DEVELOPMENT STATE OF THE NORTH ATLANTIC SWORDFISH MSE PROCESS IN MAY 2023

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SUMMARY

This document describes proposed updates to the North Atlantic Swordfish Management Strategy Evaluation Process including revisions to operating models and performance metrics. Many of these revisions are in response to the SCRS's discussion with Panel 4 in March of 2023.

RÉSUMÉ

Le présent document décrit les actualisations proposées au processus d'évaluation de la stratégie de gestion de l'espadon de l'Atlantique Nord, comprenant les révisions des modèles opérationnels et des mesures de performance. Bon nombre de ces révisions font suite à la discussion du SCRS avec la Sous-commission 4 au mois de mars 2023.

RESUMEN

Este documento describe las actualizaciones propuestas para el proceso de evaluación de la estrategia de ordenación para el pez espada del Atlántico norte, incluidas las revisiones de los modelos operativos y las mediciones de desempeño. Muchas de estas revisiones responden al debate del SCRS con la Subcomisión 4 en marzo de 2023.

KEYWORDS

Management Strategy Evaluation, simulation testing, swordfish

Introduction

The North Atlantic swordfish (hereafter swordfish) fishery has been undergoing a Management Strategy Evaluation (MSE) process since 2019. The Swordfish Species Working Group developed an operating model (OM) uncertainty grid to span the key uncertainties in stock biology and the fishery. A full factorial design of this uncertainty grid resulted in 216 OMs, which were developed in the Stock Synthesis 3 (SS3) assessment software based on the 2017 assessment of the swordfish fishery. A new stock assessment was conducted in 2022, using data up to 2020. Subsequently, the operating models in the uncertainty grid were re-conditioned based on this updated assessment.

The SCRS is scheduled to provide a final set of candidate management procedures (CMPs) to the Commission in late 2023. The SWO MSE technical team, after consultation with Panel 4 in March of 2023, made important updates to the MSE framework. The purpose of this document is to describe updates since that time to the SWO species group to support their decision making on adoption of these changes.

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1. Operating models

The 2022 stock assessment was used as a base case model for developing the OMs for the MSE. Based on previous analyses, and a recent analysis involving applying the Francis iterative re-weighting procedure to the operating models, the OMs in the grid have been placed into two categories: Reference and Robustness OMs. The reference set spans the plausible range for the key uncertainties. The robustness set serves as secondary uncertainties that require consideration by the Commission but are not the primary scenarios used in tuning.

1.1 OM reference set

The N-SWO MSE reference set approved by the SCRS during its plenary session in 2022 contains two axes that represent the most importance sources of uncertainty: steepness and natural mortality, each with three levels (**Table 1**). In March of 2023, Panel 4 requested additional examination of the steepness axis. This variable is used to describe the steepness of the stock-recruit relationship when a stock has been depleted to low levels. This variable is often linked with a stock's productivity. A higher steepness value implies a greater rate of recovery from low levels. Three steepness values are used in the reference set: 0.6, 0.75 and 0.9, while the base case model developed for the 2022 stock assessment used a value of 0.88.

Noting that for many tuna and billfish species, higher steepness values are often assumed, a profile analysis on steepness was conducted on the steepness parameter using the NSWO model version 5, which is the final version used for management advice and should represent the NSWO MSE base model. In **Figure 1**, the blue curve is the likelihood profile on the steepness parameter itself (not the entire model). The black, dashed horizontal line is at ~1.92 and indicates 95% confidence interval based on common cut-off of half of chi-squared of p=.95 with 1 degree of freedom: 0.5*qchisq(p=cutoff_prob, df=1) (r4SS). Points below this line are assumed not to be significantly different. The range of these points (green points) is approximately 0.75 to 0.95.

The red curve represents the prior distribution used on the parameter in fitting the model when steepness is estimated (beta, 54.7, 13.7; steepness = 0.80). The value of the prior was approximated via the guidance of the International Seafood Sustainability Foundation (ISSF) workshop report (ISSF 2011). The two black, dashed vertical lines represent the 2.5th and 97.5th percentile of that distribution and have a range of 0.69 to 0.88. The estimated steepness when using this prior is approximately h = 0.88. The yellow curve is simply for comparison. It is one of the priors used for tuna (beta, 18,4) from the ISSF workshop report.

In the opinion of the N-SWO technical team, the values 0.69 and 0.88 are justified as plausible bounds for steepness and defensible for use in the reference grid. Furthermore, the choice of ~0.60 is acceptable for a robustness test. This range covers steepness values that are commonly used and thought to encompass reasonable and likely values. Should the species group decide that a middle value between 0.69 and 0.88 be needed, a compensation ratio analysis (Goodyear, 1980) indicates that an appropriate steepness value be 0.8.

1.2 OM robustness set

A core set of robustness tests were approved by the SCRS plenary in 2022 and included the following uncertainties: recruitment variability, inclusion of length compositions of the catch, and a 1% increase in catchability in the historical period (all described in detail in the N-SWO MSE trial specifications document). Panel 4 requested additional robustness tests:

- 1% annual increasing catchability in the projection period
- Implementation error here is a consistent non-reported 10% overage in the TAC in each year. This test is designed to replicate illegal, unreported, or unregulated (IUU) fishing where the actual removals are 10% higher than the TAC and reported catches.
- Climate change effects in the projection period (described in more detail below)
- Effects of a minimum size limit (implemented in the CMPs and includes two scenarios: 1) A fixed 120 cm Size Limit: retention is assumed knife-edge at 120 cm for all fleets, with discard mortality applied to the fish that are captured and released below this size. 2) No Size Limit: the size limit is removed and all fish that are captured are retained and contribute to the TAC. These two scenarios are compared to the Reference OMs, which are designed to replicate the current size regulations.
- Alternative management cycles: a set of 6 operating models has the same assumptions as the Reference OMs with the exception that the management cycle is modified from the default assumption of 3 years to a 4-year interval.

Panel 4 requested that climate change impacts on the stock be examined in the operating models. The causal relationships between future climate change induced variation in environmental variables and swordfish life history is poorly understood and elucidating these links likely requires a multi-year research effort. The N-SWO MSE technical team instead chose to assume that these links exist and are simulated through scenarios related to a key life history variable: recruitment deviation. These scenarios are designed to simulate the impact of climate change on the productivity of the stock, and are implemented in the recruitment deviations for the projection years. **Figure 2** shows the Base Case (no trend in recruitment deviations) and the three scenarios:

- Decreasing Trend: a linear decrease in recruitment strength in imposed over the recruitment deviations that are generated for the projection years. The recruitment deviations are assumed to decrease by 20% at the end of the projection period.
- Increasing Trend: a linear increase in recruitment strength in imposed over the recruitment deviations that are generated for the projection years. The recruitment deviations are assumed to increase by 20% at the end of the projection period.
- Increased Variability: additional variability is added to the future recruitment by sampling between the upper and lower bounds shown in the plot.

2. Performance metrics

20 performance metrics (PMs) have been developed for the North Atlantic Swordfish MSE. These PMs are grouped into four families:

1. Status: the probability the stock is in the green quadrant of the Kobe matrix
2. Safety: the probability of the stock not falling below the biological limit reference point
3. Yield: the catch in the projection years
4. Stability: the variation in the TAC between management cycles

Panel 4 was presented with a process for culling CMPs and selecting a final set of CMPs to be considered by the Commission (**Figure 3**). Early within this CMP culling and selection process is a requirement for evaluating CMPs against a set of performance metric "minimum thresholds". The purposed of this step is to eliminate poorly performing and dominated CMPs, allowing the technical team to focus their efforts on a smaller set of CMPs for continued improvement and tuning. Panel 4 provided a set of performance metric minimum thresholds (**Table 2**) which the technical team has been using as the basis for the initial round of CMP tunings.

3. Candidate management procedures

Current development includes both model-based and model-free (empirical) CMPs (**Table 3**), all using the N-SWO Combined Index (Gillespie et al., 2022) as an indicator of abundance. Additional CMPs may use CPC produced indices generated for the 2022 N-SWO stock assessment. Model-based CMPs use a biomass surplus production model to estimate stock status and adjust the TAC based on a pre-determined decision-rule. Model-free CMPs use an abundance indicator, comparing recent index values to a baseline (or reference) set of values. The resulting ratio between recent values and the baseline values is used to adjust the TAC based on a pre-determined decision-rule. The technical team welcomes additional CMPs that the species group may want to suggest.

4. Conclusion

This document provides the rational for suggested changes to the N-SWO MSE framework in as the technical team prepared to engage with the managers and stakeholders in upcoming Panel meetings.

References

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Table 1. Operating model grid approved the SCRS in 2022

Variable	Stock assessment base case model	Operating model grid		
Steepness	0.88	0.6	0.75	0.9
Natural mortality	0.2	0.1	0.2	0.3
SigmaR (recruitment variability)	0.2	0.2	0.6	
Include CAL	TRUE	TRUE	FALSE	
Catchability increase	0%	0%	1%/year	

Table 2. Summary of the North Atlantic Swordfish Performance Metrics.

Family	Name	Description	Minimum Acceptable Values
Status	PGK_10	Probability of being in Green Zone of Kobe Space (SB>SBMSY & F<FMSY) in year 10 (2033)	51, 60, 70
	PGK_med	Probability of being in Green Zone of Kobe Space (SB>SBMSY & F<FMSY) in years 6-10 (2029-2033)	51, 60, 70
	PGK_long	Probability of being in Green Zone of Kobe Space (SB>SBMSY & F<FMSY) in years 11-30 (2034-2053)	51, 60, 70
	PGK	Probability of being in Green Zone of Kobe Space (SB>SBMSY & F<FMSY) over all years (2024-2053)	51, 60, 70
	PGK_30	Probability of being in Green Zone of Kobe Space (SB>SBMSY & F<FMSY) in year 30 (2053)	51, 60, 70
	POF	Probability of Overfishing (F>FMSY) over all years (2024-2053)	
	PNOF	Probability of Not Overfishing (F<FMSY) over all years (2024-2053)	
Safety	LRP_short	Probability of breaching the limit reference point (SB<0.4SBMSY) in any of the first 10 years (2024-2033)	5, 10, 15
	LRP_long	Probability of breaching the limit reference point (SB<0.4SBMSY) in any of years 11-30 (2034-2053)	5, 10, 15
	LRP	Probability of breaching the limit reference point (SB<0.4SBMSY) in any year (2024-2053)	5, 10, 15
	nLRP_short	Probability of not breaching the limit reference point (SB>0.4SBMSY) in any of the first 10 years (2024-2033)	85, 90, 95
	nLRP_long	Probability of not breaching the limit reference point (SB>0.4SBMSY) in any of years 11-30 (2034-2053)	85, 90, 95
	nLRP	Probability of not breaching the limit reference point (SB>0.4SBMSY) in any year (2024-2053)	85, 90, 95
Yield	TAC1	TAC (t) in the first implementation year (2024)	
	AvTAC10	Median catches (t) over years 1-10 (2024-2033)	
	AvTAC30	Median catches (t) over years 11-30 (2034-2053)	
Stability	VarC	Median variation in TAC (%) between management cycles over all years	
	MaxVarC	Maximum variation in TAC (%) between management cycles over all years	No minimum value and 25

Table 3. Summary of the Candidate Management Procedures.

Code	Name	Class	Description
SP1	Surplus Production 1	Model-Based	Schaefer surplus production model, with a HCR that linearly reduces F when estimated B/BMSY is < 0.8BMSY
SP2	Surplus Production 2	Model-Based	Same as SP1, but uses a Fox production model
IR1	Index Ratio 1	Model-Free	Adjusts the TAC based on ratio of the mean Combined Index over the last 3 years to the mean index over the previous 3 years before that
IR2	Index Ratio 2	Model-Free	Same as IR1, but mean index values are calculated as over the 2 most recent years and the 2 years before that
CE	Constant Exploitation Rate	Model-Free	Aims to keep the exploitation rate constant at the recent historical level

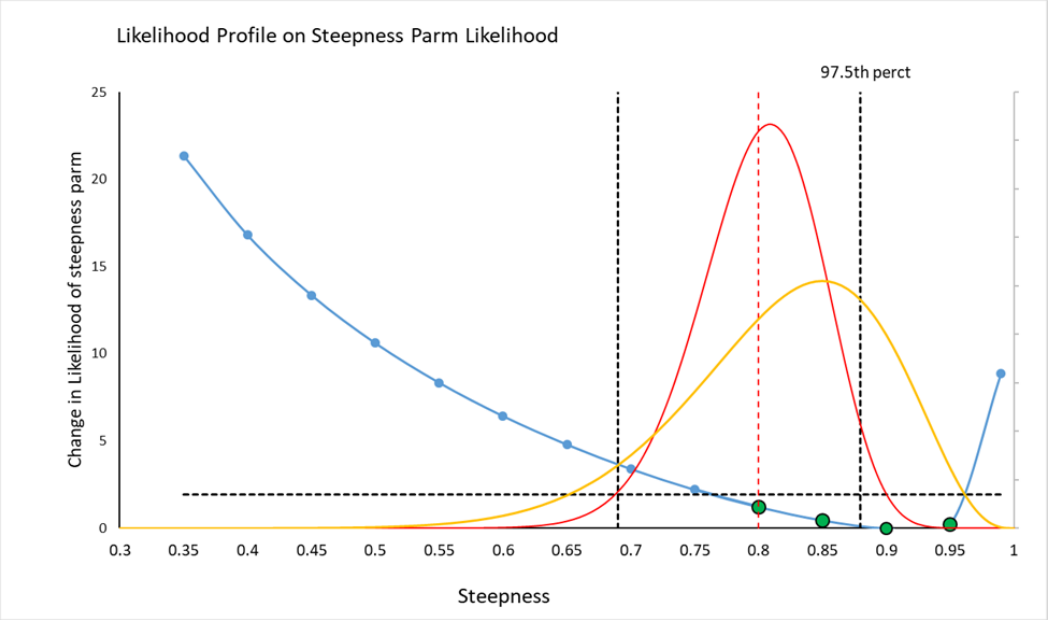

Figure 1. Likelihood profile on steepness for the NSWO model, version 5 (version used of management advise in 2022).

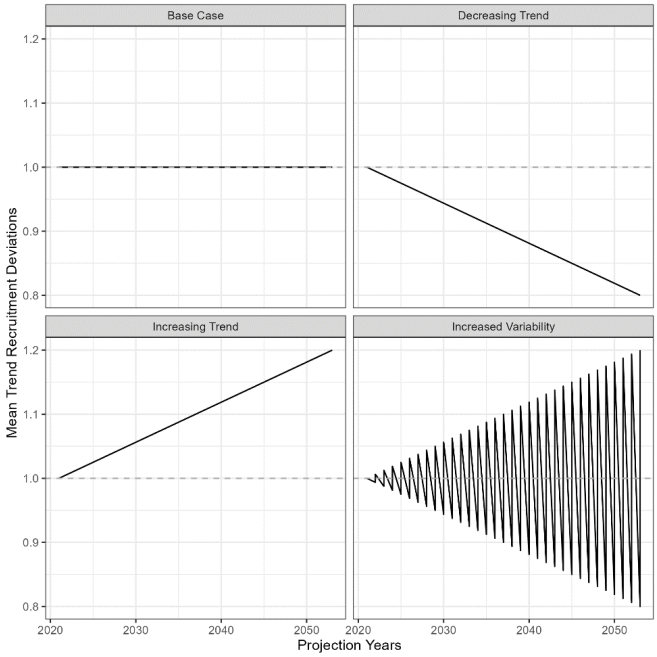

Figure 2. The Base Case and 3 scenarios for persistent patterns in recruitment deviations in the projection years.

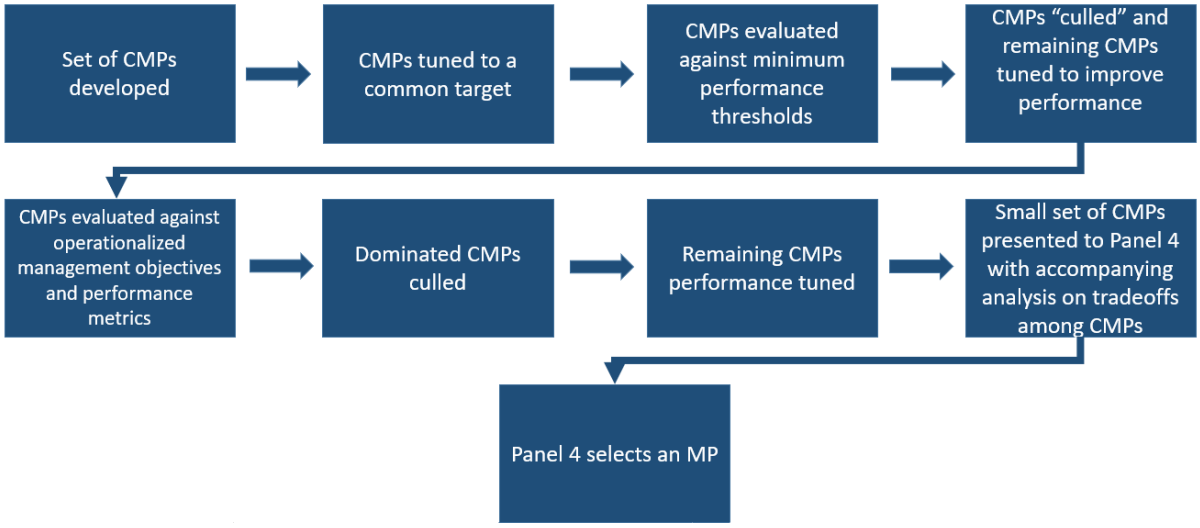

Figure 3. Proposed CMP culling and selection process