**Performance of example management procedures for Atlantic bluefin tuna**

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*SUMMARY*

To do last

*KEYWORDS*

*Management Strategy Evaluation, bluefin tuna, operating model, management procedure*

# Introduction

The Management Strategy Evaluation (MSE)/Management Procedure (MP) process is subtle and sometimes complex, and therefore it can be difficult to grasp the essences and implications if presented only in an abstract way. In an attempt to aid the process for enhanced understanding, this document provides an illustrative example of the development of Candidate Management Procedures (MPs) for the Eastern North Atlantic bluefin tuna resource. Its purpose is to draw attention to key components of this process, especially the catch vs resource depletion risk considerations that arise, so as to guide the further development of the MSE/MP process for bluefin tuna within ICCAT.

The document first develops Operating Models (OMs) to be used to test candidate MPs (CMPs) which are based on statistical catch-at-length (SCAL) assessments of the resource using the most recent data available, and also sets out a few options for projecting these dynamics into the future in line with plausible future recruitment scenarios. The data series to be used as input to the CMPs are specified, and the process used to generate future associated observed values for these developed. Some relatively simple empirical CMPs are specified, and these are applied to the four OMs specified for the resource to determine catch vs resource depletion risk performance. Finally the implications of the outcomes from these calculations for the further development of the ICCAT MSE/MP process for bluefin tuna are discussed.

A Management Strategy Evaluation (MSE, Butterworth 1999, Cochrane 1998) approach has been proposed for Atlantic bluefin tuna as a suitable framework for providing robust management advice consistent with the precautionary approach (GBYP 2017a). A principal task in the construction of an MSE framework is the development of operating models which represent credible hypotheses for population and fishery dynamics. Operating models are typically fishery stock assessment models which are fitted to data to ensure that model assumptions and estimated parameters are empirically credible (Punt et al. 2014, e.g. CCSBT 2011).

A general approach for testing MPs using MSE established two sets of operating models. The reference trials (‘Base case’) are considered to reflect the most plausible hypotheses and are the primary basis for identifying the best performing management procedure. Robustness trials are used to determine whether the management procedure behaves as intended in scenarios that are less likely.

In this paper the design of the reference set of operating models is described including the fit of these models to data.

< Purpose of document >

Feedback

Metrics

MP examples

# Methods

Two example management procedures were tested for the reference case operating model. The first EMP1 is a very simple index target MP that makes incremental adjustments to the TAC depending on the proximity of index observations to a target level. The second MP, EMP2 originates from Radermeyer and Butterworth (2015) and also accounts for changes in the slope of indices (whether there is a positive or negative trend) in addition to proximity to a target index level. Both of these MPs are empirical; they calculate TACs directly from abundance indices.

All MPs were tested on OM #1, the reference case operating model that uses the best model estimates of abundance for both stocks, high natural mortality rate and low age at maturity (Carruthers and Butterworth, SCRS/2017/223).

***Example Management Procedure 1***

EMP1 is a very simple index target MP. In each year *y*, that the TAC is calculated, three inputs are required: the previous TAC recommendation, an mean index *Jy* over the most recent five years and a target level for that index *Jtarg*. The MP either decreases the TAC by 10%, keeps the TAC the same, or increases the TAC by 10% depending on the ratio of the mean index *Jy* to the target index *Jtarg*:

(1)

(2)

***Example Management Procedure 2***

EMP2 is somewhat more complex and provides TAC adjustment accounting for both the ratio of the current index to the target index *Jratio*, but also the longer-term trend *s*.

 (3)

where

 is the slope of a log-linear regression of the index against year over the last six years (*y*-6 to *y*-1);

, control parameters

Similarly to EMP1 (where only TAC changes of +/- 10% are permitted), EMP2 constrains the maximum inter-annual change in the TAC to 15% (both up or down).

***Indices and control parameters***

For these examples, the Japanese Longline index for the North East Atlantic (JPLL\_NEAtl2) was used for setting TACs for the eastern area and the Gulf of Mexico Larval Survey (GOM\_LAR\_SUV) was used for setting TACs in the West. Mean values for these indices over the last 5 years were approximately 6 for the Japanese Longline index and 0.6 for the Gulf of Mexico Larval index.

Values were chosen for the target index levels and up/down control parameters to attempt to achieve an appropriate trade-off amongst performance statistics for conflicting objectives (such as high catches and low risk of unintended resource depletion).

**Table 1.** Control parameters for Example Management Procedures 1 and 2 (EMP1, EMP2)

|  |  |
| --- | --- |
| Control parameter | Value |
| *up* | 0.05 |
| *down* | 0.15 |
| *up* | 0.05 |
| *down* | 0.15 |
| *J*targ -JPLL\_NEAtl2 (East MP) | 4.8 |
| *J*targ - GOM\_LAR\_SUV (West MP) | 0.66 |

***Other ‘management procedures’ for performance comparison***

Four other management procedures were evaluated to frame the performance of the example management procedures. These included four constant catch MPs that were zero catches (ZeroC), 50%, 100% and 150% of current catches (CurC50, CurC100, CurC150, respectively).

***Performance measures / statistics***

**Table 2.** Performance measures / statistics used to evaluate the performance of management procedures

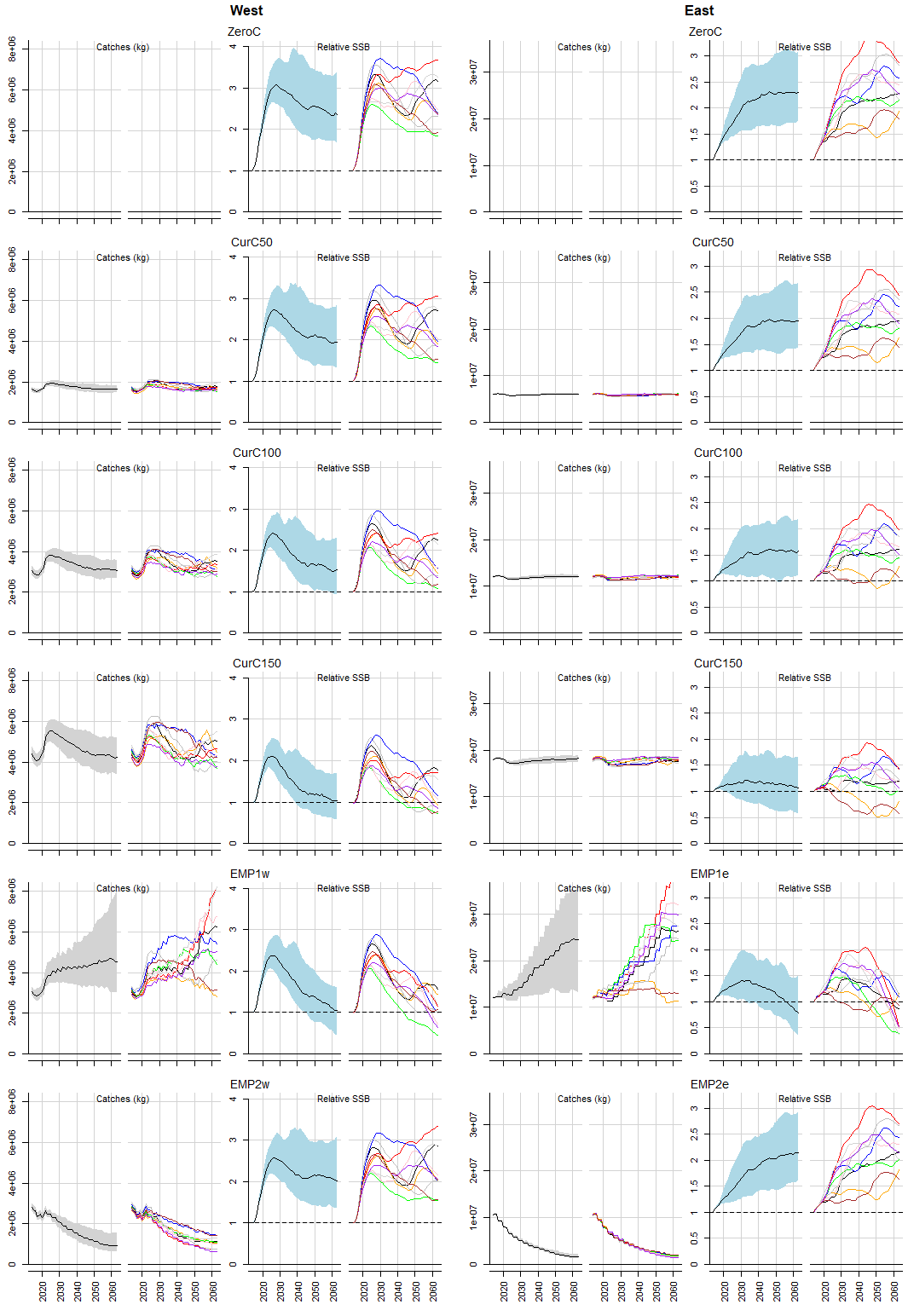
|  |  |
| --- | --- |
| **Performance Measure** | **Abbreviation** |
| a) Annual average catch for the first, second and third 10-year period of MP application | C10, C20, C30 |
| b) Spawning biomass depletion calculated relative to the deterministic equilibrium in the absence of catches for the recruitment function that applies after 10, 20 and 30 years of MP application. | D10, D20, D30 |
| c) The lowest spawning biomass depletion over the 30 years for which the MP is applied calculated relative to the deterministic equilibrium in the absence of catches for the recruitment function that applies after 30 years. | LD |
| d) Spawning biomass depletion after 30 years, but calculated relative to the trajectory that would have occurred had no catches been taken over the full period for which MP application is being considered. | DNC |
| e) The lowest spawning biomass depletion over the 30 years for which the MP is applied, but calculated relative to the zero catch trajectory specified in d). | LDNC |
| f) Kobe indicators: Probability of Overfishing (F>FMSY), Probability overfished state (B < BMSY), Probability green Kobe (F<FMSY and B>BMSY) over 30 projected years | POF, POS, PGK |
| g) Average annual variation in catches defined by: | AAVC |
|  |  |

# Results

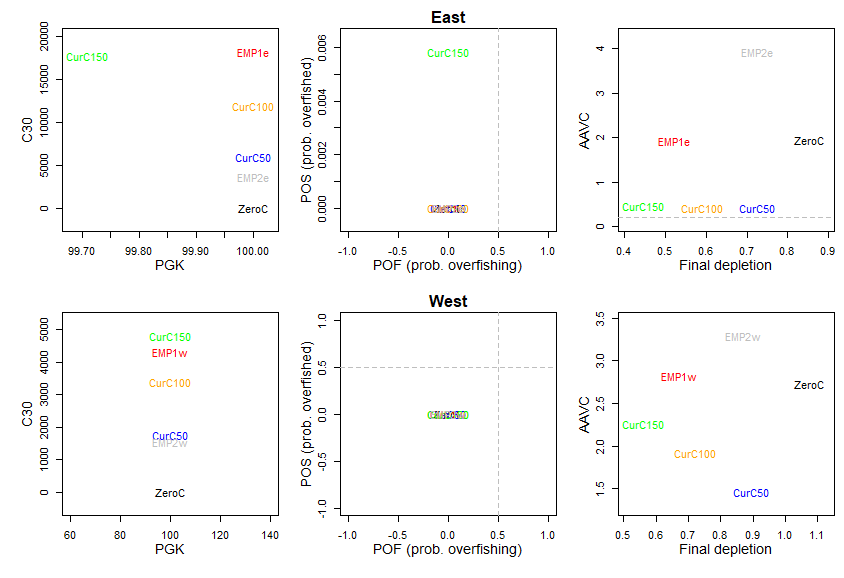
< an example interpretation of metrics, trade-offs and projections>

**Table 3.** Performance statistics for the 6 MPs for the East and West stocks (see Table 2 for definition of performance statistics). Catch statistics (C10, C20 and C30) are reported in units of thousand metric tonnes. Probability statistics such as probability of overfishing (POF), probability of overfished status (POS), probability of green Kobe zone (PGK) are reported as percentages, as is the inter-annual variability in catches (AAVC).

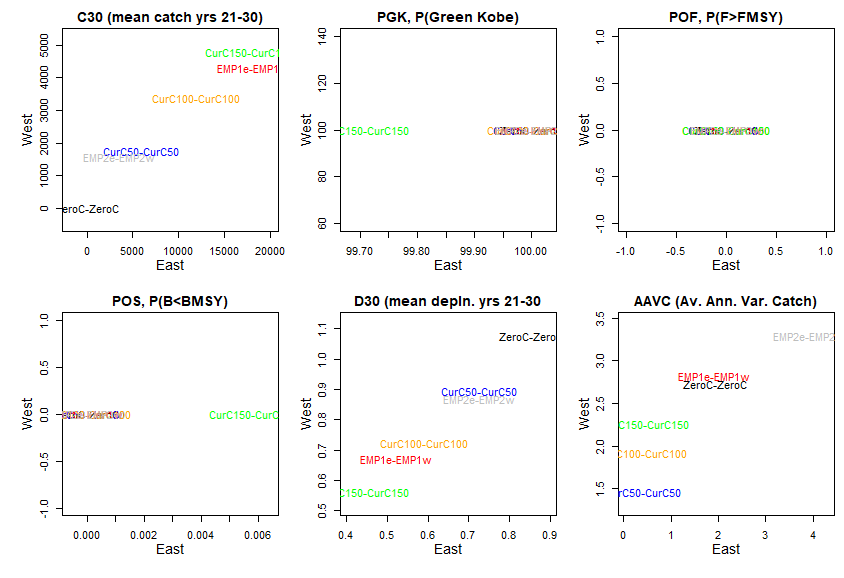




**Figure 1.** Catch and SSB trajectories for 6 MP pairs (98 simulations, OM #1). Each pair of MPs operates on the existing western and eastern areas. The result plotted here are for the West and East stocks. Each row is an MP pair. For both catch and SSB the median estimate of all simulation is a solid line with the grey shaded region representing the 5th and 95th percentiles. Colored lines represent 10 individual simulations. CurC represents current catch MPs. CurC50, CurC100 and CurC150 are 50%, 100% and 150% of current catches.



**Figure 2**. Trade-off among performance metrics within East and West stocks.



**Figure 3**. Performance metrics trade-off among East and West stocks.

# Discussion

< MP design – other options >

< Stakeholder participation >

< Other MP processes >

< R package makes this easy (reference to the third paper) >

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# References

ABT-MSE. 2017. Atlantic bluefin tuna management strategy evaluation: an R package. Available at: [accessed September 2017]

Butterworth, D.S., Punt, A.E., 1999. Experiences in the evaluation and implementation of management procedures. ICES J. Mar. Sci. 56, 985-998.

Carruthers, T.R., Kimoto, A., Powers, J., Kell, L., Butterworth, D., Lauretta, M. and Kitakado, T. 2015a. Structure and estimation framework for Atlantic bluefin tuna operating models. ICCAT SCRS/2015/179.

Carruthers, T.R., Powers, J., Lauretta, M., Di Natale, A., Kell, L. 2015b. A summary of data to inform operating models in management strategy evaluation of Atlantic bluefin tuna. ICCAT SCRS/2015/180.

CMG. 2017. Specifications for MSE trials for bluefin tuna in the North Atlantic. GBYP Core Modelling Group. ICCAT Atlantic Wide Research Programme for Bluefin Tuna. Available at: [accessed September 2017]

GBYP. 2017a. ICCAT Atlantic wide research programme for Bluefin Tuna. Available online at: http://www.iccat.int/GBYP/en/index.htm [accessed September 2017]

GBYP. 2017b. Data to inform operating models for North Atlantic bluefin tuna. ICCAT Atlantic Wide Research Programme for Bluefin Tuna. Available at: [accessed September 2017]

Cochrane, K L., Butterworth, D.S., De Oliveira, J.A.A., Roel, B.A., 1998. Management procedures in a fishery based on highly variable stocks and with conflicting objectives: experiences in the South African pelagic fishery. Rev. Fish. Biol. Fisher. 8, 177-214.

Punt, A.E., Butterworth, D.S., de Moor, C.L., De Oliveira, J.A.A., Haddon, M., 2016. Management strategy evaluation: best practices. Fish Fish. 17, 303–334, <http://dx.doi.org/10.1111/faf.12104>.

Radermeyer, R.A., Butterworth, D.S. 2015. An illustrative example of a management procedure for Eastern North Atlantic bluefin tuna. ICCAT SCRS/2015/165.

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