Western Atlantic Skipjack Management Strategy Evaluation (MSE) – Background, Structure, & Preliminary Results

This document describes core concepts of the western Atlantic skipjack tuna Management Strategy Evaluation (MSE). The intention is to provide sufficient knowledge to facilitate discussion among scientists, fishery managers and other stakeholders, commencing with the Second Intersessional Meeting of Panel 1 (on western Skipjack MSE) on 5 May 2023 and continuing in the lead up to scheduled adoption of a management procedure (MP) in November 2023. This document summarizes the MSE structure, process, preliminary results, and feedback requested at the Meeting of Panel 1 on 5 May.

Background

The Standing Committee Research and Statistics (SCRS)'s Tropical Tunas Species Group has been developing a MSE framework for West Atlantic skipjack (WSKJ) since 2020. In 2015, the Commission called for adoption of a MP for WSKJ and seven other priority stocks based on an MSE (*Recommendation by ICCAT on the development of harvest control rules and of Management Strategy Evaluation* [Rec. 15-07]). This call for an MSE has been echoed in every ICCAT tropical tunas measure since 2016, with *Recommendation by ICCAT on a multi-annual conservation and management program for tropical tunas* [Rec. 16-01] setting initial performance indicators for tropical tunas. While the East Atlantic skipjack stock is included in the multi-stock MSE with bigeye and yellowfin tunas, western Atlantic skipjack has been earmarked for its own MSE since the Commission's first MSE roadmap was adopted in 2016; this is because western skipjack tuna are caught predominantly in a single-species fishery.

External experts launched the MSE work in 2020 (SCRS/140/2020) and since then, MSE development has been conducted by the SCRS (SCRS/2022/097, SCRS/2022/180). The Commission adopted conceptual management objectives for WSKJ in 2022 (*Resolution by ICCAT on development of initial conceptual Management Objectives for Western Atlantic Skipjack* [Res. 22-02]), and 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 WSKJ MSE is built using an open-source MSE software package called openMSE. The package can input information from assessment models built with the Stock Synthesis framework (2022 Skipjack Stock Assessment Meeting (23-27 May 2022), 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

The western skipjack stock occurs from the U.S. coast to the southern Brazilian coast. Data from 5 different indices (baitboat - Brazil and other, handline, purse seine, and longline) are used to condition the MSE. On average, Brazil takes approximately 90% of the total skipjack catch in the West Atlantic, with the bulk of remaining catches (7% on average) taken by Venezuela. The MSE's historical period is from 1952 through to 2020, and projections cover the subsequent 40 years.

Operating Models (OMs)

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

1. Recruitment/steepness: a measure of the adult biomass relative to the number of young they produce; reflects stock productivity (3 options);

2. Growth vector: reflects the alternative biological parameters of the population, including different combinations of growth rate, maximum size, and natural mortality (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 two sets of "robustness" OMs to evaluate less likely but still possible scenarios, similar to more extreme "sensitivity runs" in a stock assessment. These include two distinct TAC overages (i.e., 10%, 20%) due to implementation error. These additional scenarios result in 18 robustness OMs (9x2=18).

Management Objectives

The WSKJ MSE currently includes fourteen key performance statistics as an initial benchmark for evaluation of the Commission's four agreed management objectives (see **Appendix A**). The SCRS recommends setting the limit reference point (B_{LIM}) at $0.4B_{MSY}$ for western skipjack, as has been done for other stocks, including North Atlantic swordfish, North Atlantic albacore and Atlantic bluefin tuna.

Candidate Management Procedures (CMPs)

There are currently 14 CMPs for western skipjack in three main categories being evaluated – constant catch, index-based, or assessment model-based. All currently assume a minimum 3-year management cycle and calculate a single total allowable catch (TAC) for the West Atlantic.

- Constant catch CMPs include total catches ranging from 15,000 t to 40,000 t. For reference, the 2021 catch was 19,951 t.

- The three index-based, empirical CMPs vary the catch limits based on changes in catch per unit effort (CPUE).

- There are four model-based CMPs which incorporate "hockey stick" harvest control rules. Under these harvest control rules, fishing is at F_{MSY} when above the target reference point and decreases to 10% F_{MSY} once the limit reference point is breached.

Preliminary Results

Preliminary performance results are shown for 7 representative CMPs. Full results for all CMPs are available in the Slick Shiny App linked below. The 7 representative CMPs are as follows:

- CC_15kt: Constant catch at 15,000 t.
- CC_25kt: Constant catch at 25,000 t.
- CC_35kt: Constant catch at 35,000 t. This catch is close to the MSY estimate.
- CC_40kt: Constant catch at 40,000 t.
- GB_slope: Geromont and Butterworth index slope. A rule that modifies a time-series of catch recommendations (TAC) to achieve stable catch rates.
- Islope: Index slope tracking. A rule that incrementally adjusts the time-series of catch recommendations (TAC) to maintain a constant abundance index.
- Iratio: Mean index ratio. A rule that adjusts the TAC based on a ratio between the most recent years of the relative abundance index and the respective prior years.

Most CMPs result in a high probability of being in the Kobe green quadrant into the future, except for the constant catch CMPs with TACs greater than or equal to 35 kt. Similarly, all but the constant catch CMPs equal or greater than 35 kt display a very constant trend, with the stock continuing to be neither overfished, nor subject to overfishing. The model-based CMPs are still being reviewed, so preliminary results are not included.

Feedback Requested

At the Meeting of Panel 1 on 5 May 2023, feedback is requested from managers on:

Decision Point 1: Operating model reference grid and robustness set

The SCRS seeks Panel 1 approval of the operating model reference set. The SCRS recommends that the core set of nine reference operating models be adopted. Additional scenarios can be included as robustness tests, and the SCRS welcomes feedback on the current robustness set of OMs.

Decision Point 2: Management objectives and performance statistics

The SCRS asks Panel 1 to operationalize the conceptual management objectives adopted in Res. 22-02 by adding probability values and timeframes (See **Appendix A**). The SCRS proposes a set of candidate performance statistics to measure the degree to which each of the management objectives is achieved and asks Panel 1 to provide input on any changes or additions to these proposed performance statistics.

Decision Point 3: Operational management objectives

The SCRS welcomes feedback from Panel 1 on the following CMP operational management objectives:

- Stock Status – Minimum acceptable probability of occurring in the green quadrant of the Kobe matrix using a 30-year projection period (as determined by the SCRS);

- Safety – Maximum acceptable probability of the stock falling below 0.4 SSB_{MSY} (the B_{LIM} recommended by the SCRS) at any point during the 30-year projection period;

- Stability – Maximum acceptable percent change in TAC between management periods, as well as whether or not this maximum acceptable change should be the same for increases as for decreases in TAC, and (for model-based CMPs) whether such a restriction should be imposed regardless of whether or not stock biomass is below or above B_{MSY}.

Decision Point 4: Management Cycle

The SCRS has been developing CMPs based on a management cycle of 3 years, but welcomes feedback from Panel 1 on whether or not a shorter or longer cycle is preferred (*note: this is expected to affect CMP performance*).

Other Resources

West Atlantic Skipjack MSE interactive Shiny App (includes preliminary results)
Harveststrategies.org MSE outreach materials (multiple languages)

Acknowledgements

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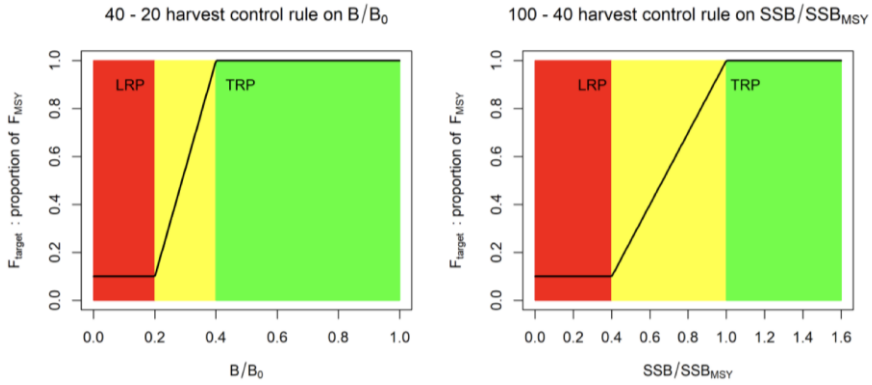

Figure 1. Candidate "hockey stick" harvest control rule (HCR) for the assessment model-based MPs.

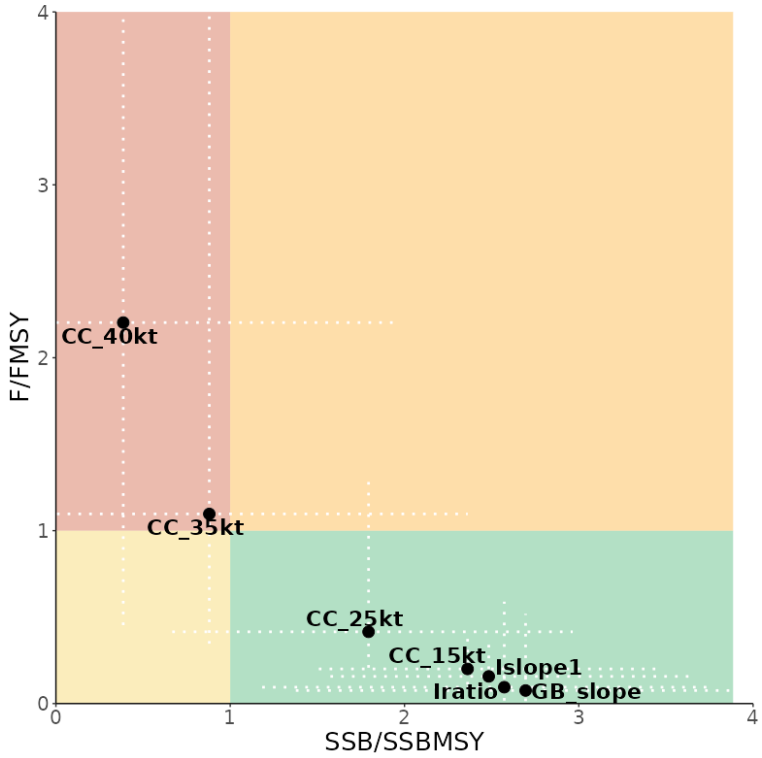

Figure 2. Kobe plot of median stock status in Year 40 of the projection for the 6 representative CMPs described above. All CMPs but constant catch at 35 kt have a high probability (>90%) of being in the green quadrant of the Kobe plot (i.e., stock is not overfished and not subject to overfishing).

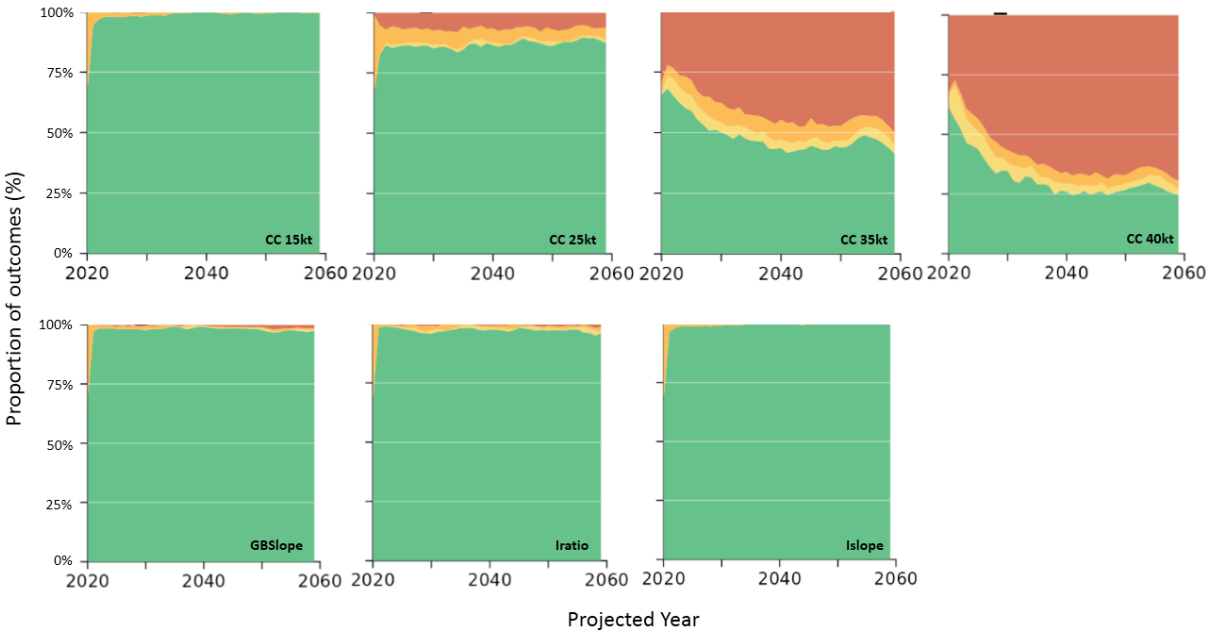

Figure 3. Plot of Kobe status in each year of the 40-year projection period. Green is not overfished and no overfishing. Orange is overfishing but not overfished. Yellow is overfished but no overfishing. Red is both overfished and subject to overfishing. All CMPs but constant catch at 35 kt or higher have a high probability of being in the green quadrant of the Kobe plot throughout the projection period.

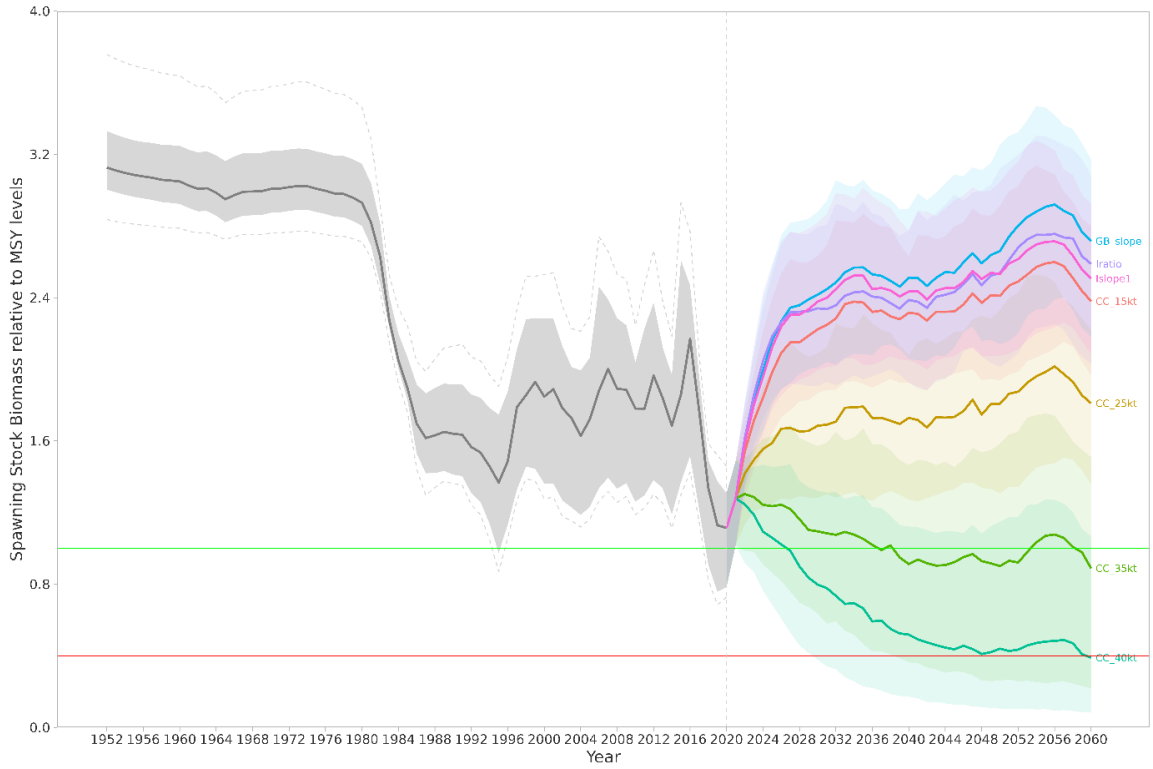

Figure 4. Plot of stock status relative to SSB_{MSY} in both the historical and projection period. The green horizontal line depicts the target reference point, while the red horizontal line depicts the limit reference point. All CMPs but constant catch at 35 kt have generally level or increasing stock status trends.

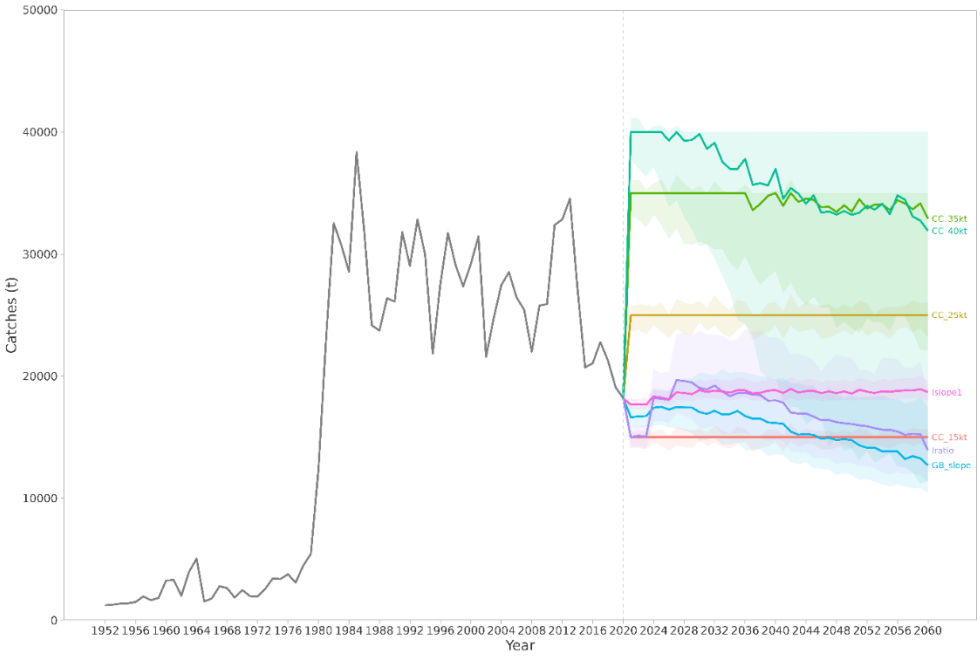

Figure 5. Plot of the catches time-series in both historical and projection period. The green horizontal line depicts the target reference point, while the red horizontal line depicts the limit reference point. All CMPs but constant catch at 35 kt have generally level or increasing stock status trends.

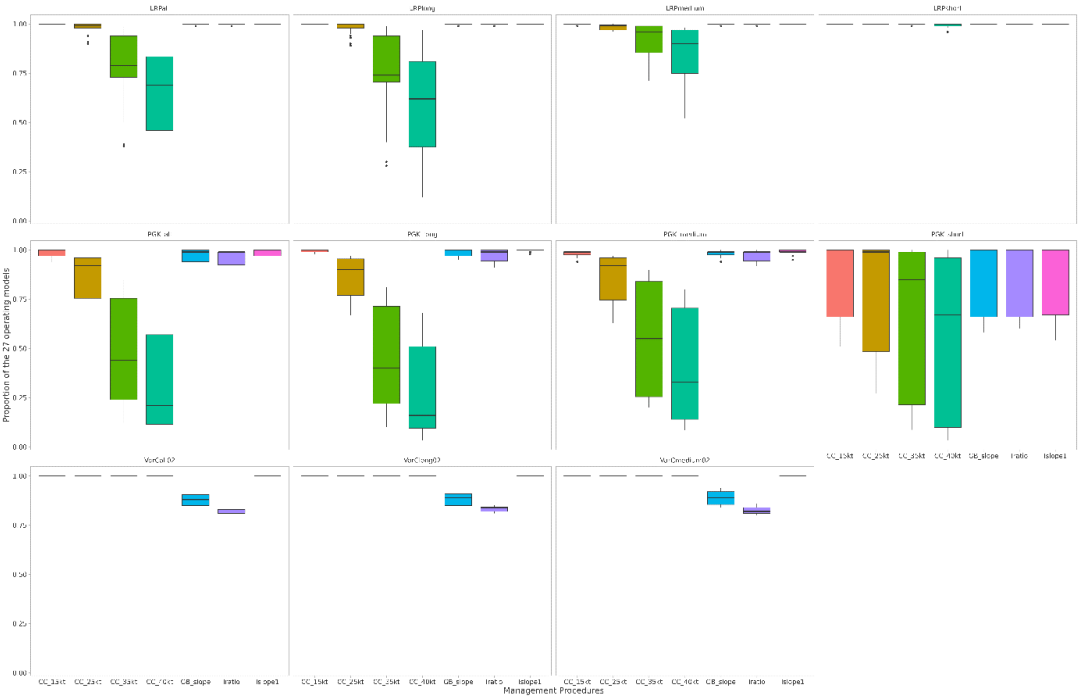

Figure 6. Boxplot of CMP performance against eleven principal performance statistics. Points represent the median value, thick bars represent the 25th to 75th percentiles, and thin bars represent the full range of results. All performance metrics are defined such that higher values mean better performance. Thus, (a) PGK represents the probability of the stock being in the Kobe green quadrant over the analysis period; (b) LRP represents the probability of not breaching the limit reference point (i.e., $0.4B_{MSY}$) at any point over the analysis period); (c) VarC represents of the probability of the TAC varying by less than 20% over the analysis period. For example, 100% for LRP means that the CMP has a 100% chance of NOT breaching the limit reference point, and 100% of VarC means that the variation in TAC was less than 30% during the period. Appendix A includes a definition of each performance statistic presented here.

Appendix A

Management objectives (from Res. 22-02) and the proposed corresponding performance statistics

Management Objectives (Res. 22-02)	*Proposed corresponding performance statistics*
Status The stock should have a [XX% or greater]% probability of occurring in the green quadrant of the Kobe matrix using a [X]-year projection period as determined by the SCRS.	**PGK_{short}**: Probability of being in the Kobe green quadrant (i.e., SSB≥SSB_{MSY} and F<F_{MSY}) in year 1-3 **PGK_{medium}**: Probability of being in the Kobe green quadrant (i.e., SSB≥SSB_{MSY} and F<F_{MSY}) in year 4-10 **PGK_{long}**: Probability of being in the Kobe green quadrant (i.e., SSB≥SSB_{MSY} and F<F_{MSY}) over years 11-30 **PGK_{all}:** Probability of being in the Kobe green quadrant (i.e., SSB≥SSB_{MSY} and F<F_{MSY}) over years 1-30
Safety There should be no greater than [XX]% probability of the stock falling below B_{LIM} at any point during the X-year projection period.	**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 1-3 **LRP_{medium}**: Probability of breaching the limit reference point (i.e., SSB<0.4*SSB_{MSY}) over years 4-10 **LRP_{long}**: Probability of breaching the limit reference point (i.e., SSB<0.4*SSB_{MSY}) over years 11-30 **LRP_{all}**: Probability of breaching the limit reference point (i.e., SSB<0.4*SSB_{MSY}) over years 1-30
Yield Maximize overall catch levels in the short (1-3 years), medium (4-10 years) and long (11-30 years) terms.	**AvC_{short}** – Median catches (t) over years 1-3 **AvC_{medium}** – Median catches (t) over years 4-10 **AvC_{long}** – Median catches (t) over years 11-30
Stability Any changes in TAC between management periods should be [XX]% or less.	**$VarC_{medium}$** – Variation in TAC (%) between management cycles over years 4-10 **$VarC_{long}$** – Variation in TAC (%) between management cycles over years 11-30 **Var_{all}** – Variation in TAC (%) between management cycles over years 1-30 Scaled alternatives: **$VarC_{medium}02$** – Probability of TAC varying by less than 20% between management cycles over years 4-10 **$VarC_{long}02$** – Probability of TAC varying by less than 20% between management cycles over years 11-30 **$Var_{all}02$** – Probability of TAC varying by less than 20% between management cycles over years 1-30

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. 22-02 for WSKJ).

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.