Proposal for amending the management procedure adopted for the Indian Ocean swordfish and practical aspect for its first implementation

15th Working Party on Methods

Thomas Brunel[1] and Iago Mosqueira[1]

1 Introduction

Based on the outcome of the management strategy evaluation presented at the 8th Session of the Technical Committee on Management Procedure, the commission adopted resolution 24/08 on a management procedure for swordfish in the IOTC area of competence.

The chosen management procedure corresponds to the MP1 in the working document presented to the TCMP08 (Brunel and Mosqueira, 2024). The adopted MP is a data-based MP, relying on the use of a CPUE index as indicative of the recent development in stock biomass.

While inspecting of the simulation results presented at TCMP08, two discrepancies (one technical and one practical) were found concerning the approach used to implement the MP for the first time in the MSE compared to the real-life. In this document, the impact of these issues on the performance of the adopted MP is evaluated. An amendment of the adopted MP is also proposed in order to restore the performance to similar levels as presented at TCMP08.

The present document also gives a description of the adopted MP, and proposed amended version, and specifies how it should be implemented.

2 Description of the adopted MP

2.1 Data needs

The input data for the MP is the standardized longline catch per unit effort (CPUE) for the Japanese longline fishery in the Northwestern area. These are derived from the standardization analysis approach described in Matsumoto et al. (2023) for the NW region only of the Indian Ocean.

2.2 TAC multiplier

The MP defines the rate of change in TAC (Total Allowable Catch) compared to the previous TAC, a TAC multiplier, based on the slope of the CPUE and the distance to a target CPUE value (Figure 1).

[1] Wageningen Marine Research, Haringkade 1, Postbus 68, 1976CP, IJmuiden, The Netherlands. thomas.brunel@wur.nl ; iago.mosqueira@wur.nl

An increasing CPUE trend or a recent CPUE above the target CPUE value will lead to an increase in the TAC. Conversely, a decrease in the CPUE or a recent CPUE below the target CPUE value will lead to a decrease in the TAC. If the current CPUE relative to the target and the CPUE slope are in opposite directions, the TAC change could be in either direction, depending on the magnitude of these indicators, and the associated control parameters.

Formally, the future TAC is calculated from a proportion, TAC_{mult}, of the current TAC, and defined as:

$$TAC_{mult} = 1 + k_a Sl + k_b D$$

Where :

- Sl is the slope of the log CPUE over the last 5 years (y-5 to y-1, if y is current year)
- D is the difference between recent CPUE value (average over the last 3 years, y-3 to y-1) and the target CPUE value (i.e. recent CPUE − CPUEtarget),
- ka and kb are responsiveness parameters

The MP parameters to apply for the adopted management procedure, as obtained by tunning it to the specified management objective, are :

ka = 2.1; kb = 1.2; $CPUE_{target}$ = 0.7125

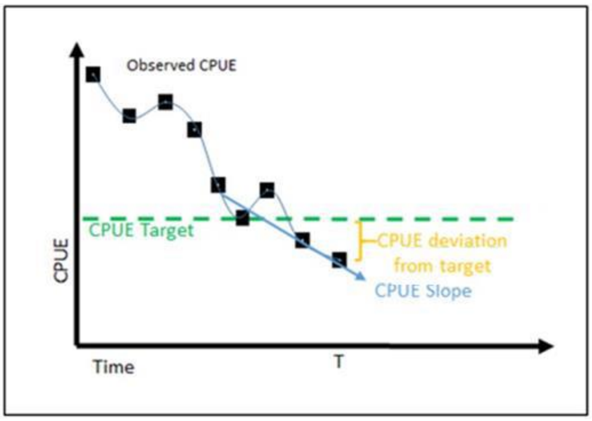

Figure 1: illustration of calculation of the recent slope in the CPUE index and the distance to the target CPUE level, which are used in the MP to compute the TAC multiplier.

2.3 TAC stabilization mechanism

The adopted MP also has a TAC stabilization mechanism, by which the TAC cannot increase by more than 15% or decrease by more than 10% on each management cycle.

Concretely that means that if the TAC_{mult} value coming out of the harvest control rule is larger than 1.15, it should be set at this value, and conversely, if it is lower that 0.90, it should be set at this value.

2.4 Final TAC calculation

Following the two steps described above, the new TAC should be calculated as follows :

$$TAC_{new} = \begin{cases} TAC_{mult} \times TAC_{cur} if 0.90 < TAC_{mult} < 1.15 \\ 0.9 \times TAC_{cur} if TAC_{mult} \leq 0.90 \\ 1.15 \times TAC_{cur} if TAC_{mult} \geq 1.15 \end{cases}$$

with TAC_{new} being the new TAC to be set for the next management cycle and TAC_{cur} the current TAC.

3 Suggested amendment to the adopted MP

3.1 Context

Upon further inspection of the swordfish MSE output following TCPM08, it was discovered that the conditions under which the first implementation of the MP was simulated for the TCMP08 are likely to differ to some extent from the situation in real-life. In the simulation presented at TCMP08, the CPUE index used for the first MP implementation was simulated not only for future years in the simulation period, but also for the final years of the historical period (2020 to 2022). As a result, the first TAC calculation was based on index values for 2020 to 2022 simulated by the index generating function in the MSE framework. In real-life, however, the first MP implementation will rely on the most recent available CPUE index, which covers the years 2020 to 2022.

Starting the simulation of index values in 2020 versus 2023 leads to differences in the CPUE trend and mean values used for calculating the first TAC. In the MSE results presented at TCMP08, where the index is simulated from 2020, the CPUE index shows a sharp decrease in 2020—the first year it is simulated—followed by a steady increase until 2030 (Figure 2). In the correct configuration, where simulation starts in 2023, the CPUE index values for 2020 to 2022 are the actual observed values, and simulation begins from 2023 onward. In these simulations, the index increases until 2022, drops in 2023, and then increases again thereafter.

The second discrepancy between the conditions in which the MP was tested and its implementation in real-life is that the MSE assumed a one-year management lag (TAC calculated in a given year, y, being implemented in the following year, $y+1$), while following the final text of the MP resolution adopted in 2024, the management lag will be of two years. The TAC calculation are to take place at the WPB at the end of the year y, and to be reviewed and accepted by the Commission at the start for the following year, $y+1$, to be applied one year after, $y+2$. For the TCMP08, a robustness test was presented which showed that the adopted MP was robust also with a two-year management lag. However, some other performance indicators deteriorated (slightly lower catches).

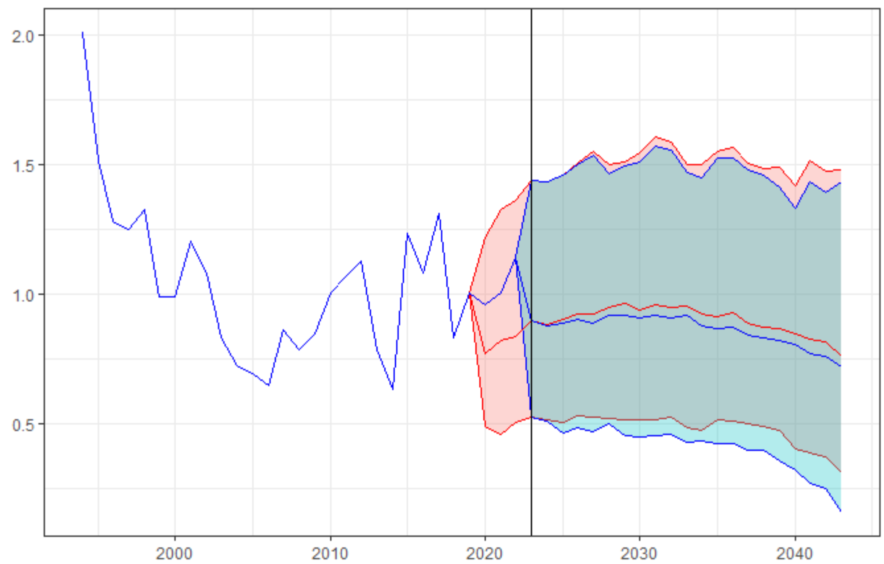

Figure 2 : historical and simulated CPUE index values for the MP1 run presented at the TCMP (red, simulated since 2020) and for the same MP run with the corrected index generating function (in blue, simulated since 2023). Vertical line shows the first year in the MP simulations.

3.2 Additional MP runs

These two different approaches regarding CPUE index result in different slope and mean index being used in the first MP implementation and therefore lead to setting different initial TACs. This difference in the initial TACs has an impact on further development of the stock and future TACs in the simulation period, and ultimately, the performance indicators are affected.

In order to evaluate the impact of replacing the 2020 to 2022 CPUE index values by simulated values, simulations applying the adopted MP (called ***MP1_TCMP***) were rerun applying a correction to the methodology, in which only future CPUE index values are simulated (i.e. not including the recent past, 2020 to 2022). In this simulation, the MP parameters used are the same as in the adopted MP, as detailed above. This new run of MP1 (called ***MP1_correc***.) shows the performance of the adopted MP when the CPUE index is used as in real-life.

The MP was also tuned again (to re-estimated the target CPUE value) for simulations in which the real index values are used for 2020 and 2022 instead of simulated ones. The tuning criteria used was the same as used for the adopted MP, a probability of being in the green quadrant of the Kobe plot over the period 2034:2038, p(Kobe green), of 60%. This run (called ***MP1.2***) shows which change in the MP parameter $CPUE_{target}$ is required to achieve the management objective, and what would be the performance of the resulting MP.

Finally, the MP with the corrected index generating function was also retuned for a MP implementation involving a two-year management lag. This run (***MP1.3***) also shows which change in the MP parameter $CPUE_{target}$ are required to achieve the management objective, given the longer management lag.

The table 1 summarizes the four runs to be compared. The performance of the these four runs is compared using the same metrics as used for the evaluation of MP performances presented at the TCMP08.

Table 1 : description of the run presented

Run name	Description
MP1_TCMP	MP1 run presented at TCMP08
MP1_correct.	MP1 run with the corrected index generating function, same parameters as MP1_TCMP
MP1.2	MP1 run with the corrected index generating function and <u>retuned</u> (new target CPUE value)
MP1.3	MP1 run with the corrected index generating function and a <u>two-year management lad</u> and <u>retuned</u> (new target CPUE value)

3.3 Results

The performance of the adopted MP when using the real CPUE index value for the years 2020 to 2022 (***MP1_correc***.) varies slightly compared to the performance presented at TCMP08 (***MP1_TCMP***, table 2, figure 3). The MP leads to a slightly higher fishing pressure, with higher catches (both short and longer term) and a slightly lower SB/SBmsy overall. The management objective used to tune the MP is not reached for the run MP1_correc. (*p(Kobe green)* = 54%).

Tuning the MP so that it achieves the management objective of p(Kobe green) = 60% while using the real CPUE index values instead of the simulated values for 2020 to 2022 indicates that a target CPUE value of 0.7625 should be used instead of 0.7125. Performance of the MP (***MP1.2***) after retuning is very similar to the performance of the adopted MP presented at TCMP08 (***MP1_TCMP***). Overall stock size and catch level are very similar. The only noticeable difference is the reduced TAC variability.

Finally, tuning same MP using a two-year management lag shows that the management objective is reached for a target CPUE value of 0.75 (***MP1.3***). The performance of the resulting MP is very similar to the performance of the MP tuned with the one-year management lag.

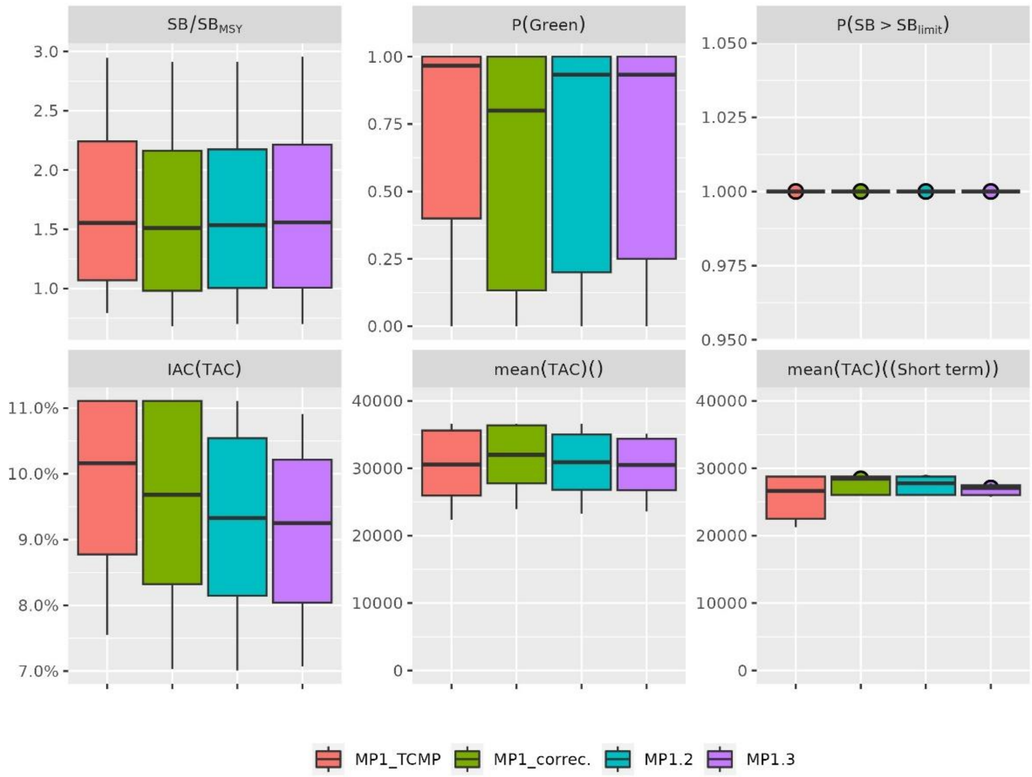

Figure 3. Boxplots comparing the 4 MP runs (see list in table 1) with respect to key performance measures averaged over the period 2024-2038 (except for mean(TAC)ST which is averaged for 2024-2027). Horizontal line is the median, boxes represent 25th - 75th percentiles, thin lines represent 10th - 90th percentiles.

Table 2 : summary of the performance of the 4 MP runs (see list in table 1) with respect to key performance indicators (median across stock replicates, with the limits of the envelop representing 80% of the distribution in parentheses).

MP	SB/SB_{MSY}	P(SB>=SBMSY)	P(SB>SBLIM)	P(GREEN)	MEAN(TAC)	C/MSY	IAC(TAC)	MAX TAC DECREASE	MAX TAC INCREASE	TIMES TAC CHANGES
MP1_TCMP	1.55 (0.79-2.95)	1.00 (0.00-1.00)	1.00 (1.00-1.00)	0.61 (0.00-1.00)	30561.42 (22351.47-36599.21)	0.95 (0.71-1.15)	10.16 (7.55-11.11)	0.00 (-3179.74-0.00)	4845.72 (3186.14-6191.75)	4.00 (4.00-4.00)
MP1_CORRECT.	1.51 (0.68-2.91)	1.00 (0.00-1.00)	1.00 (1.00-1.00)	0.54 (0.00-1.00)	32002.84 (23949.50-36599.22)	0.99 (0.72-1.17)	9.68 (7.03-11.11)	-2365.66 (-3311.82-0.00)	4845.74 (2349.92-6191.75)	4.00 (4.00-4.00)
MP1.2	1.53 (0.70-2.91)	1.00 (0.00-1.00)	1.00 (1.00-1.00)	0.60 (0.00-1.00)	30906.28 (23270.07-36599.20)	0.97 (0.72-1.14)	9.33 (7.01-11.11)	-2714.10 (-3509.68-0.00)	4775.14 (1054.55-6191.75)	4.00 (4.00-4.00)
MP1_3	1.56 (0.70-2.96)	1.00 (0.00-1.00)	1.00 (1.00-1.00)	0.61 (0.00-1.00)	30500.10 (23595.75-35120.69)	0.97 (0.69-1.12)	9.25 (7.07-10.91)	-2714.10 (-3290.35-0.00)	4853.44 (3664.06-6191.75)	4.00 (4.00-4.00)

SB/SB_{MSY} : ratio of the spawning biomass over spawning biomass corresponding to MSY (average over 2024-2038)

P(SB>=SBMSY) : proportion of the years with spawning biomass larger than the spawning biomass corresponding to MSY (calculated over 2024-2038)

P(SB>SBLIM) : proportion of the years with spawning biomass larger than the limit spawning biomass (calculated over 2024-2038)

P(GREEN) : proportion of the years where the stock is in the green quadrant of the Kobe plot (calculated over the tuning period, 2034-2038)

MEAN(TAC) : average TAC in tonnes (average over 2024-2038)

C/MSY : ratio of the annual catch over MSY (average over 2024-2038)

IAC(TAC) : percentage of change between successive TACs (average, calculated every 3 years over the period 2024-2038)

MAX TAC DECREASE AND MAX TAC INCREASE : largest TAC increase and decrease (in tonnes, over the period 2024-2038)

TIMES TAC CHANGES : number of times the TAC value changes (over the period 2024-2038, varies between 0 and 4)

3.4 Conclusion

The performance of the adopted MP was evaluated using inaccurate CPUE index values for 2020 to 2022 compared to the real-life implementation of this MP. Implementing the MP using the real index values for 2020 to 2022 instead of simulated ones leads to only minor differences in the performance of the MP, the main one being that management objective, p(Kobe green) = 60%, is no longer met. The overall characteristics of the MP, however, remain unchanged.

Given this minor differences in the MP performance, it can be assumed that the relative differences in the performance of the candidate MPS, MP1 to 6, as presented at TCMP08 would also remain unchanged if all MPs were run with the correct index generating function. These errors are not likely to change the ground on which MP1 was chosen over the 5 other MPs presented.

Despite the only minor impact on performance caused by this error, it could be advised to propose an amendment to the adopted MP, in order to comply with the management objective of p(Kobe green) = 60% under the conditions of its implementation in real life. Such an amendment should be based on the newly tuned MP using the correct index generating function, and applying the two-year management lag (MP1.3). The corresponding parameters are summarised in the table 3 below.

Table 3 : MP parameters for the adopted MP and proposed amendment

MP parameter	Adopted MP MP1_TCMP	Proposed amendment MP1.3
ka	2.1	2.1
kb	1.2	1.2
$CPUE_{target}$	0.7125	0.75

4 Application of the adopted MP, and proposed amendment (as for its first implementation, in 2024)

The latest available CPUE time series in 2024 for the first TAC calculation according to the adopted MP covers the period 1994-2023 (the last 5 years are shown in table 4). The reference catch used for the calculation is the 2023 nominal catch estimate from the IOTC, 26545 tonnes, as available on the IOTC website[2] (16 September 2024 release).

A step by step illustration of the calculation is given below. It can be reproduced using the R code provided in annex 1.

- Slope calculation

Sl=0.01621 (slope of linear regression for the last 5 log transformed CPUE values against years)

- Recent CPUE calculation

$\text{recent CPUE} = 1.0599$ (average of the last 3 CPUE values)

[2] https://iotc.org/data/datasets/latest/NC/SCI

- TAC multiplier calculation

$$TAC_{mult} = 1 + k_a Sl + k_b D = 1 + 2.1 \times 0.01621 + 1.2 \times (1.0599 - 0.7125) = 1.4509$$

- Application of the TAC stabilizer (maximum 15% increase)

$$TAC_{mult} = 1.15$$

- TAC calculation

$$TAC_{new} = TAC_{mult} \times TAC_{cur} = 1.15 \times 26545 = 30526.75$$

In case the MP is amended following the recommendation above, a $CPUE_{target}$ value of 0.75 should be used following the MP1.3. The TAC multiplier would then be of 1.4060, which should also be capped at 1.15 after application of the TAC stabilizer, leading to the same TAC_{new} as with the MP adopted after TCMP08.

Table 4 : last 5 years of the UJPLL_NW Cpue index available in 2024

YEAR	CPUE (UJPLL_NW)
2019	0.9643708
2020	0.9284214
2021	1.0507628
2022	1.214772
2023	0.914258

References :

Brunel, T, and Mosqueira, I, 2024. IOTC Swordfish Management Strategy Evaluation IOTC-2024-TCMP08-05-Rev2

Matsumoto, T., Taki, K., Ijima, H., Kai, M. 2023. CPUE standardization for swordfish (Xiphias gladius) by Japanese longline fishery in the Indian Ocean using zero-inflated Bayesian hierarchical spatial model. IOTC–2023–WPB21–14_Rev1.

Annex 1 : R script to implement the adopted MP

```
#MP parameters                    as per resolution 24/08
ka <- 2.1
kb <- 1.2
cpue.target <-0.7125
max.up <- 1.15                    # max 15% increase
max.down<- 0.9                    # max 10% decrease

# year definition
ay <- 2024                        # assessment year, current year
slope.yrs <- seq(ay-5,ay-1)       # year period for the calculation of the slope of the cpue,
                                  # 5 last years of data
mean.yrs<- seq(ay-3,ay-1)         # year period for the calculation of the mean of the cpue,
                                  # 3 last years of data

#data
cpue<-read.csv("CPUEindex.csv")   # cpue index
cpue<-subset(cpue, assess.year == ay)

TACcur <- 26545                   # current TAC, but last available catch estimate for the first
                                  # MP implementation, here, nominal catch in 2023



#TACmult calculation
slope <-  coef(lm(log(data) ~ year,
          data=subset(cpue, year %in% slope.yrs)))[2]
mean.cpue<-mean(cpue$data[cpue$year %in% mean.yrs])
TACmult<- 1 + ka*slope + kb* (mean.cpue-cpue.target)

#TAC stabilitzer
if (TACmult > max.up) TACmult   <- max.up
if (TACmult < max.down) TACmult <- max.down

# TAC calculation
TACnxt <- TACmult * TACcur

TACnxt
```