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North Atlantic Swordfish MSE – Background & Structure

Executive Summary

This document describes core concepts of the North Atlantic swordfish management strategy evaluation (MSE). The intention is to provide sufficient knowledge to facilitate discussion among scientists, fishery managers and other stakeholders, commencing with the First Intersessional Meeting of Panel 4 on North Atlantic Swordfish MSE on 6 March 2023 and continuing in the lead up to scheduled adoption of a management procedure (MP) in November 2023. This document summarizes the MSE structure and process.

Background

The SCRS's Swordfish Species Group has been developing a management strategy evaluation (MSE) framework for North Atlantic swordfish (NSWO) for a decade. In 2009, ICCAT called for development of a limit reference point for swordfish (*Supplemental recommendation by ICCAT to amend the rebuilding program for North Atlantic swordfish* [Rec. 09-02]), and the Commission adopted 0.4*B_{MSY}[1] as the interim limit reference point in 2013 (*Recommendation by ICCAT for the conservation of North Atlantic swordfish* [Rec. 13-02]). Recommendation 13-02 also tasked the SCRS with development of a harvest control rule for NSWO. In 2015, the Commission called for adoption of a management procedure (MP) based on an MSE for 8 priority stocks, including NSWO (*Recommendation by ICCAT on the Development of Harvest Control Rules and of Management Strategy Evaluation* [Rec. 15-07]). In 2017, the SCRS developed an integrated, sized-structured stock assessment model for NSWO on which a future MSE would be based. Funds were provided by the Commission in 2018 to develop the simulation framework, and following initial work by the SCRS, an MSE expert was contracted in 2019 to develop the NSWO MSE. MSE development by the SCRS then began in earnest. The Commission adopted conceptual management objectives for NSWO in 2019 (*Resolution by ICCAT on development of initial management objectives for North Atlantic swordfish* [Res. 19-14]) to help guide MSE development. In 2022, the SCRS carried out a new stock assessment in which the base case model was modified to incorporate discard mortality of undersized fish, and the MSE was updated with this new model. The MSE work is on track for ICCAT to adopt an MP in 2023, in accordance with the Commission's MSE workplan.

MSE Overview

The NSWO MSE is built using an open-source MSE software package called openMSE. The package can input information from Stock Synthesis stock assessments (the 2022 ICCAT Atlantic Swordfish Stock Assessment Meeting, in this case) to efficiently create – and then customize – an MSE framework for testing candidate management procedures (CMPs), including the approximately 100 CMPs that come preloaded in openMSE.

Indices of Abundance

Data from six different longline indices and a harpoon index were used in the stock assessment and are used to condition the MSE. A combined index that incorporates data from seven CPCs is being used as the primary index for CMP development. The MSE's historical period is from 1950 through to 2020, and projections cover the subsequent 30 years.

Operating Models

Each operating model (OM) in the MSE represents a plausible scenario/a potential truth for the dynamics of the stock and fishery. The NSWO MSE includes 9 main operating models (i.e., the "reference set or grid of OMs") based on two major sources of uncertainty:

1. Stock productivity: steepness of the relationship between stock size and recruitment potential is one of the most important and uncertain inputs into stock assessments. Practically, this is often thought of as a measure of the stock's ability to rebuild biomass when depleted to a low level (3 options);

[1] Spawning stock biomass (SSB; biomass of mature females), is used in this MSE.

2. Natural mortality: the rate at which individuals die of natural causes (3 options).

The 9 OMs allow for all combinations of these options (3x3=9). All OMs are considered to be equally plausible, so they are weighted equally.

There are also three sets of "robustness" OMs to evaluate the performance of the CMPs under less likely but still possible scenarios, similar to more extreme "sensitivity runs" in a stock assessment. These include 1) increased natural variability in recruitment, 2) removal of catch-at-length data from the fitting process, and 3) an assumed 1% annual increase in catchability for the indices used to condition the OMs.

An environmental variable related to the Atlantic Multidecadal Oscillation (AMO) is used to modulate catchability in some of the indices. In previous versions of the OM reference grid, the AMO was included as one of the uncertainties. Analyses revealed that use of the environmental covariate had no detectable influence on either the predicted stock size or CMP performance. Therefore, the AMO covariate was included in all models in the reference set. The impact of changing alternative environmental conditions on CMP performance may be examined in additional robustness tests, if desired.

The OMs were developed to match the existing size limit regulations as closely as possible, where fleets have the options of a minimum length of 119 cm lower jaw fork length (LJFL) for retained NSWO, or a 125 cm size limit with a 15% tolerance. As in the most recent NSWO stock assessment, the OMs assume a minimum size limit and associated discard mortality in the fishery. Should Panel 4 wish to test alternative minimum size formulations, the SCRS proposes to do so through the addition of robustness OMs.

Management Objectives

The NSWO MSE currently includes seven key performance statistics as an initial benchmark for evaluation of the Commission's selected management objectives (see **Appendix A**). Panel 4 input is requested to a) operationalize the management objectives (by completing the probability blanks in Res. 19-14 and adding timeframes) and b) provide input on the proposed performance statistics. The former was discussed at the 2021 Intersessional meeting of PA4, but only one CPC provided feedback, so the proposed probabilities are not presented here, as more feedback is needed before these values can be used.

Candidate Management Procedures

The SCRS's Swordfish Species Group is working collaboratively to develop and test a number of CMPs. All CMPs currently assume a 3-year management cycle and calculate a single total allowable catch (TAC) for the North Atlantic. Existing CMPs are all model-based rather than empirical (empirical CMPs use indices of abundance to directly set the TAC rather than putting them through a model). The North Atlantic albacore MP (*Recommendation by ICCAT on conservation and management measures, including a management procedure and Exceptional Circumstances Protocol, for North Atlantic albacore* [Rec. 21-04]*)* is model-based, whereas the Atlantic bluefin tuna MP (*Recommendation by ICCAT establishing a management procedure for Atlantic bluefin tuna to be used for both the western Atlantic and eastern Atlantic and Mediterranean management areas* [Rec. 22-09]) is empirical. Panel 4 input is solicited with regard to CMP specifications, including limits on maximum and/or minimum TAC and maximum/minimum percent change in TAC from one management cycle to the next.

Next Steps

Three Panel 4 meetings are scheduled in 2023 for the exchange of information among the SCRS, Panel 4, and stakeholders in advance of the 2023 Commission meeting. The Swordfish Species Group has also appointed ambassadors to help improve understanding of the MSE and answer questions. The ambassador sessions will be run in English, French and Spanish.

Feedback is requested at the First Intersessional Meeting of Panel 4 in March from managers on the following decisions (described in more detail in NSWO MSE Extended Summary [PA4_03/2023]):

1. Operating model reference grid and robustness set

Beginning in 2018, the swordfish MSE technical team identified uncertainties and evaluated their relative importance in stock dynamics and under a variety of candidate management procedures. The SCRS has identified the most consequential uncertainties, which now form a core set of nine reference OMs which are being used in CMP testing and development. The SCRS welcomes comments and any additional uncertainties that Panel 4 may suggest, noting that these may be included as robustness tests.

2. Approach for incorporating evaluation of the minimum size limit

Minimum size limits were introduced in the first management measure for Atlantic swordfish (*Recommendation by ICCAT for the conservation of Atlantic swordfish stocks* [Rec. 90-02] and *Recommendation by ICCAT regarding the implementation of an alternative option for the conservation of undersized Atlantic swordfish and the reduction of fishing mortality* [Rec. 95-10]). In subsequent years, it was noted that high levels of at-haulback mortality in undersized fish may be impacting the usefulness of this management measure. Resolution 19-14 requests that the SCRS evaluate this uncertainty within the MSE. The SCRS is seeking clarity from Panel 4 on how to proceed with this request. The issue is complex and requires additional analysis, so the SCRS considers that the best approach would be to evaluate the effect of minimum size limits on CMP performance through a robustness test.

3. Management objectives and performance metrics

The SCRS is requesting that Panel 4 provide threshold probability values and timeframes for the conceptual management objectives found in Res. 19-14. These threshold probabilities for status, safety, and stability will serve as guides for the SCRS in the development of CMPs. Once those probabilities are met, CMPs will be tuned to maximize yield. The SCRS has developed a set of candidate performance metrics to support generating these management objective probabilities, and further recommends that Panel 4 provide their preferences on which performance metrics are to be used. The SCRS is currently using the interim B_{LIM} established in the NSWO recommendations (*Recommendation by ICCAT for the Conservation of North Atlantic Swordfish* [Rec. 13-02]; $B_{LIM} = 0.4*B_{MSY}$) for the performance indicator of Safety.

4. CMP specifications

The SCRS recommends that Panel 4 endorses the development of both empirical and model based CMPs that use a three-year (or longer) management cycle. Additionally, the SCRS recommends that CMPs provide a constant annual Total Allowable Catch (TAC) for each management cycle and that the CMP developers be allowed to use either the longline combined index, or individual, CPC-provided indices. The SCRS requires input from Panel 4 on management cycle length, the minimum and maximum change in TAC between management cycles, and on their desire for potential inclusion of a minimum and/or maximum TAC.

5. Overall process

The SCRS recommends that Panel 4 approve the MSE development timelines and CMP tuning process defined by the SCRS (see detailed timelines in Appendix A of NSWO MSE Extended Summary [PA4_03/2023]); a description of the two-step tuning process is contained in the same document). There are several meetings scheduled in 2023 for review of NSWO MSE progress and results: three Panel 4 meetings (March, June/July, and October), each coinciding with a NSWO MSE ambassador meeting. The SCRS is scheduled to address NSWO MSE at two technical team meetings (January and September), the Intersessional meeting of the Swordfish Species Group (including MSE) (May), a regular Swordfish Species Group meeting (September), and a full meeting of the SCRS (September). The objectives of the First Intersessional Meeting of Panel 4 on North Atlantic Swordfish MSE (March) are to review the MSE structure and to discuss decision points listed here. Subsequent Panel 4 meetings will address other key decision points and review results from the CMP development process. NSWO MSE ambassador sessions will be open to a broader group as accredited by their respective CPCs. The objective of these meetings is to present results and key decision points to stakeholders. In addition to these meetings, the technical team will be meeting regularly to advance development of CMPs and communications materials. Should Panel 4 and the SCRS be satisfied with the MSE structure and CMPs, the Commission is scheduled to adopt a management procedure in November 2023, for implementation in 2024.

Other Resources

North Atlantic Swordfish MSE splash page
North Atlantic Swordfish MSE interactive Shiny App (includes preliminary results)
Harveststrategies.org MSE outreach materials (multiple languages)

Appendix A

Management objectives (from Res. 19-14) and the proposed corresponding performance statistics

Management Objectives (Res. 19-14)	*Proposed Corresponding Performance Statistics*
Status The stock should have a greater than [__]% probability of occurring in the green quadrant of the Kobe matrix	**PGK_{short}**: Probability of being in the Kobe green quadrant (i.e., $SSB \geq SSB_{MSY}$ and $F < F_{MSY}$) in year 10 **PGK_{long}**: Probability of being in the Kobe green quadrant (i.e., $SSB \geq SSB_{MSY}$ and $F < F_{MSY}$) over years 11-30
Safety There should be a less than [__]% probability of the stock falling below B_{LIM} ($0.4*B_{MSY}$ as interim)	**LRP_{short}**: Probability of breaching the limit reference point (i.e., $SSB < 0.4*SSB_{MSY}$) over years 1-10 **LRP_{long}**: Probability of breaching the limit reference point (i.e., $SSB < 0.4*SSB_{MSY}$) over years 11-30
Yield Maximize overall catch levels	**AvC10:** Median catches (t) over years 1-10 **AvC30:** Median catches (t) over years 11-30
Stability Any increase or decrease in TAC between management periods should be less than [__]%	**VarC:** Variation in TAC (%) between management cycles

Appendix B

Key terminology used in this document

Limit reference point (LRP): A benchmark for an indicator that defines an undesirable biological state of the stock such as the B_{LIM} or the biomass limit which is undesirable to be below. To keep the stock safe, the probability of violating an LRP should be very low.

Management objectives: Formally adopted social, economic, biological, ecosystem, and political (or other) goals for a stock and fishery. They include high-level or conceptual objectives often expressed in legislation, conventions or similar documents. They must also include operational objectives that are specific and measurable, with associated timelines. When management objectives are referenced in the context of management procedures, the latter, more specific definition applies, but sometimes conceptual objectives are adopted first (e.g., Res. 19-14 for NSWO).

Management procedure (MP): Some combination of monitoring, assessment, harvest control rule and management action designed to meet the stated objectives of a fishery, and which has been simulation tested for performance and adequate robustness to uncertainties. Also known as a harvest strategy.

Management strategy evaluation (MSE): A simulation-based, analytical framework used to evaluate the performance of multiple management procedures relative to the pre-specified management objectives.

Operating model (OM): A model representing a plausible scenario for stock and fishery dynamics that is used to simulation test the management performance of CMPs. Multiple models will usually be considered to reflect the uncertainties about the dynamics of the resource and fishery, thereby testing the robustness of management procedures.

Performance statistic: A quantitative expression of a management objective used to evaluate how well an objective is being achieved by determining the proximity of the current value of the statistic to the objective. Also known as a performance metric or performance indicator.

Reference Grid: The operating models that represent the most important uncertainties in stock and fishing dynamics, which are used as the principal basis for evaluating CMP performance. The reference operating models are specified according to factors (e.g., natural mortality rate) that have multiple levels (possible scenarios for each factor, e.g., high / low natural mortality rate). Reference operating models are organized in a usually fully crossed orthogonal 'grid' of all factors and levels.

Robustness Set: Other potentially important uncertainties in stock and fishing dynamics may be included in a Robustness Set of operating models that provide additional tests of CMP performance robustness. They can be used to further discriminate between CMPs. Compared to the Reference Grid operating models, the Robustness Set models will be typically less plausible and/or influential on performance.