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PROGRESS ON CHARACTERIZATION OF STRUCTURAL UNCERTAINTY IN TROPICAL TUNA STOCKS' DYNAMICS WITH SUMMARY OF DISCUSSIONS HELD DURING THE TROPICAL TUNA MSE MEETING (29-31 MARCH 2021)

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SUMMARY

The MSE for the Atlantic tropical tuna stocks started in 2018 by developing a proposal on how to conduct this MSE in a series of phases. The present document corresponds to the second phase of the tropical tuna MSE by attempting to define the axes of uncertainty to be considered in the Operating Models of the tropical tuna MSE. This work follows document SCRS/2021/016 where the main sources of uncertainty characterized for tropical tunas in ICCAT and other RFMOs were reviewed. In this document we expand the description of potential axes of uncertainty by reviewing the uncertainty of other tuna stocks and by summarizing the points of discussion and agreements reached in ICCAT's Tropical Tuna MSE meeting (29-31 March 2021). We also propose the steps to start the conditioning of Operating Models.

RÉSUMÉ

La MSE pour les stocks de thonidés tropicaux de l'Atlantique a débuté en 2018 par l'élaboration d'une proposition sur la manière de mener cette MSE en plusieurs phases. Le présent document correspond à la deuxième phase de la MSE consacrée aux thonidés tropicaux et tente de définir les axes d'incertitude à considérer dans les modèles opérationnels de la MSE consacrée aux thonidés tropicaux. Ce travail fait suite au document SCRS/2021/016 qui passait en revue les principales sources d'incertitude décrites pour les thonidés tropicaux à l'ICCAT et dans d'autres ORGP. Dans le présent document, la description des axes d'incertitude potentiels sont élargis en examinant l'incertitude d'autres stocks de thonidés et en résumant les points de discussion et les accords conclus lors de la réunion du Groupe technique sur la MSE pour les thonidés tropicaux de l'ICCAT (29-31 mars 2021). Nous proposons également les étapes nécessaires pour commencer le conditionnement des modèles opérationnels.

RESUMEN

La MSE para los stocks de túnidos tropicales del Atlántico comenzó en 2018 desarrollando una propuesta sobre cómo llevar a cabo esta MSE en una serie de fases. Este documento corresponde a la segunda fase de la MSE para los túnidos tropicales e intenta definir los ejes de incertidumbre que deben considerarse en los modelos operativos de la MSE para los túnidos tropicales. Este trabajo sigue trabajo del documento SCRS/2021/016, en el que se revisaron las principales fuentes de incertidumbre descritas para los túnidos tropicales en ICCAT y en otras OROP. En este documento, ampliamos la descripción de los posibles ejes de incertidumbre revisando la incertidumbre de otros stocks de túnidos y resumiendo los puntos de debate y de acuerdo alcanzados en la reunión del Grupo técnico sobre MSE para los túnidos tropicales (29-31 de marzo de 2021). Proponemos también los pasos para iniciar el condicionamiento de los modelos operativos.

KEYWORDS

Management Strategy Evaluation, Operating Models, uncertainty, tropical tunas, bigeye, yellowfin, skipjack

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1. Introduction

In MSE, *structural uncertainty* is the basis for developing axes of uncertainty and for conditioning Operating Models, which are described as a group of plausible mathematical representations of the system being managed, including the biological components (fish stock dynamics) and the fishery which operates on the stock (Punt *et al.*, 2014). In ICCAT's tropical tuna stock assessments *structural uncertainty* is characterized by combining alternative model results (*model uncertainty*) and different model configurations (*input uncertainty*). It is expected that the range of uncertainties considered in the MSE will go beyond the axes used for stock assessment.

In this document we provide an overview of potential options for axes of uncertainty for the Atlantic tropical tunas MSE from the factors used to characterize the *structural uncertainty* in the stock assessments of ICCAT and other RFMOs. In addition, the ICCAT's intersessional meeting of tropical tunas MSE Technical Group discussed options for the axes of uncertainty and for conditioning Operating Models. Here, we summarize the factors agreed and propose alternative ways forward to condition Operating Models, including best practices of tuna MSEs across tuna RFMOs (Sharma *et al.*, 2020).

This document has been developed using information from the tropical tuna stock assessments in ICCAT and elsewhere. We have used, such us, stock assessment meeting reports, SCRS (or other science providers'), plenary reports and stock assessment model files.

2. Structural uncertainty for the MSE of East Atlantic skipjack, bigeye and yellowfin tunas

The structural uncertainty considered in Atlantic and other oceans' tropical tunas was reviewed in SCRS/2021/016 (Merino *et al.*, 2021), including the uncertainty in biological parameters of fish stocks, fishery exploitation patterns and information content of the data used in stock assessment. Starting from the factors of uncertainty considered in tropical tuna assessments and MSEs, the tropical tunas MSE Technical Group agreed on a preliminary list of axes of uncertainty for Atlantic tropical tunas, which included:

- Steepness (as in all tropical tuna stock assessments and MSEs)

- SigmaR (considered in Atlantic bigeye stock assessment)

- Natural mortality (as in Atlantic and East Pacific bigeye stock assessments and Indian Ocean bigeye and yellowfin MSEs).

- Growth (as in West and Central Pacific bigeye, East Pacific bigeye and yellowfin and Indian Ocean bigeye and yellowfin MSEs).

- Selection of the largest fish of the population (shape of selectivity for longline fleets) (considered in the East Pacific assessments of bigeye and yellowfin and Indian Ocean bigeye and yellowfin MSEs).

- Maturity (not seen in any uncertainty grids of tropical tunas' assessments or MSE).

- Additional options for data (CV of CPUEs at different values and other options of weighting considered in the assessments).

This initial list can be expanded by reviewing the factors of uncertainties of other MSEs such as North Atlantic albacore, Atlantic bluefin, North Pacific albacore, Southern bluefin, Atlantic swordfish, Indian Ocean albacore and swordfish. After the review of these, the factors not included in the revision of Merino et al (2021) and that could potentially be included in the tropical tuna MSE are:

- North Atlantic albacore MSE (Merino *et al.*, 2017) includes natural mortality, steepness and dynamic catchability (for longline fleets). In this regard, the increasing catchability hypothesis could apply to the Atlantic tropical tunas MSE. It is accepted that purse seine fleets operating on Fish Aggregating Devices (FADs) have increased their fishing capacity by using echosounder buoys, supply vessels and other technologies.

- Atlantic bluefin MSE includes recruitment, natural mortality rate, spawning fraction and length composition weighting. Recruitment uncertainty is not characterized by the steepness parameter only but also by R0 (virgin stock recruitment) which is one option that could also be included in the tropical tuna MSE. The spawning fraction is probably comparable to the Maturity factor and the weighing of length composition data is usual practice in many stock assessments and MSEs too (e.g. Indian Ocean yellowfin, bigeye and albacore).

- North Pacific albacore MSE prioritizes the characterization of uncertainty on recruitment (autocorrelation and steepness), natural mortality, growth and juvenile movement. These parameters reflect uncertainty in stock productivity (ISC, 2021). From these, autocorrelated recruitment was not considered in the Atlantic MSE technical meeting and could be considered at later stages. The stock assessment models currently applied to Atlantic tropical tuna stocks do not consider movement between areas but one option for a configuration with movement could potentially be considered in the MSE.

- In the Southern bluefin MSE (CCSBT, 2017) the structural uncertainty is characterized using options for steepness, natural mortality, fecundity and weight of CPUE. All these except fecundity are already included in the list of factors agreed during the tropical tuna MSE technical group meeting. In Stock Synthesis fecundity can be modelled with two optional functions describing the relationship between the weight of females and number of eggs and the weight or length of females or through changes in their parameters. Indirectly, the choice of the function as well as options for its parameterization could have some effect in the stock recruitment relationship.

- The Atlantic swordfish MSE (SCRS_P/2020/004) characterizes uncertainty with options for gear selectivity, length composition data, sensitivity to CPUE, steepness and natural mortality.

- The Indian Ocean albacore and swordfish MSE (IOTC, 2021) characterizes uncertainty with options for natural mortality, steepness, data weighting, catchability increase, recruitment variability, CPUE and selectivity model.

From this additional review of uncertainty, we see that some options were not considered in the initial list of factors agreed by the tropical tunas MSE Technical Group: increasing catchability options, alternative options to describe uncertainty on recruitment (R0, fecundity) and movement between areas. Other options not considered in any of the reviewed tuna and tuna-like MSEs are sampling errors non-stationarity of processes (e.g. recruitment). Sharma *et al.*, 2020 recommends that these are incorporated in the MSE processes.

3. Steps for conditioning Operating Models

After agreeing the list of factors to be included in the axes of uncertainty the next step is to agree on how to select values for the different parameters. This could be done by using randomly sampling pre-defined probability distributions for each parameter, by using ranges of values with minimum, median and maximum options or by using expert knowledge. Often parameters of the MSE are determined by using values x% larger and lower than the values used in the stock assessments or that are considered more plausible. Other factors such as the shape of the selectivity curve or growth curves are characterized by using alternative options from biological studies or expert knowledge.

After the model parameters and functions are agreed the next step is to condition the OM by running stock assessment models. Stock Synthesis has been used in the recent assessments of Atlantic bigeye and yellowfin and a prototype is being developed for East Atlantic skipjack. These models will be run with the model configurations that contain all possible combinations between factors. Once this is complete, the next step should be to validate and filter OMs using specific tests to assess their plausibility (Sharma *et al.*, 2020). This is seldom done across tuna RFMOs and can be done using diagnostics of convergence, residual distribution, data cross-validation, analysis of plausibility of reference points (virgin biomass, MSY etc), analysis of plausibility of historical trends of the stock, likelihood profiles and other options. Recently, a R package called *ss3diags* that contains a set of diagnostics has been developed for Stock Synthesis models (Carvalho *et al.*, In press). This package can rapidly evaluate the plausibility of stock assessment models such as Stock Synthesis and it is in use for example, in assessments of Indian Ocean tuna stocks.

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