. 1, 5, 7 and 8).

- When testing NT4 under "cpuehcv" robustness scenario (Increase the future CPUE CV to 30%), median behaviors of both TAC and TRO are similar to the reference set, but the lower probability interval of TRO becomes larger than that for the reference set (Fig. 1, 6, 7, and 8).

・ Acknowledgements

The author thanks Dr. Richard Hillary for all efforts to modify the OM projection code and for kindly sharing his example MP code using POP index.

5. References

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

CCSBT (2018) Report of the Ninth Operating Model and Management Procedure Technical Meeting. 18-22 June 2018. Seattle, USA

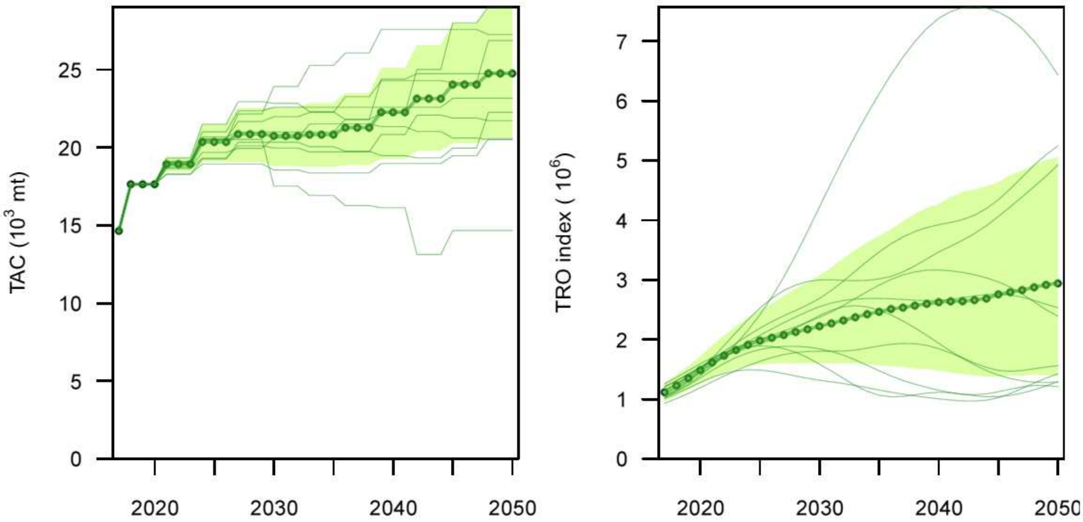
Hillary R, Preece A, Davies C (2016) Methods for data generation in projections. CCSBT-ESC/1609/BGD06 (*Previously* CCSBT-OMMP/1609/07)

Takahashi N (2018) Initial trials of a new candidate management procedure for southern bluefin tuna. CCSBT-ESC/1809/BGD05 (*Previously* CCSBT-OMMP/1806/11)

Table 1. Values for the tuning parameters of NT4

	maxTACchange_%TRO_0	
Tuning parameter	3000_30	3000_35
I_{target}^{POP}	2500000	2500000
t_{POP}	3	3
$k1_{CPUE}$	0.20	0.20
$k2_{CPUE}$	0.75	0.30
$t1_{CPUE}$	10	10
$k3_{CPUE}$	0.10	0.10
$k4_{CPUE}$	3.00	3.00
$t2_{CPUE}$	10	10
k_{GT}^{limit}	0.75	0.75
t_{GTlimt}	2	2
N_{age2}^{limit}	840000	840000

(a) NT4, 30%TRO_0, by 2035, maxTACchange = 3000 t, "Reference set (base16)"



(b) NT4, 35%TRO_0, by 2040, maxTACchange = 3000 t, "Reference set (base16)"

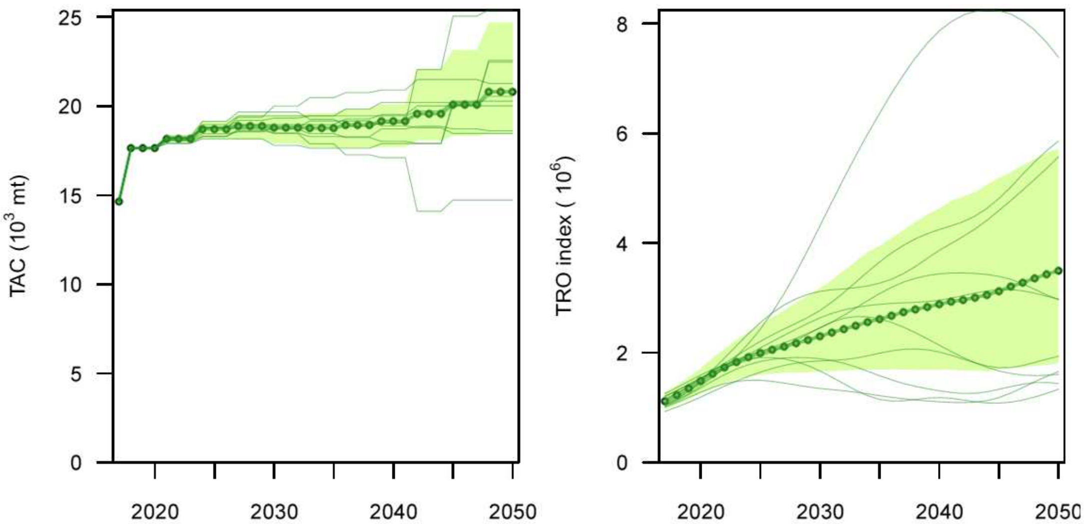
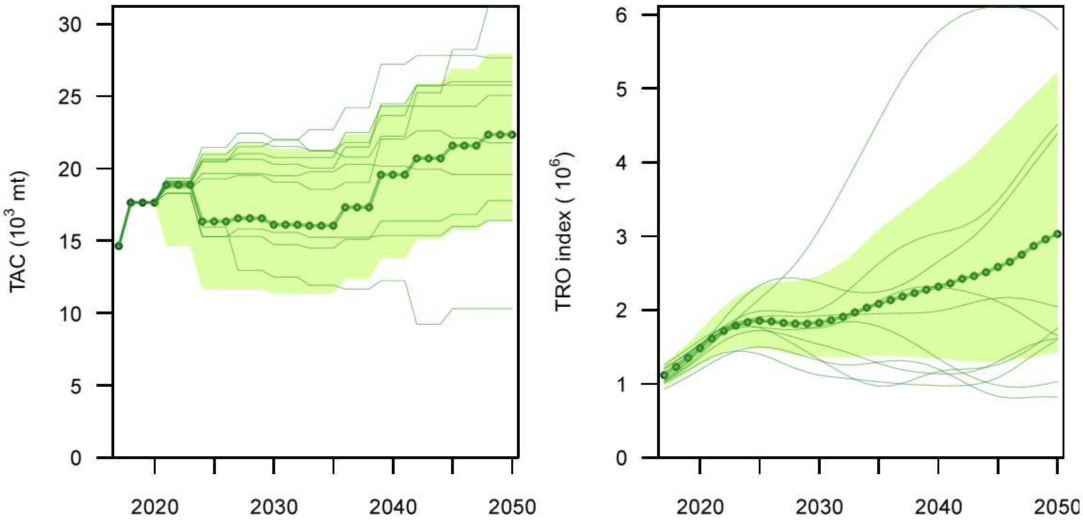


Fig. 1. Trajectories of TAC and spawning stock size in total reproductive output (TRO) for the tuning point of providing a 50% probability of reaching (a) 30% of TRO_0 by 2035 and (b) 35% of TRO_0 by 2040 with maximum TAC changes of 3000 t from simulation test results of NT4 CMP based on the "reference set (base16)" OM.

(a) NT4, 30%TRO0, by 2035, maxTACchange = 3000 t, "reclow5"



(b) NT4, 35%TRO0, by 2040, maxTACchange = 3000 t, "reclow5"

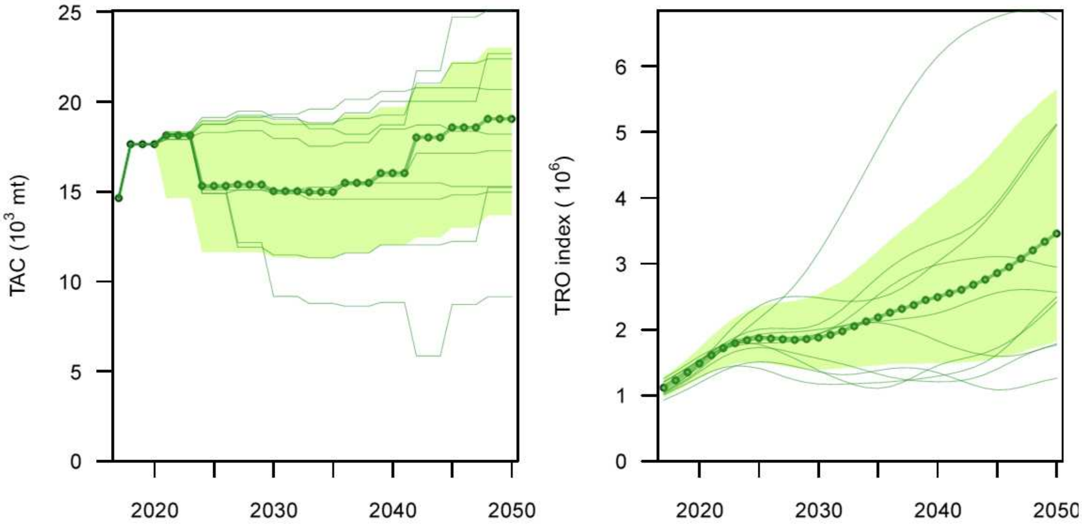
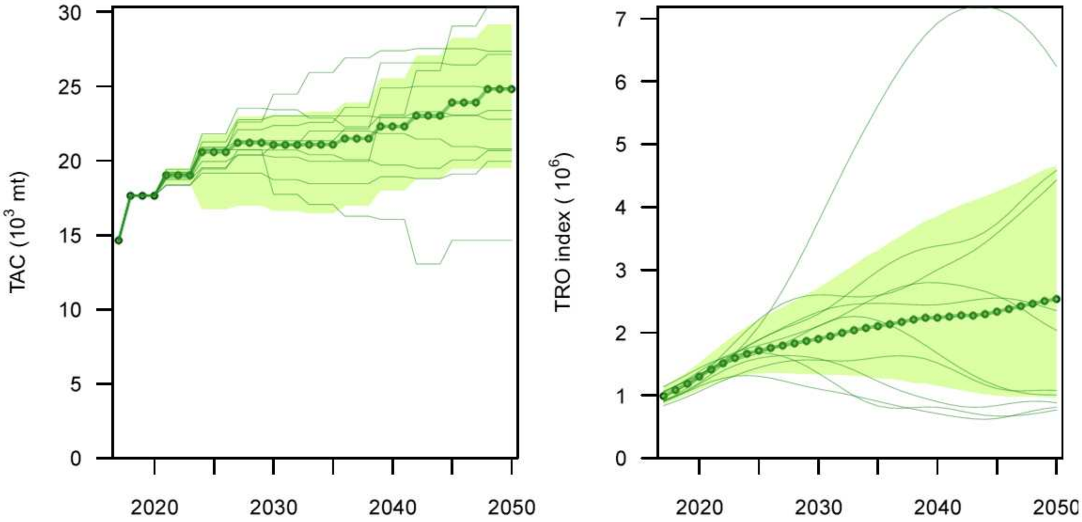


Fig. 2. Trajectories of TAC and spawning stock size in total reproductive output (TRO) from robustness test result of NT4 CMP under "reclow5" scenario.

(a) NT4, 30%TRO_0, by 2035, maxTACchange = 3000 t, "cpueupq"



(b) NT4, 35%TRO_0, by 2040, maxTACchange = 3000 t, "cpueupq"

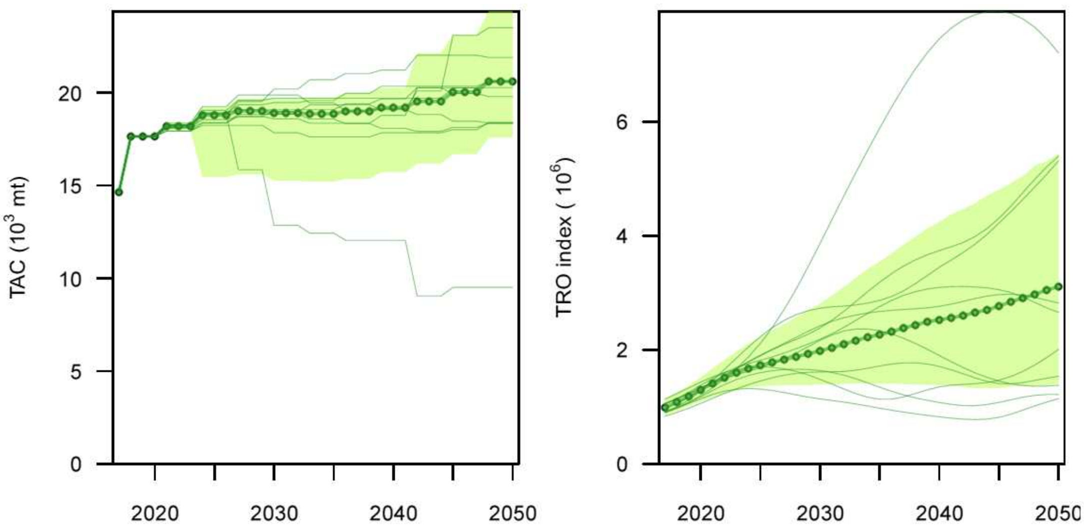
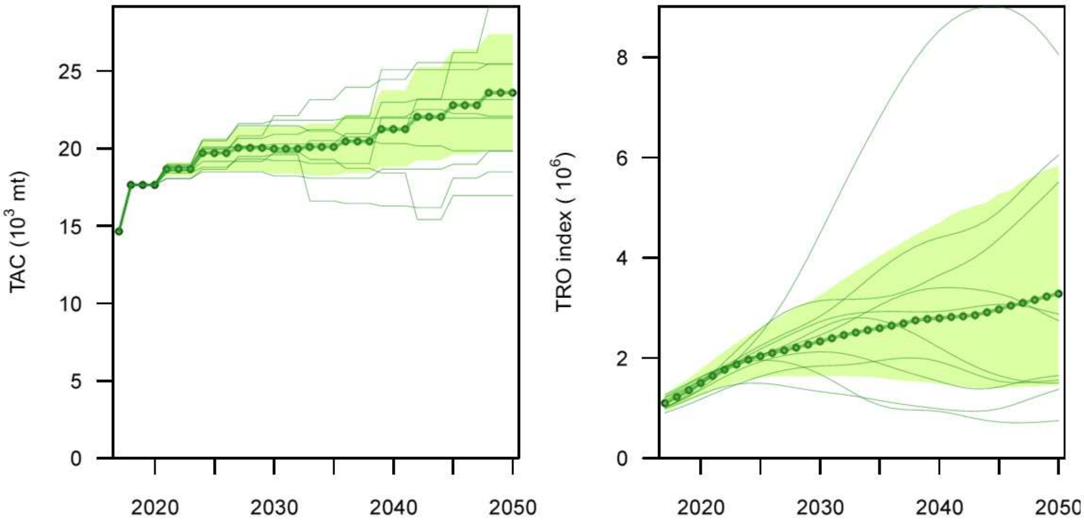


Fig. 3. Trajectories of TAC and spawning stock size in total reproductive output (TRO) from robustness test result of NT4 CMP under "cpueupq" scenario.

(a) NT4, 30%TRO_0, by 2035, maxTACchange = 3000 t, "cpueom75"



(b) NT4, 35%TRO_0, by 2040, maxTACchange = 3000 t, "cpueom75"

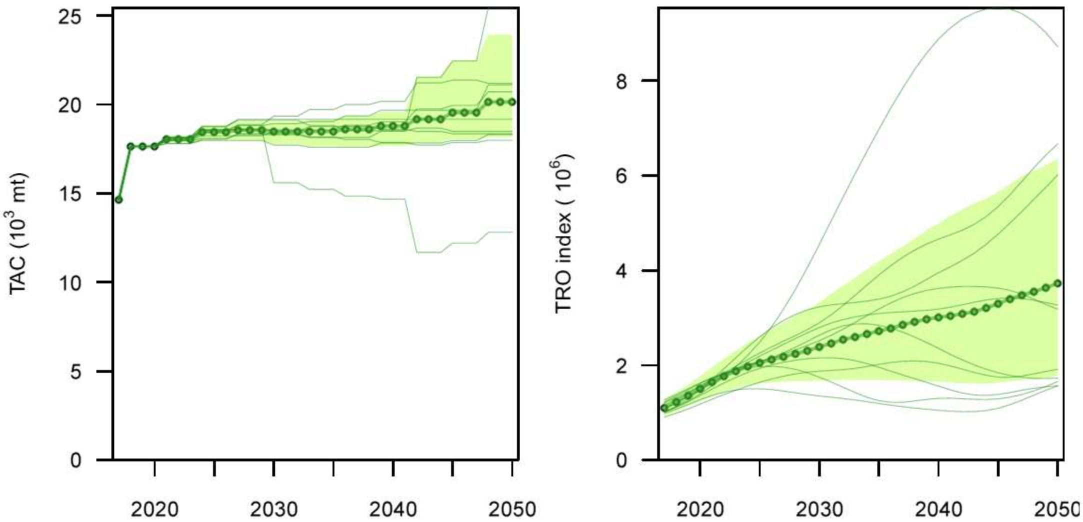
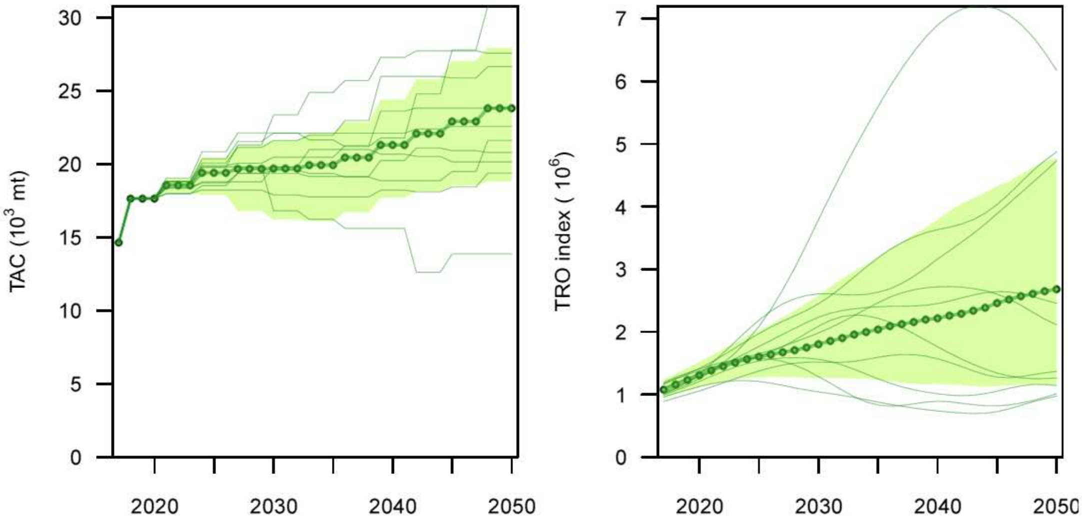


Fig. 4. Trajectories of TAC and spawning stock size in total reproductive output (TRO) from robustness test result of NT4 CMP under "cpueom75" scenario.

(a) NT4, 30%TRO_0, by 2035, maxTACchange = 3000 t, “as2016”



(b) NT4, 35%TRO_0, by 2040, maxTACchange = 3000 t, “as2016”

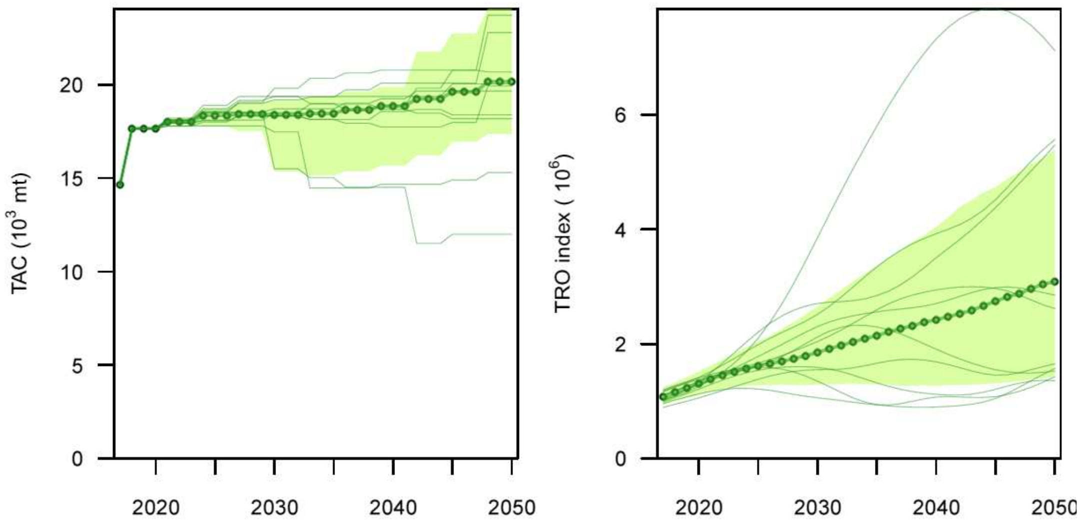
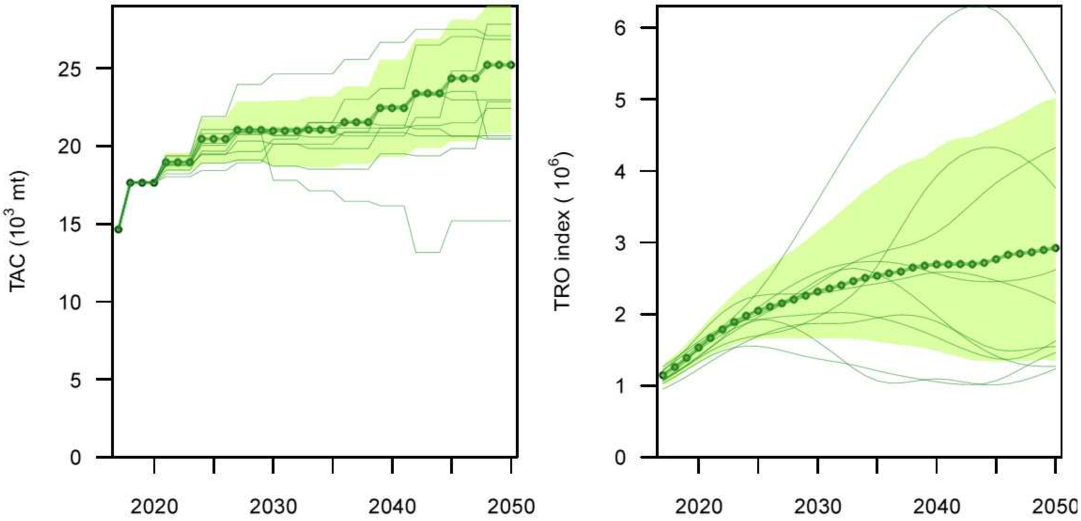


Fig. 5. Trajectories of TAC and spawning stock size in total reproductive output (TRO) from robustness test result of NT4 CMP under “as2016” scenario.

(a) NT4, 30%TRO_0, by 2035, maxTACchange = 3000 t, "cpuehcv"



(b) NT4, 35%TRO_0, by 2040, maxTACchange = 3000 t, "cpuehcv"

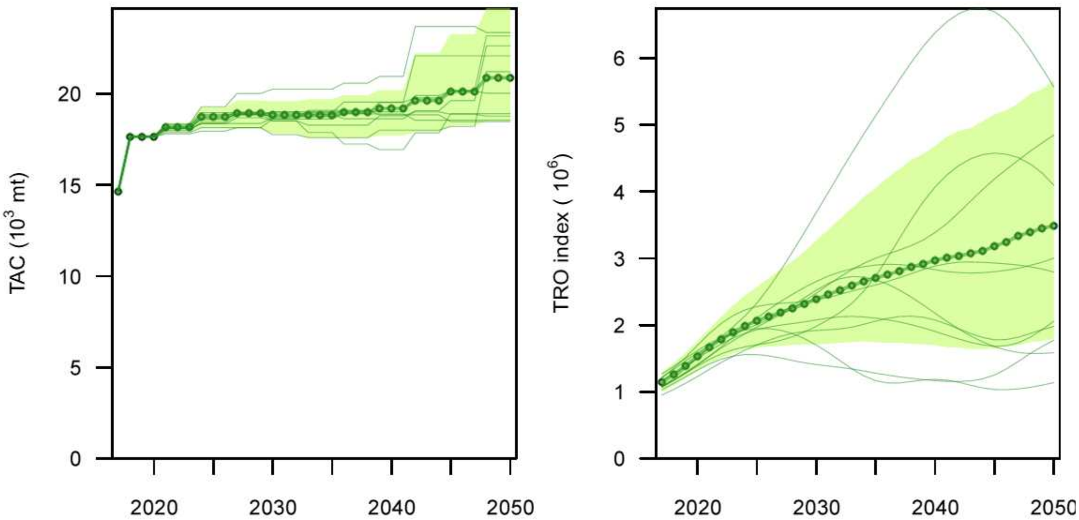


Fig. 6. Trajectories of TAC and spawning stock size in total reproductive output (TRO) from robustness test result of NT4 CMP under "cpuehcv" scenario.

(a) TAC

(b) Relative SSB index

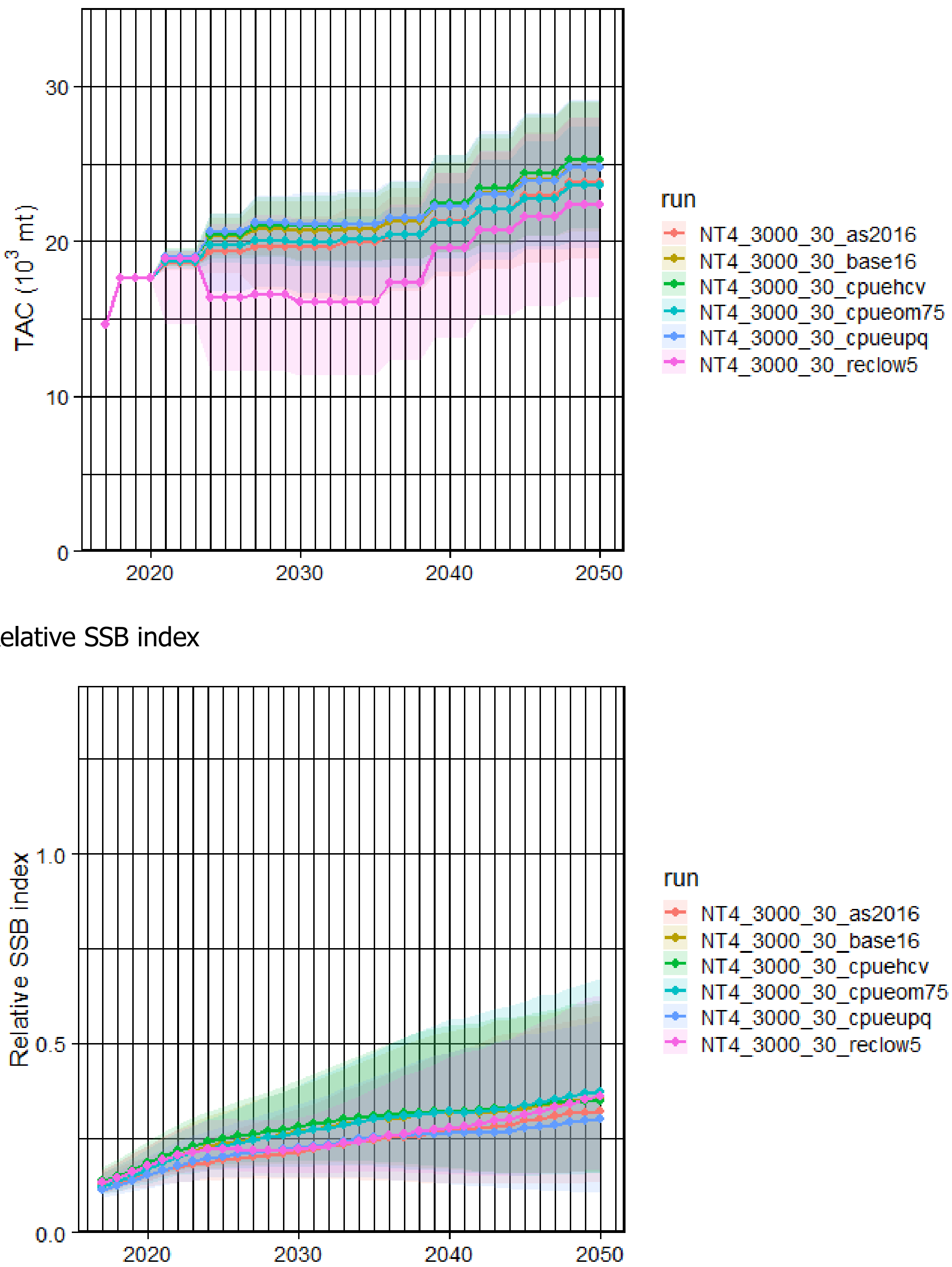
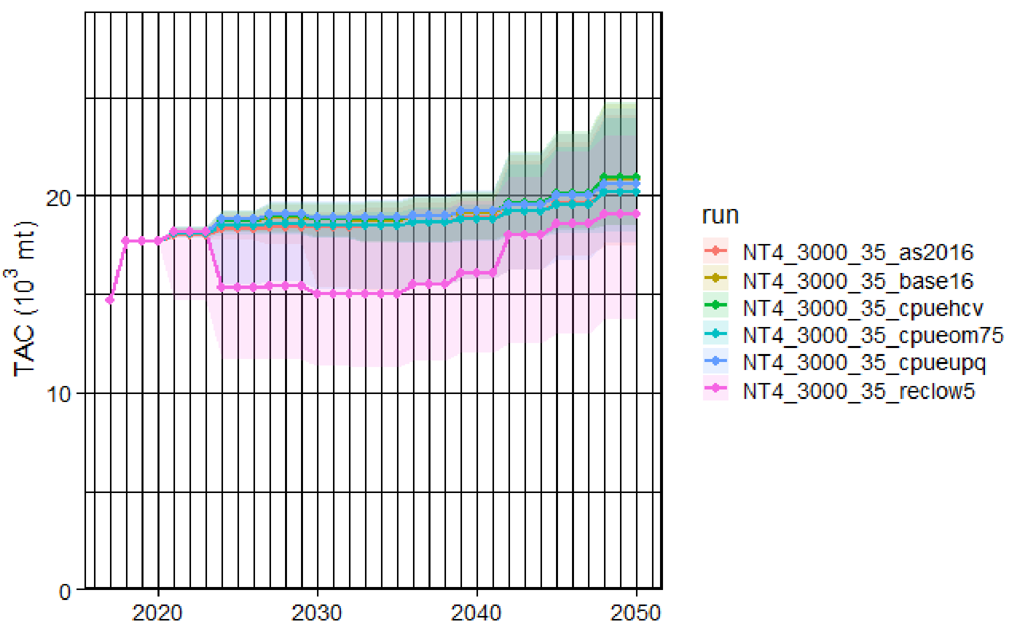


Fig. 7. Comparisons of trajectories of TAC and relative SSB index between the reference set run (tuned) and selected robustness tests for NT4 (30%TRO_0, by 2035, maxTACchange = 3000 t).

(a) TAC



(b) Relative SSB index

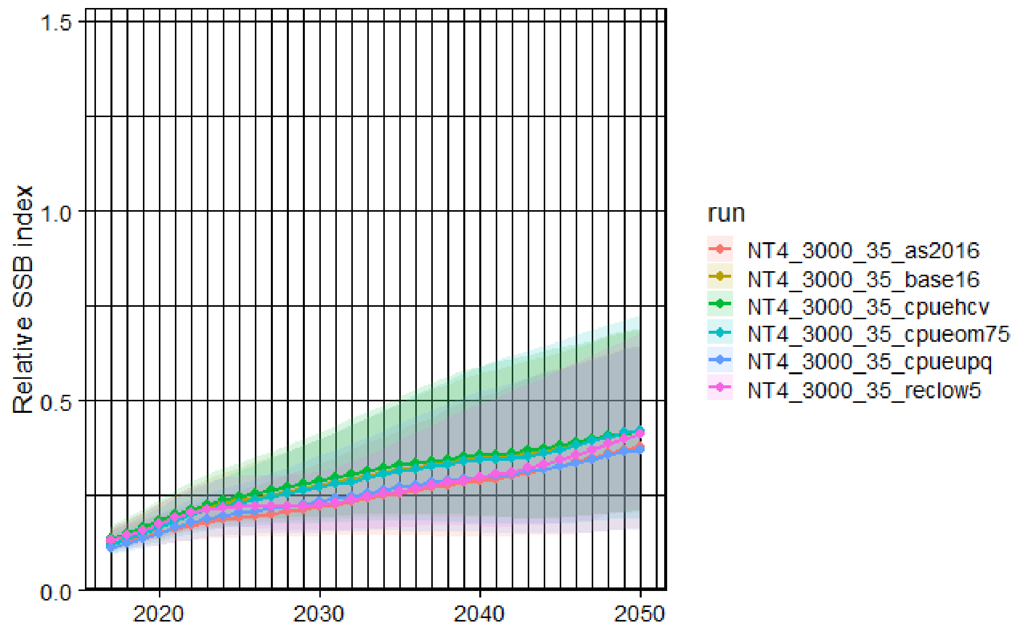


Fig. 8. Comparisons of trajectories of TAC and relative SSB index between the reference set run (tuned) and selected robustness tests for NT4 (35%TRO_0, by 2040, maxTACchange = 3000 t).