GRAPHIC UNDERSTANDING OF HOW THE CAPE TOWN PROCEDURE CALCULATES TAC

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ケープタウンプロシージャが如何に TAC を計算するかのグラフによる理解

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Abstract: In this paper, the authors attempt to explain the mechanics and specifications of the Cape Town Procedure (CTP) graphically with an explanation to the Extended Commission in mind, and to provide a basis for further discussion on the communication issue between scientists and managers. Based on graphic understanding of how the CTP calculates TAC, the mechanics and specifications of the CTP are summarized in very simple form, and then the authors attempt to identify a key point that can resolve the miscommunication occurred between scientists and manages.

要旨： 本文書では、著者は拡大委員会に説明することを念頭に置いてケープタウン方式（CTP）の仕組みと仕様を、グラフを使って説明することを試み、また、科学者と管理者間のコミュニケーション問題に関するさらなる議論の土台を提供することを試みる。CTP がどのように TAC を算定するかのグラフによる理解を基に、CTP の仕組みと仕様がとても単純な形で要約され、その上で著者は科学者と管理者間で起こったミスコミュニケーションを解消することができる要点を特定することを試みる。

1. Introduction

The Cape Town Procedure (CTP) was used to recommend a TAC of southern bluefin tuna (*Thunnus maccoyii*) for the 2021-2023 fishing seasons in 2020 in CCSBT. At the 2020 meeting of the Extended Commission (EC), some Members commented that they had expected the CTP to recommend a TAC increase due to positive information on the recovery of the spawning stock in previous years, and they were disappointed that it had not (CCSBT 2020). This gap between such expectation and the outcome probably came from insufficient communication between scientists and managers. One solution to fill in the gap and to facilitate the scientist-manager communication may be that the Extended Scientific Committee (ESC) explains the mechanics and specifications of the CTP graphically to the EC and assists the EC to gain a better understanding of characteristics/behaviors of the CTP and how the CTP calculates a TAC.

In this paper, we attempt to explain the mechanics and specifications of the CTP graphically with an explanation to the EC in mind, and to provide a basis for further discussion on the communication issue between the EC and the ESC. All figures in this paper are simply conversions from equations in Hillary et al. (2020).

2. Mechanics and specifications of the CTP

The CTP determines rates of TAC increase/decrease separately for longline CPUE, gene-tagging (GT), and close-kin mark recapture (CKMR) components (represented by symbols, Δ^{CPUE}, Δ^{GT}, and Δ^{CKMR}), based on information from CPUE, age 2 SBT abundance estimates from GT, and parent-offspring pairs (POPs) and half-sibling pairs (HSPs) data of CKMR. Then, TAC for the next period (TAC_{next}) is calculated from TAC for the previous period (TAC_{prev}) such as:

$$TAC_{next} = TAC_{prev} \times (1 + \Delta^{CPUE} + \Delta^{CKMR}) \times \Delta^{GT} \qquad \text{(eq. 1)}$$

How to determine Δ^{CPUE}, Δ^{GT}, and Δ^{CKMR} in the CPUE, GT, and CKMR parts in the CTP is explained in the following sections.

2.1. Setting a target reference

Before determining the rates of TAC increase/decrease separately in the CPUE, GT, and CKMR parts, the CTP estimates time series of total reproductive output (TRO) of the spawning stock using relatively a simple adult-only population dynamics model with CKMR POPs and HSPs data (Fig. 1). Then, as a reference value (Iref), the average over 2003 to 2014 of the time series is calculated, and a value of 1.5 x Iref is set as a target reference to be used within the CTP (not shown in Fig. 1 due to a scaling issue of the y axis, too high to show for the current scale of the y axis). In addition, the recent 3-year average of TRO is calculated (e.g., for the 2020 case, averaged over 2017 to 2019). A difference between this 3-year average and the target reference is taken into account when determining the rates of TAC increase/decrease in the CPUE and CKMR parts (not in the GT part) later on. This difference between the 3-year average of TRO and the target reference is utilized within the CTP as information that indicates the degree to which the spawning stock rebuilding has been achieved.

There is one thing that is worth to mention here about the TRO time series estimated within the CTP before proceeding to explain further. Although the time series of TRO in recent years after 2011 shows an increasing trend, we can see that the rate of this increase is actually very gradual if the y axis scale is changed to wider one as the current y axis scale focuses only on a very narrow range (Fig. 1). This rate of increase is different from (much more gradual than) the ones that was estimated from full stock assessments using the operating model (OM). This difference probably comes from different models used in the CTP (relatively a simple model) and in the OM (a complex integrated model). This is a very important point to understand characteristics/behaviors of the CTP.

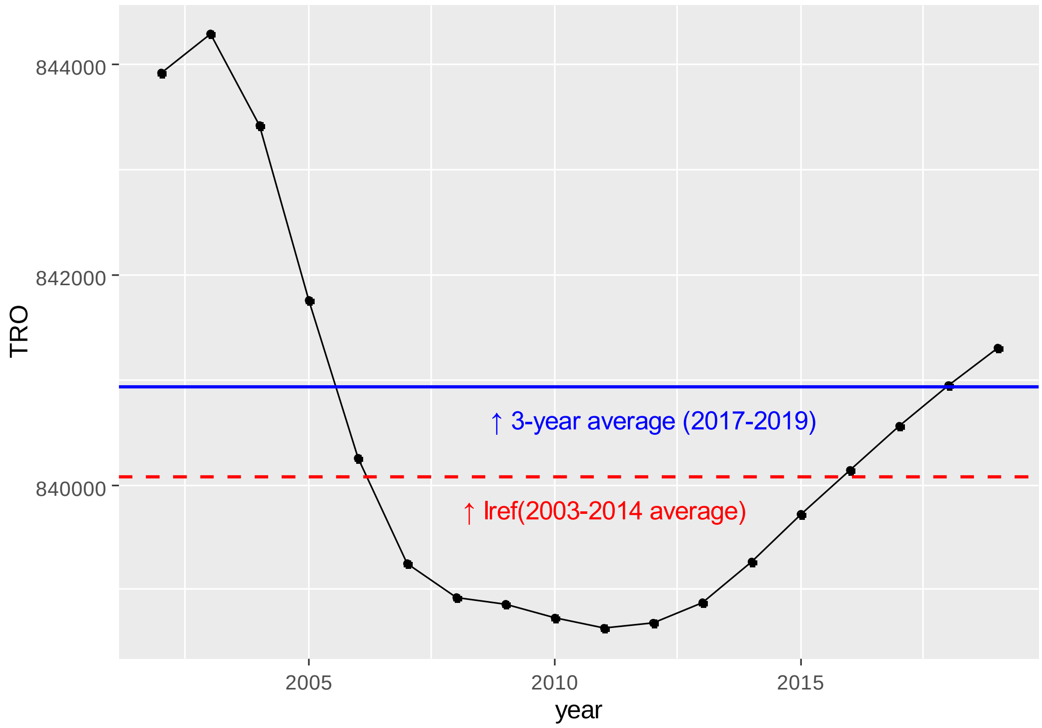

Fig. 1. Time series of TRO estimated using a simple adult-only population dynamics model in the CTP with 2020 CKMR POPs and HSPs data (black line with points), the average over 2003 to 2014 of the time series as a reference value (Iref, red dashed line), and the recent 3-year average of TRO over 2017 to 2019 for the 2020 case as an example (blue line). A value of 1.5 x Iref (ca. 1,260,000) is set as a target reference to be used within the CTP (not shown here due to a scaling issue of the y axis, too high to show for the current scale of the y axis).

2.2. Longline CPUE part

If the recent 4-year average of longline CPUE index is above the prespecified upper threshold (1.42) or below the prespecified lower threshold (0.45), a rate of TAC increase/decrease based on CPUE (Δ^{CPUE}) is determined from the relative level of the 4-year average to the prespecified threshold (Fig. 2). The rate of TAC increase/decrease for CPUE is also modified according to the difference between the recent 3-year average of TRO and the target reference (described in 2.1 above). Otherwise, the CPUE index is not used for TAC calculation (set Δ^{CPUE} to 0).

A comparison between historical CPUE series and the prespecified upper/lower thresholds is shown in Fig. 3.

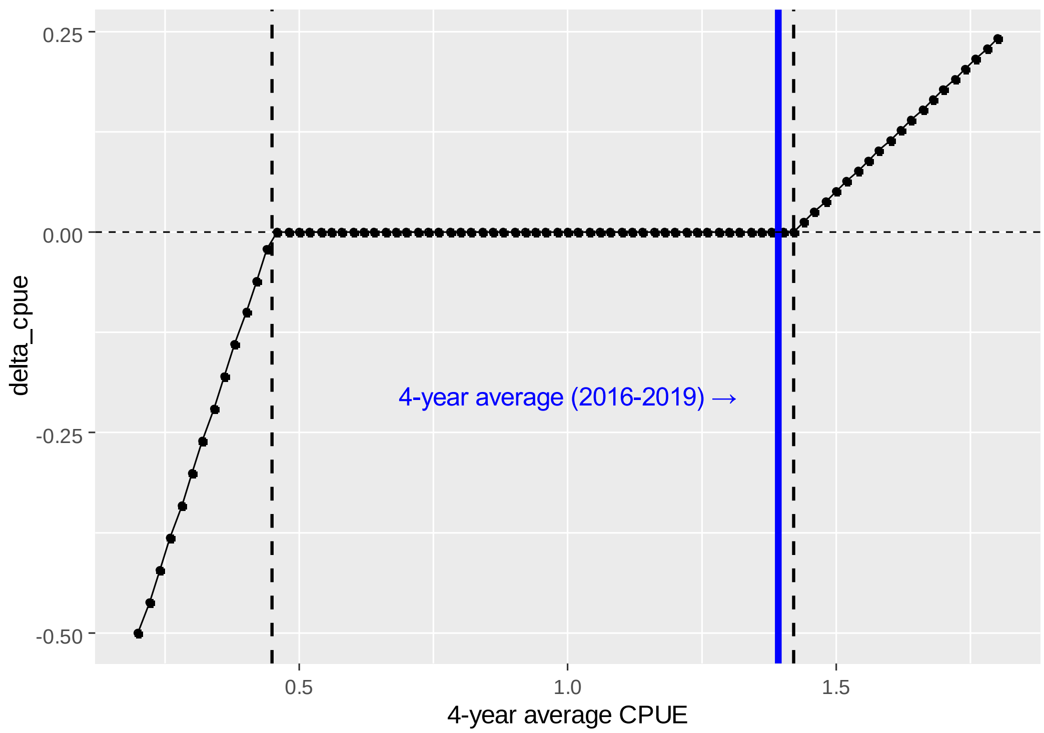

Fig. 2. Changes of TAC increase/decrease rate based on CPUE (Δ^{CPUE}) as the recent 4-year average of longline CPUE changes (black line with points), and the 4-year average of CPUE over 2016 to 2019 which indicates $\Delta^{CPUE}=0$ (blue line). The 2020 case is shown as an example here. The changing pattern of TAC increase/decrease rate for CPUE (the slope of the black line with points) changes depending on the difference between the recent 3 year-average of TRO and the target reference (described in 2.1 above). The prespecified upper threshold (1.42) and lower threshold (0.45) are also shown (black dashed lines).

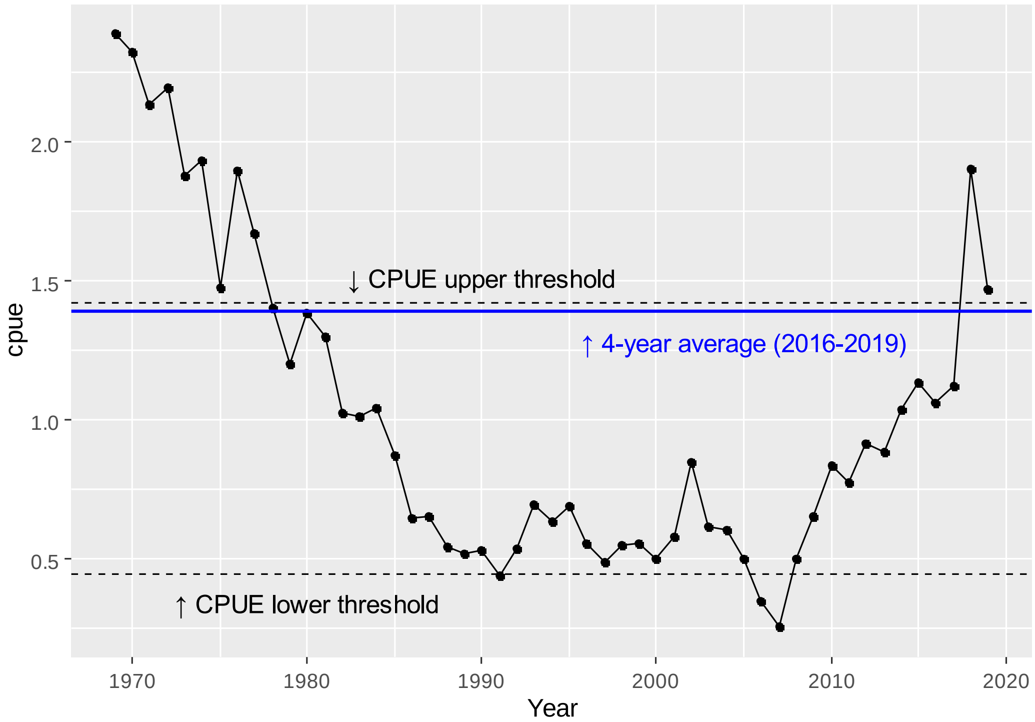

Fig. 3. A comparison between historical CPUE series (black line with points) and the prespecified upper (1.42)/lower (0.45) thresholds (black dashed lines). The recent 4-year average of CPUE over 2016 to 2019 for the 2020 case is also shown as an example (blue line).

2.3. CKMR part

First, a value of threshold trend (λ) is determined taking into account the difference between the recent 3 year-average of TRO and the target reference (described in 2.1 above). Fig. 4 illustrates changes of λ as the difference between the 3 year-average of TRO and the target reference changes. Second, the trend of the TRO time series over recent 5 years is estimated using log-linear regression. Finally, only if this estimated trend of the TRO time series is greater than the threshold trend λ, then the rate of TAC change based on CKMR data (Δ^{CKMR}) is allowed to be positive/increase (Figs. 5 and 6). Otherwise, Δ^{CKMR} is determined as negative/decrease according to the magnitude of the estimated trend.

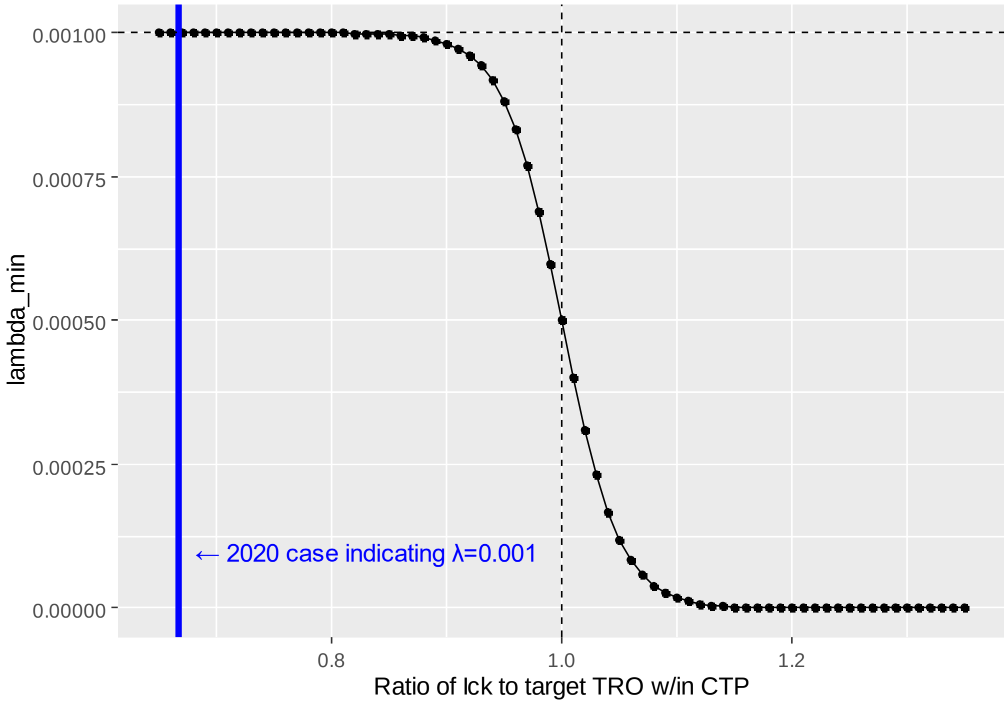

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Fig. 4. Changes of threshold trend (λ) as the difference (ratio) between the recent 3-year average of TRO and the target reference (described in 2.1 above) changes (black line with points). As an example, the blue line illustrates the 2020 case, indicating λ=0.001.

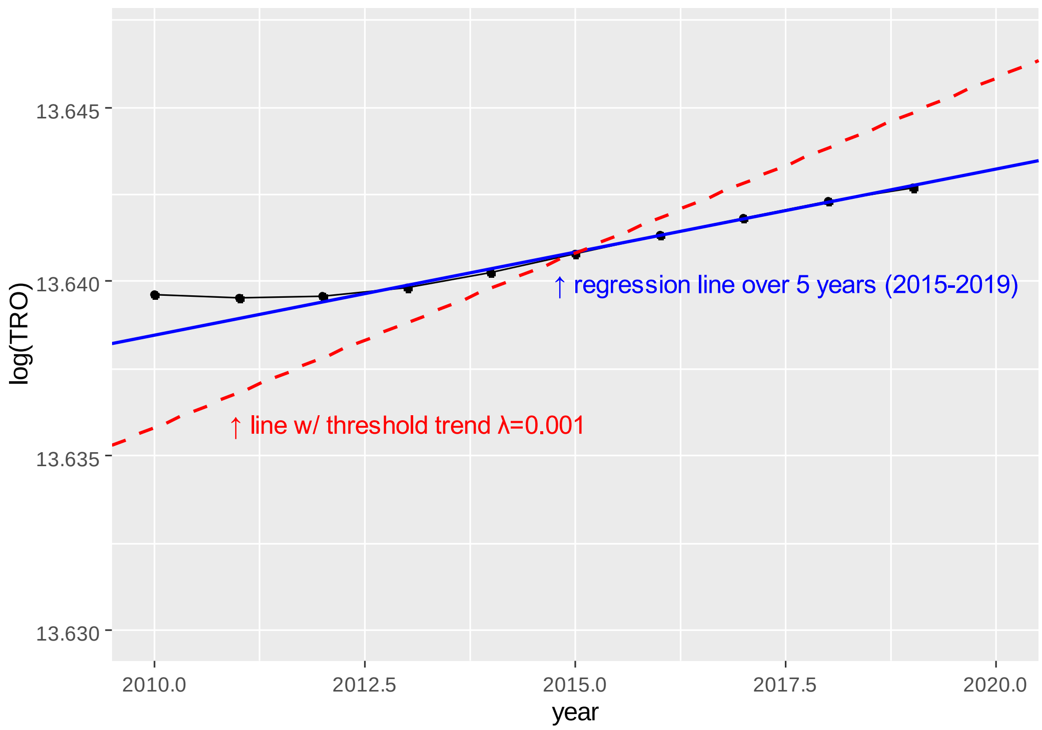

Fig. 5. TRO time series estimated in the CTP from CKMR data (black line with points, a part of the TRO time series plotted in Fig. 1), the log-linear regression line estimated from the TRO time series of the recent 5 years (blue line, over 2015 to 2019 in this case), and the line with the threshold trend (slope) λ (red dashed line, λ=0.001 in this case). The value of λ (the slope of the red dashed line) changes depending on the difference between the recent 3-year average of TRO and the target reference (see Fig. 4). The 2020 case is shown as an example here.

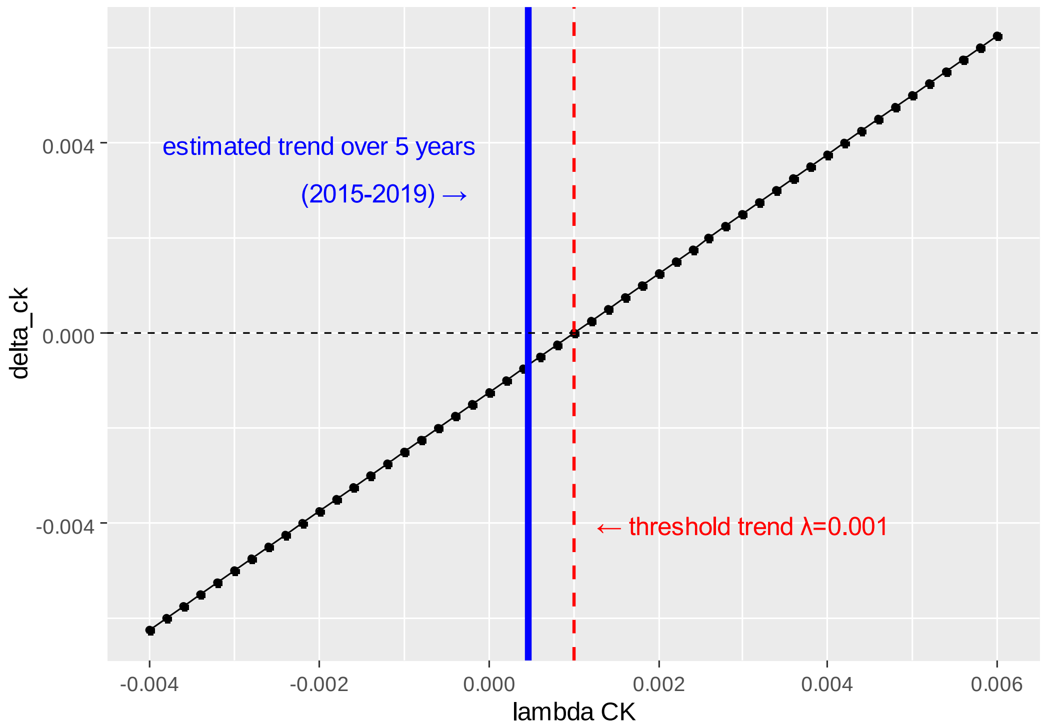

Fig. 6. Changes of TAC increase/decrease rate based on CKMR (Δ^{CKMR}) as the estimated trend (slope) of the TRO time series over recent 5 years changes (black line with points), and the threshold trend (slope) λ (red dashed line, λ=0.001 in this case). The changing pattern of TAC increase/decrease rate for CKMR (slope of the black line with points) changes depending on the difference between the recent 3 year-average of TRO and the target reference (described in 2.1 above). The value of λ (the location of the red dashed line) also changes depending on the difference between the recent 3-year average of TRO and the target reference (see Fig. 4). The 2020 case is shown as an example here. The blue line represents the trend (slope) of the TRO time series over recent 5 years (2015 to 2019) estimated using log-linear regression for the 2020 case (the slope of the blue line in Fig. 5), which illustrates that the estimated trend is smaller than the threshold trend λ (red dashed line), indicating a slight decrease rate (Δ^{CKMR}=-0.00066 in this case).

2.4. GT part

The GT part of the CTP uses numbers of matches and estimates of age 2 SBT abundance obtained from GT for determining a rate of TAC increase/decrease (Δ^{GT}). If the recent 5-year average (weighted by numbers of matches) of the age 2 abundance estimates is above the prespecified upper threshold (2600000) or below the prespecified lower threshold (1000000), Δ^{GT} is determined from the relative level of the 5-year weighted average to the prespecified threshold (Fig. 7). Otherwise, the information from the GT is not used for TAC calculation (set Δ^{GT} to 1).

A comparison between historical time series of age 2 abundance estimated from the OM and the prespecified upper/lower thresholds is shown in Fig. 8.

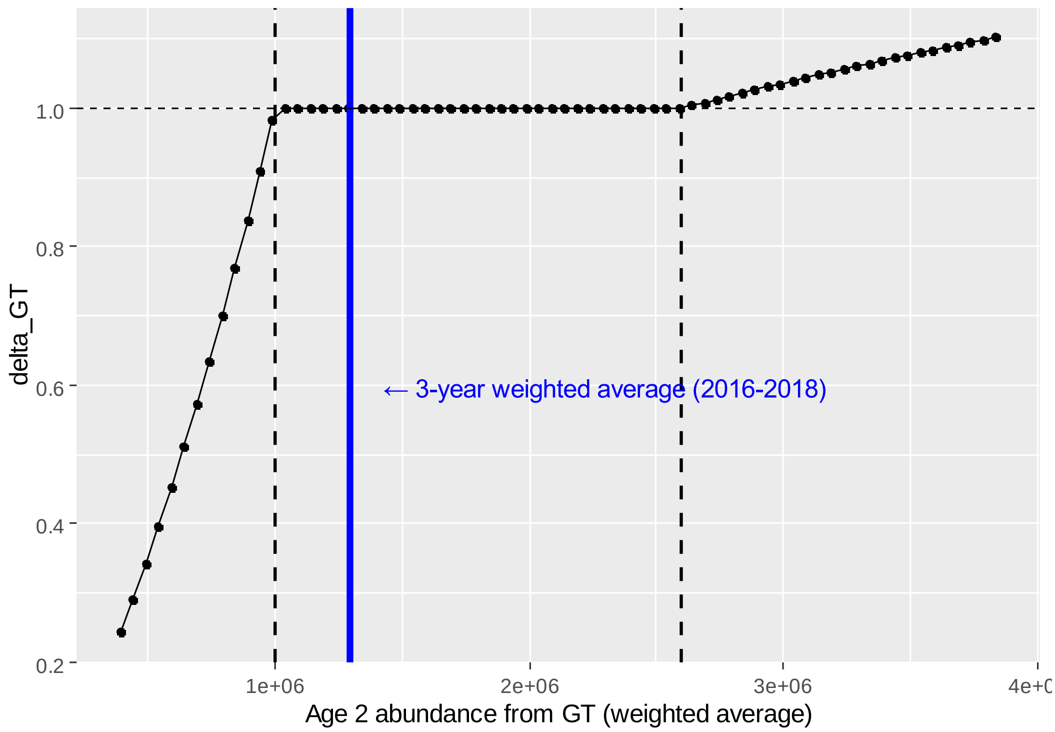

Fig. 7. Changes of TAC increase/decrease rate based on GT (Δ^{GT}) as the recent 5-year average (weighted by numbers of matches) of age 2 SBT abundance estimates changes (black line with points), and the 3-year weighted average of age 2 abundance estimates for the 2020 case which indicates $\Delta^{GT}=1$ (blue line). The 2020 case is shown as an example here. In 2020, only 3 estimates of age 2 abundance for 2016, 2017, and 2018 were available for calculating the 5-year weighted average. The prespecified upper threshold (2600000) and lower threshold (1000000) are also shown (black dashed lines).

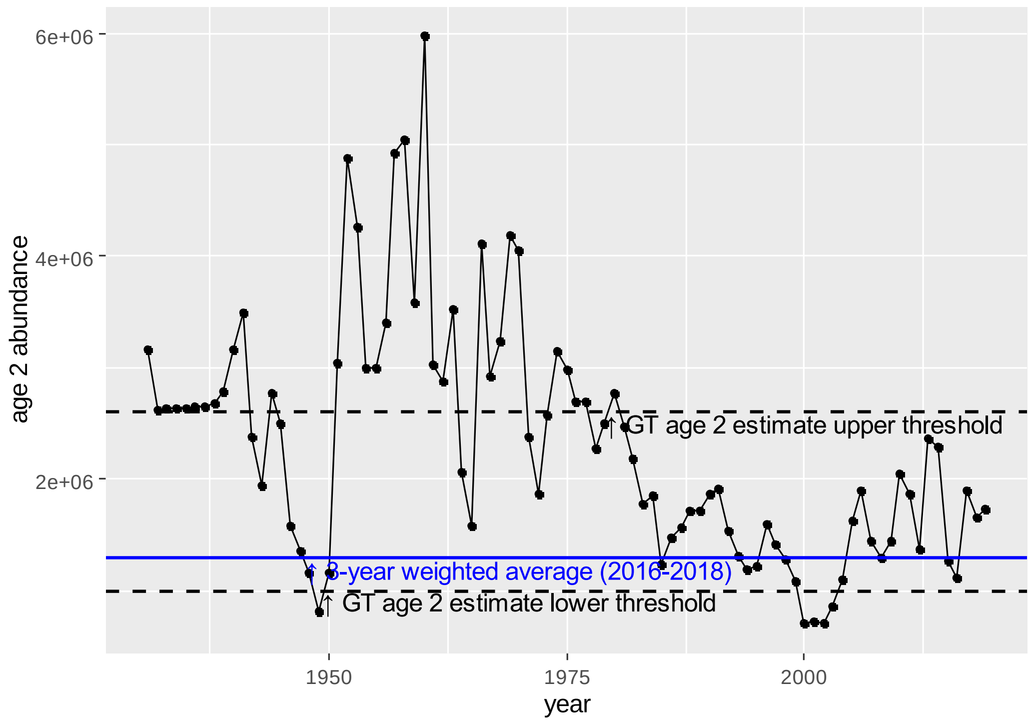

Fig. 8. A comparison between historical time series of age 2 abundance estimated from the OM (black line with points) and the prespecified upper (2600000)/lower (1000000) thresholds (black dashed lines). The recent 3-year average of CPUE over 2016 to 2018 for the 2020 case is also shown as an example (blue line).

3. Summary of the mechanics and specifications of the CTP

Based on graphic understanding of how the CTP calculates TAC above, the mechanics and specifications of the CTP can be summarized in very simple form as follows:

- Only when information from CPUE and/or GT indicates "very high" or "very low" levels, information from CPUE and/or GT is used for TAC calculation in addition to information from CKMR (see 2.2, 2.3, and 2.4).
- Otherwise, only information from CKMR is used for TAC calculation (see 2.3).
- Degrees to which how CPUE and GT is "very high" and "very low" are defined as prespecified upper and lower thresholds (see 2.2 and 2.4).
- The recent trend of time series of spawning stock TRO estimated by the model in the CTP is different from (much more gradual than) the ones estimated in full stock assessments using the OM, which tends to produce a conservative TAC for facilitating stock rebuilding if only information from CKMR is used as the CTP prioritize stock rebuilding and conservation in the first place (see 2.1 and 2.3).

It is considered that the point noted in the last fourth bullet is very important to understand characteristics/behaviors of the CTP. As explained in 2.1, the difference of the recent TRO trend between the CTP and stock assessments using the OM probably comes from different models used in the CTP (relatively a simple model) and in the OM (a complex integrated model). Which model is better or worse, correct or wrong is not an issue here because which model is right for a situation totally depends on the purpose for which it is used. Recall the fact that even though the CTP uses relatively a simple population dynamics model, it showed the best performance among the four candidate management procedures when tested. Instead, it can be argued that how the mechanics and specifications of the CTP, especially the point noted in the last fourth bullet, can be clearly explained to the EC is probably a key to resolve the miscommunication occurred between scientists and managers about the CTP.

4. How to present graphically future TAC predicted by projections using the CTP

Actual operation of the CTP with real observation data (CPUE, GT, CKMR) produces only one TAC value for the next season block. On the other hand, in projections (MP tests and stock assessments), there are 2000 future TAC values for a year predicted corresponding to a 2000 scenarios set of the OM. Although how the CTP calculates a TAC from the data and its characteristics can be understood by the graphic illustrations of its mechanics and specifications described in previous sections (2.1 through 2.4), the picture of how expected future TAC values from the CTP are distributed cannot be seen by those graphic illustrations. The graph of future TAC trajectory using the median with the lower 5 and upper 95 percentiles used in the presentation about the CTP to the EC is one way to get a general idea about central tendency and variability of probability distribution for future TAC in the presence of extreme values. However, if the shape of the distribution is distorted/skewed from an unimodal distribution, simply presenting the traditional TAC trajectory using the median with the lower 5 and upper 95 percentile could provide managers with wrong impression that the median trajectory is the most likely and the lower and upper end is the least likely. If managers are so misled, they may be overly optimistic, which could result in miscommunication between ESC and EC such as that occurred in the 2020 EC meeting. In such a case, a histogram is very useful for presenting the whole picture of the distribution.

Histograms of TAC (every 3 years from 2021) predicted by projections when the CTP was tested in 2019 are shown in Fig. 9. For example, in the 2021 case (TAC for the 2021-2023 seasons, Fig. 9a), there are many frequencies found around 17,600 t of TAC, which could not be seen by the graph of future TAC trajectory using the median with the lower 5 and upper 95 percentiles. Note that the histograms of future TAC in Fig. 9 are based on projections when the CTP tested in 2019, and thus current histograms may change as data used in the CTP have been updated since 2019.

When a probability distribution of future TAC predicted by projections is presented to the EC in future, histograms of predicted TAC are very helpful to view the picture of the distributions, and thus should be presented along with the traditional graph of future TAC trajectory using the median with the lower 5 and upper 95 percentiles. Besides, when there are some future possibilities which may put downward pressure to the future TAC distribution (e.g., updates of input data to the CTP), such information should be clearly explained to EC alongside the histograms, so that the managers can recognize possible risks of the downward outcome in advance. Such additional efforts to better explain the traditional projection graphs will be useful to improve future communication between ESC and EC.

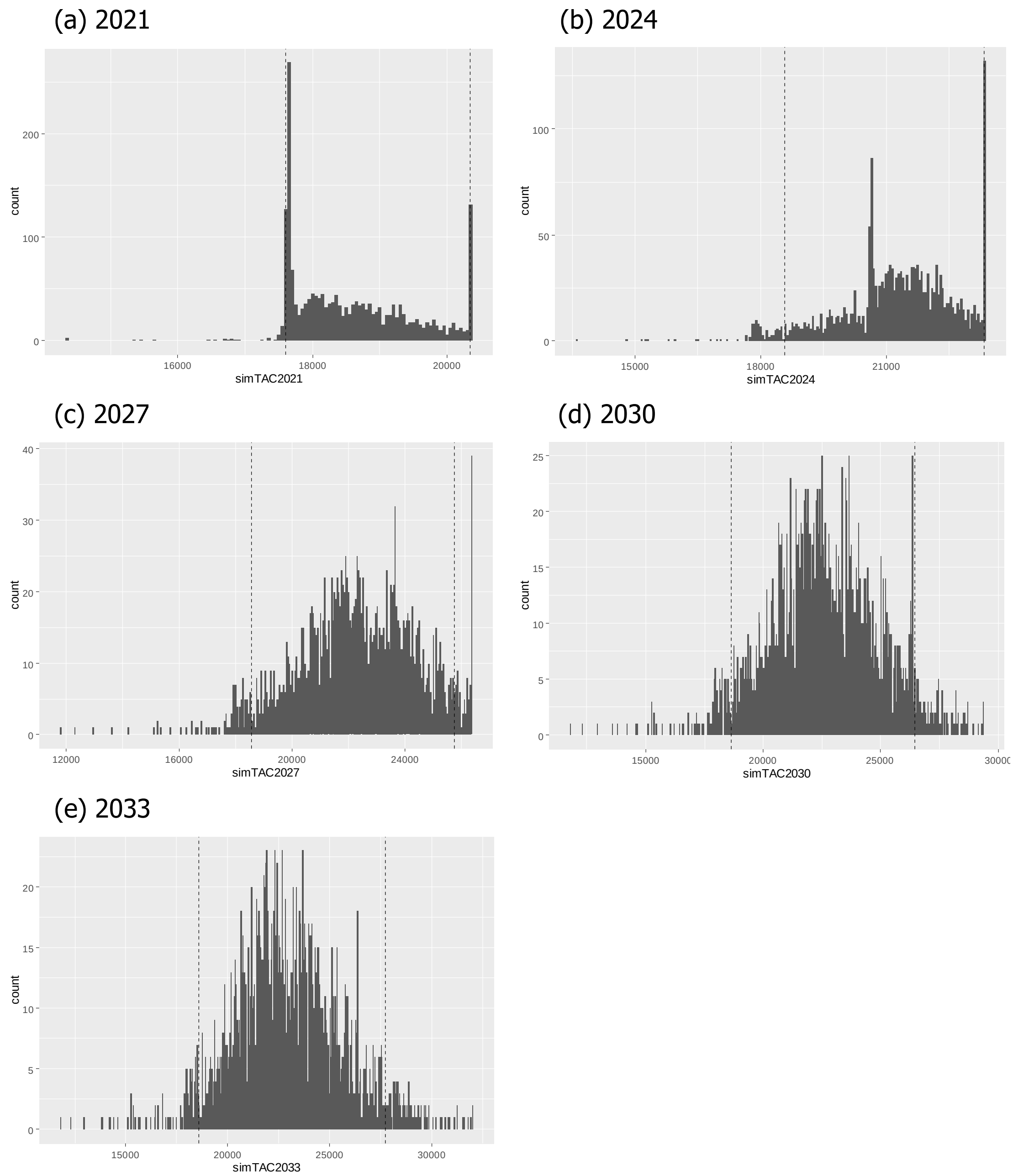

Fig. 9. Histograms of TAC (every 3 years from 2021) predicted in projections when the CTP was tested in 2019. Dashed lines represent the lower 5 and upper 95 percentiles.

References

CCSBT. 2020. Report of the twenty seventh annual meeting of the Commission, 16 October 2020, Online. The Commission for the Conservation of Southern Bluefin Tuna, Canberra, Australia. 101 pp.

Hillary, R., A. Preece and C. Davies. 2020. Running the Cape Town procedure for 2020. CCSBT-ESC/2008/BGD06 (Previously CCSBT-OMMP/2006/08).