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Report of the Third Intersessional Meeting of Panel 4 on North Atlantic Swordfish Management Strategy Evaluation (MSE)

(*Online, 10-11 October 2023*)

1. Opening of the meeting and meeting arrangements

Mr. Amar Ouchelli (Algeria), Chair of Panel 4, opened the meeting and welcomed the participants.

The Secretariat explained the arrangements for the virtual meeting, including noting the timing of the lunch and coffee breaks.

2. Appointment of the Rapporteur

Dr Lisa Crawford (United States) was appointed as Rapporteur.

3. Adoption of agenda

The SCRS Chair proposed modifying two agenda items: removing item 8c. Final tuning objective, given that tuning had already been completed; and adding a new agenda item between items 8a. and 8b. to select a final Candidate Management Procedure (CMP) or reduce the list of CMPs.

The agenda was adopted with the proposed changes and is attached as **Appendix 1**.

The list of participants is included as **Appendix 2**.

4. Review of Panel 4 feedback and requests in June 2023

Dr Kyle Gillespie (SCRS Swordfish Species Group Coordinator and North Atlantic Swordfish (SWO-N) Rapporteur) delivered a presentation (**Appendix 3**). Dr Gillespie reviewed the discussions, decisions, and requests made by the Panel at its March and June meetings. He explained that the goals of this meeting were to communicate the final results of the management strategy evaluation (MSE) process and to provide information and support for Panel 4 decision-making on management procedure (MP) specifications.

a. Management and tuning objectives

The *Resolution by ICCAT on development of initial management objectives for North Atlantic swordfish* (Res. 19-14) established conceptual management objectives addressing four areas: safety, stock status, stability, and yield. During the March and June intersessional meetings, the Panel began to operationalize the management objectives, establishing initial values for safety, status, and stability.

b. Primary performance metrics

To evaluate the management objectives through MSE, performance metrics that included timeframes were established. For safety, the SCRS assessed as the primary performance metric the probability of breaching the limit reference point (LRP; $SB<0.4SB_{MSY}$) over the entire 30-year projection period (LRP_{ALL}). With respect to status, the primary metrics were PGK_{SHORT}, PGK_{MEDIUM}, PGK_{ALL}, POF (probability of overfishing), and PNOF (probability of not overfishing). Regarding stability, the primary performance metric considered was VarC, which is the mean variation in the total allowable catch (TAC) between management cycles across all years. Finally, the primary metrics with regard to yield were median TAC over years 1-10 (short), median TAC over years 11-20 (medium), and median TAC over years 21-30 (long); as well as the TAC in year one (TAC1).

c. Priority robustness tests

During the last two Panel 4 meetings, a prioritized set of robustness tests were selected: a 1% increase historical and projected catchability (R1); a 1% increase in historical catchability (R2); the effects of climate change (R3a and 3b); implementation error and/or IUU fishing (R4); and minimum size limits (R5). Results of each robustness test were presented by the SCRS, with the exception of test R5, which needs more analysis. Further, the SCRS noted that current climate change robustness tests, which are based on potential recruitment changes, were developed to serve as a proxy pending further work to better account for climate change in the MSE process.

d. Minimum Total Allowable Catch (TAC) change

The SCRS was tasked with testing a threshold value of 200 t as the minimum TAC change between management cycles. In scenarios where the minimum TAC change for CMPs is less than 200 t, there would be rollover of the previous TAC. The SCRS was also asked to evaluate management cycle lengths of 3 and 4 years.

5. Summary of work completed since the June 2023 meeting of the Panel

Dr Gillespie summarized the significant work completed by the SCRS on CMP development. The efforts undertaken by the SCRS include testing models, developing robustness tests, creating an interactive website to show tradeoffs between robustness tests, aggregating data into a combined data index, and presenting the results for SCRS review and approval.

6. CMPs and their results, examples of some MPs rejected by the sub-group

Dr Gillespie presented a small subset of the over 60 CMPs that were developed with multiple versions and tuning levels. These CMPs, which were tuned to achieve 51%, 60%, and 70% PGK_{SHORT} were presented. If a CMP was unable to pass the safety criterion (i.e., 15% or less chance of breaching LRP), it was rejected or redeveloped until it met the safety threshold. CMPs that made it through filtering were compared and final tradeoffs were examined. He continued to describe the SCRS methodology for filtering those CMPs that are considered "dominated" during testing by examining the tradeoffs between PGK and median TAC over short, medium, and long timeframes. "Dominated" CMPs are those with worse performance with respect to both metrics. CMPs are only removed from further testing if they are considered "dominated" in all three timeframes.

After removing dominated CMPs and those that failed to meet the safety management objective, Dr Gillespie presented a short list of CMPs, which included both model based and empirical approaches: namely: SPSSFox (model-based) and CE, FX4, MCC5, and MCC7 (empirical).

Dr Gillespie explained the shortlisted CMPs and their variants across 51%, 60%, and 70% PGK. The characteristics of each CMP were described, including minimum TAC, the reference period, number of TAC steps, and CMP type. After describing the CMPs, Dr Gillespie used the Shiny App web tool to demonstrate CMP performance and tradeoffs. Using the tool, different plot types, key information on elements of MSE, brief descriptions of models and robustness tests, overview of prepared CMPs, and detailed technical overview of MSE can be visualized. The filtering option can be used to omit or view CMPs based on characteristics and performance as reflected in performance metrics. He showed an example of using CMP filters and demonstrated tradeoff selections to specify which performance metrics are shown in quilt plots. Dr Gillespie also stressed the importance of looking at differences among the CMPs, not absolute TAC values, as some CMPs may have identical results in performance but differences in TAC adjustments, and the data are not available to predict the actual TAC.

One CPC asked if, similar to what was done for northern albacore, SCRS had tested a bifurcated approach to stability for the model based CMPs, as requested at previous Panel 4 intersessional meetings. Specifically, when $B>B_{MSY}$, a +/-25% stability clause would apply but when $B<B_{MSY}$, TAC increases could still be limited

to +25% but there would be no limit on TAC decreases. Dr Gillespie noted that there had not been time to conduct this analysis to date.

7. Robustness tests

Dr Gillespie reminded the Group that robustness tests present very challenging scenarios to the models and can reveal qualities that would not typically be seen in the reference set of OMs. Dr Gillespie presented the performance of the CMPs for various robustness tests using the Shiny App web tool. Dr Gillespie also explained that the results for the minimum size limit robustness test (R5) were not finalized because of low confidence in the results given the inherent confounding factors and unpredictable nature of possible future changes in the SWO-N stock or fleet. This test will be prioritized in the future work of the SCRS. He also reiterated the continuing work to improve the incorporation of climate change into the MSE.

8. Key decisions anticipated to be taken by PA4

Selection of recommended MPs

a. Final operational management objectives

The Panel further considered the initial operational management objectives with a view to identifying final threshold values for safety, status, and stability.

Safety

All of the CMPs tested achieved the safety threshold, and had a less than 5% probability of reaching the LRP at any point during the projection period. Therefore, selecting 5, 10, or 15% for safety would not narrow down the CMPs list as they all passed the most stringent safety test. The SCRS Chair indicated that different robustness scenarios, such as R3b, with large negative deviations could mean big reductions in recruitment. In general, the SPSSFox CMP performed a bit better on average in avoiding the LRP. MCC7 had better performance in terms of stability but did not perform as well with this robustness test.

One CPC suggested that a 15% probability of breaching the LRP would be sufficiently precautionary, and the approach would be in line with bluefin tuna MSE. The CPC elaborated that SWO-N is healthier and, generally speaking, more data rich than bluefin tuna, so this threshold would be appropriate given the circumstances. Another CPC suggested a safety percentage of 10%. In response, a CPC suggested it could go along with 10%, but that it would be necessary to be clear in the report that such a decision did not set a precedent for other MSEs moving forward. Given the lack of consensus between 10 and 15%, a final decision on the value to include in the safety management objective could not be taken. As noted above, however, this decision point does not affect the available list of CMPs and the Chair noted that taking the decision at a later date will not slow the work of the Panel.

Status

Noting that three values, 51%, 60%, and 70%, for the status management objective were still in play, the SCRS asked the Panel to consider choosing a single value or at least narrowing the options. One CPC suggested narrowing the options as a first step, indicating that 51% PGK should be removed as there was too much risk to the stock associated with this value. The Panel agreed to remove 51% PGK and selected at least 60% PGK as the final management objective. It was noted that, despite selecting 60% as the threshold for further consideration, CMPs with a 70% PGK could still be selected as the management objective notes "60% or greater," which would include the value of 70%.

Setting a minimum threshold of 60% PGK resulted in three CMPs (CE_b, MCC5_b, and MCC7_b) falling below that value for certain timeframes. To ensure those CMPs would be eligible for selection, the Panel discussed the possibility of retuning them. One CMP (CE_b) only missed the threshold by .01 for one timeframe (PGK_{MEDIUM}) and was at or over the threshold in other timeframes. While this CMP could be retuned if the SCRS had time, it was agreed that it did not require retuning to be considered viable. The other two CMPs, however, missed the threshold by a wider margin and in multiple timeframes. The Panel, therefore,

requested that they be retuned. The SCRS acknowledged that the retuning is feasible, but unforeseen circumstances could create challenges and, as such, the requested revisions could not be guaranteed.

Stability

The Panel did not make a final decision regarding the terms of the stability management objective. One CPC expressed a preference for no caps. Another noted a preference for a +/- 25% cap on changes in the TAC. A CPC recalled the Panel 4 request from its June 2023 intersessional meeting that SCRS test a bifurcated approach for model-based CMPs to ensure the TAC could be reduced in a timely way if overfishing of the stock occurred and the stock became overfished, noting that the northern albacore CMP used such an approach to stability. After a detailed exchange to ensure the request was fully understood, it was agreed that testing of the SPSSFox CMP would be undertaken to look at a +/-25% change in TAC when $B>B_{MSY}$ and +25% TAC increase and no limit on TAC decreases when $B<B_{MSY}$. It was agreed that this work by the SCRS should be undertaken as a priority and presented as a variant to the current SPSSFox CMP so that its performance can be compared.

Following a discussion with the technical team, the SCRS confirmed that the SPSSFox model-based CMP bifurcation testing could likely be completed.

b. Select final CMP or reduce list

Dr Gillespie explained that all CMPs are fundamentally different with different TAC levels, TAC change levels, and differences in variability. He underscored that some CMPs do better than others when presented with a challenging robustness test, such as R3b. The SCRS Chair further explained that the "mostly constant catch" CMPs, MCC5 and MCC7, were based on the reference period of 2017-2019 and if the stock decreased or increased by less than a certain percentage, the TAC was maintained. In this context, he noted that these CMPs perform well at maintaining catch level at the current level and have good stability. However, these CMPs had a hard time staying above LRP in challenging scenarios.

One CPC noted that the FX4 CMP did not do well with climate change robustness test R3b and suggested removing it from consideration. The Panel supported this suggestion. Further noting that performance of CE_c and SPSSFOX_c was not adequate relative to other CMPs, the Panel agreed to also remove these CMPs from consideration.

Dr Gillespie presented potential tasks before the technical team and the amount of time they would take, relative to the amount of time before the Annual Meeting. The Panel confirmed that completing the SPSSFox model-based CMP bifurcation testing was a high priority for the SCRS as this had been previously agreed by the Panel in June 2023. The next priority was to retune MCC5_b and then of MCC7_b so both could achieve 60% PGK in all timeframes. It was noted that CE_b could be retuned if the SCRS had time but that the CMP could still be considered as a viable option regardless as it only fell marginally below 60% PGK in the medium timeframe.

The Chair summarized that, based on discussions, the reduced list of CMPs to be further considered by the Panel during the Annual Meeting included MCC5_b, MCC5_c, MCC7_b, MCC7_c, CE_b, and SPSSFox_b.

c Final MP specifications

i. Management cycle

Dr Gillespie explained that there are very small differences between management cycle lengths of 3 and 4 years, although this test was conducted for just three CMPs and with a single OM within the reference grid. One CPC pointed out that a 4-year cycle would be aligned with the bluefin tuna MSE cycle come 2032 and asked what that would mean for the workload of the SCRS if the MSEs have to be managed simultaneously.

The SCRS Chair responded that this would be a heavy workload, and it would be difficult to carry out the assessment work during that year and would lead to limited expert engagement. He explained that the 4--year cycle might cause problems with robustness in terms of recruitment deviations found in test R3b, as there would be a one year slower response to changing conditions. Dr Gillespie further explained that there are a number of CMPs that were not analyzed with a 4-year management cycle because there was

insufficient time to run the whole grid. Based on the behavior seen in the results, he hypothesized that there would likely not be a significant difference in the 3- and 4-year management cycle for other CMPs. He also explained that testing a sizable number of CMPs across a 4-year cycle length would be difficult to achieve between now and the November meeting. One CPC expressed a preference for a 3-year management cycle since there were no distinguishable differences between the 3- and 4-year management cycle lengths. The CPC noted that this would also alleviate an unsustainable increase in the SCRS workload in 2032, which would also impact the work of the Commission. Taking these considerations into account, there was general agreement among the Panel for a 3-year management cycle.

ii. Minimum TAC change

A CPC proposed establishing a 200 t minimum TAC change threshold to reduce the administrative burden of implementing a de minimis TAC change resulting from the application of the MP. The SCRS reported that, during testing, it was unclear whether any changes in TAC of 200 t or less would be meaningful as most CMPs require stepped changes in TACs and the steps are greater than 200 t. In that case, a 200 t or less minimum TAC change threshold would not apply in most cases. The SCRS offered to run this analysis across the entire reference set to evaluate the impacts, if requested. The Panel agreed to a minimum TAC change threshold value of 200 t.

d. MP implementation schedule

Dr Gillespie reviewed the MSE implementation schedule. 2024 is considered year 1–assuming an MP is adopted by ICCAT in 2023. In the final year of the management cycle, the MP would be updated with new data and applied again. Periodic checks of the stock would be performed and new stock information would be incorporated when it became available starting after one or two management cycles. New information may also contribute to setting new timelines for the MSE review and may require reconditioning of OMs to make sure they are biologically relevant. Dr Gillespie asked for Panel input on the timeline for MSE review.

One CPC suggested that 2032 is too far into the process to have the first MP review, pointing out that for the bluefin tuna MSE, the MP will be reviewed after 6 years. The CPC suggested 2029 for the review (after 2 cycles of application) would be more appropriate. This suggestion was supported by other CPCs. One CPC noted its agreement in principle to the timeline being discussed but reserved its final position on the MP implementation schedule until the Annual Meeting, noting that delaying this decision would not impact the SCRS workload over the next few weeks.

A CPC noted that the last SWO-N stock assessment was conducted in 2022 and suggested the next assessment should be conducted in 2027. Another CPC was willing to consider holding the assessment in either 2027 or 2028. Others supported a 2028 assessment. A CPC noted that it did not yet have a position on this question and suggested the issue be deferred to the Annual Meeting. The SCRS Chair agreed that this matter did not need to be resolved by the Panel at this meeting.

A CPC asked if the combined index (CI) of abundance should be updated every year. Dr Gillespie explained that for some species, there are annual updates to the index, but this is not the case for SWO-N. The norm has been to update the CI as necessary, as it feeds the MP to inform how to set the TAC for the next cycle. Additional data processing and data submission, however, should allow the CI to be updated every year. Drawing information from ICCAT databases and individual CPC data could be considered by the SCRS technical team. If the Panel were to request that the CI be updated yearly, then the CPCs would need to provide new data every year. The SCRS Chair explained that this point could be considered as part of the exceptional circumstances protocol, which should be developed over the next year for adoption in 2024. They explained the practice undertaken pursuant to other MSEs where, after adoption of the MP, the SCRS develops an initial draft of an exceptional circumstances protocol proposing which of the MSE performance indicators are most important and that, through an iterative process with the Panel, the protocol is eventually finalized and adopted by the Commission. The Panel agreed to further consider the timing for updating the CI and the timing and process for developing an exceptional circumstances protocol at the Annual Meeting.

9. Development of a management measure

Dr Gillespie reviewed the components of an MP for SWO-N to be incorporated into a management measure, including management objectives, the harvest control rule, management cycle length, any minimum TAC change threshold, the exceptional circumstances protocol, and the list of performance measures, the MP implementation schedule, and other aspects.

Three CPCs indicated that they were working on a SWO-N proposal that would combine elements of the current recommendation with the MP components. There was agreement to collaborate on the development of a single proposal if possible, to try to avoid having competing proposals on the table at ICCAT in November. The Panel Chair thanked the CPCs for their willingness to work together and reiterated the need for flexibility at the Annual Meeting to come to agreement on the selection of a CMP.

10. Other matters

No other matters were discussed.

11. Adoption of the report and closure

The Chair requested the meeting report from the Rapporteur within one week of the end of the meeting. The Panel agreed to an expeditious process for adopting the report by correspondence.

The Chair thanked the Secretariat, SCRS, interpreters, Rapporteur, and participants for their hard work and contributions to the meeting and adjourned the meeting.

Agenda

1. Opening of the meeting and meeting arrangements
2. Appointment of the Rapporteur
3. Adoption of agenda
4. Review of Panel 4 feedback and requests in June 2023:
    a. Management and tuning objectives
    b. Primary performance metrics
    c. Priority robustness tests
    d. Minimum Total Allowable Catch (TAC) change
5. Summary of work completed since the June 2023 meeting of the Panel
6. CMPs and their results, examples of some MPs rejected by the sub-group
7. Robustness tests
8. Key decisions anticipated to be taken by PA4

    Selection of recommended Management Procedures (MPs)

    a. Final operational management objectives

    b. Select final CMP or reduce list

    c. Final MP specifications

        i. Management cycle
        ii. Minimum TAC change

    d. MP implementation schedule
9. Development of a management measure
10. Other matters
11. Adoption of the report and closure

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Third Intersessional Meeting of Panel 4 on North Atlantic Swordfish MSE

Goals

Communicate final results for the North Atlantic Swordfish Management Strategy Evaluation (SWO-N MSE)

Provide information to support Panel 4 decision making on MP selection and MP specifications

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Agenda

Review of Northern Swordfish MSE

4. Review of Panel 4 feedback and requests in June 2023:
   a. Management and tuning objectives
   b. Primary performance metrics
   c. Priority robustness tests
   d. Minimum Total Allowable Catch (TAC) change
5. Summary of work completed since the June 2023 meeting of the Panel
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Agenda

7. Robustness tests
8. Key decisions anticipated to be taken by PA4
- Selection of recommended Management Procedures (MPs)
  a. Final operational management objectives
  b. Final MP type
  c. Final MP specifications
     i. Management cycle
     ii. Minimum TAC change
  d. MP implementation schedule
9. Development of a management measure

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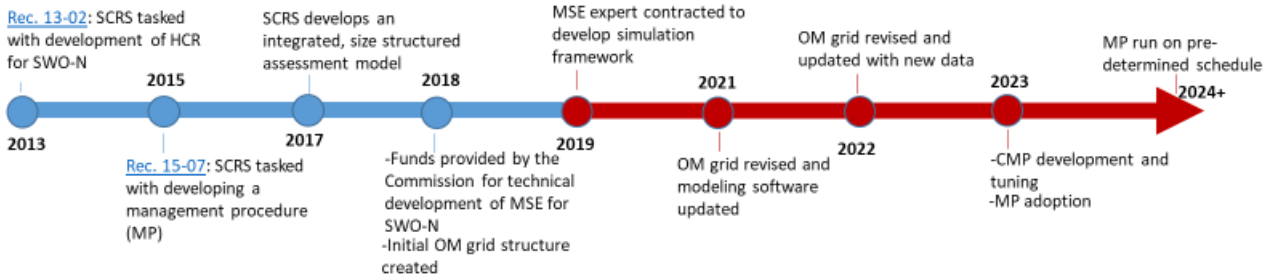
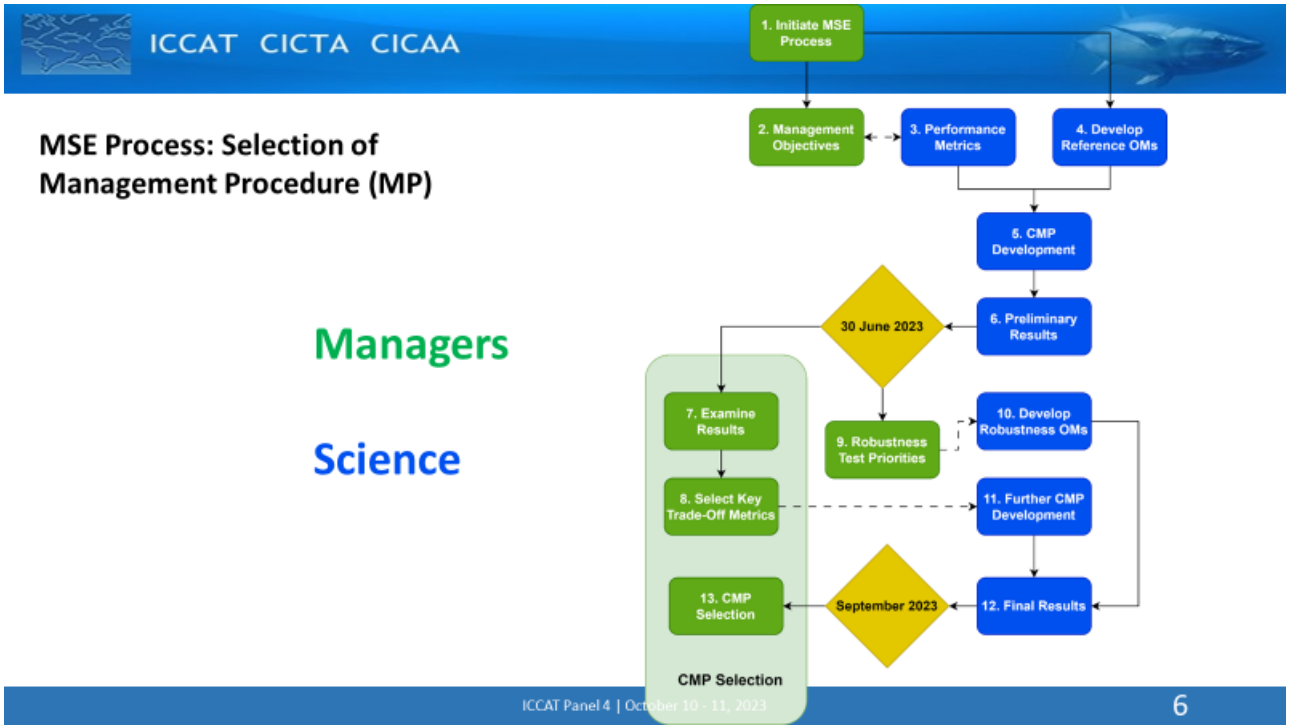
SWO-N MSE development

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MSE Process: Selection of Management Procedure (MP)
Managers
Science
1. Initiate MSE Process
2. Management Objectives
3. Performance Metrics
4. Develop Reference OMs
5. CMP Development
6. Preliminary Results
30 June 2023
7. Examine Results
8. Select Key Trade-Off Metrics
9. Robustness Test Priorities
10. Develop Robustness OMs
11. Further CMP Development
12. Final Results
September 2023
13. CMP Selection
CMP Selection
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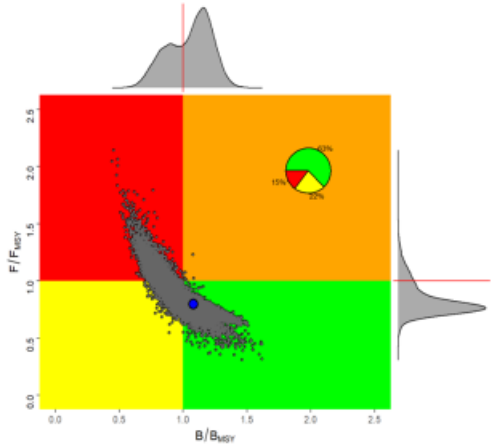
2022 SWO-N stock assessment

- Fully integrated stock assessment model for North Atlantic swordfish first developed for 2017 SWO-N assessment

- Data inputs
  - Data to 2020
  - Landings (8 fleets)
  - CPUE (6 indices)
  - Age specific CPUE (5 indices)
  - Length composition (7 fleets)



Operating models

- Reference operating models
  - The most important uncertainties in the stock and the fishery
- Robustness operating models
  - Other potentially important uncertainties or scenarios
  - May be considered less plausible
  - "Stress tests"

Final Reference OM grid

Variable	*Stock assessment base case model*	*Operating model grid*		
Steepness	0.88	0.69	0.8	0.88
Natural mortality	0.2	0.1	0.2	0.3

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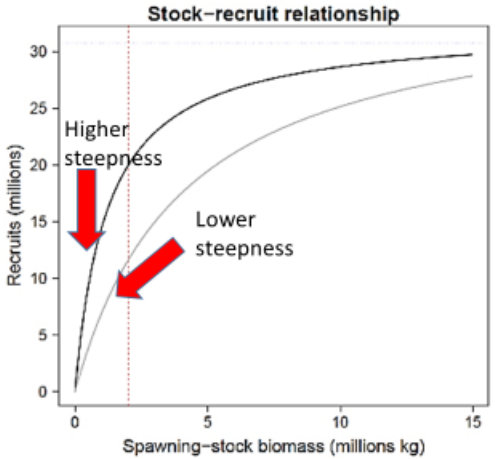
Operating model grid

- Core uncertainty: stock productivity
  - Ability to recovery from low abundance levels
  - Natural mortality (death rate in the population)



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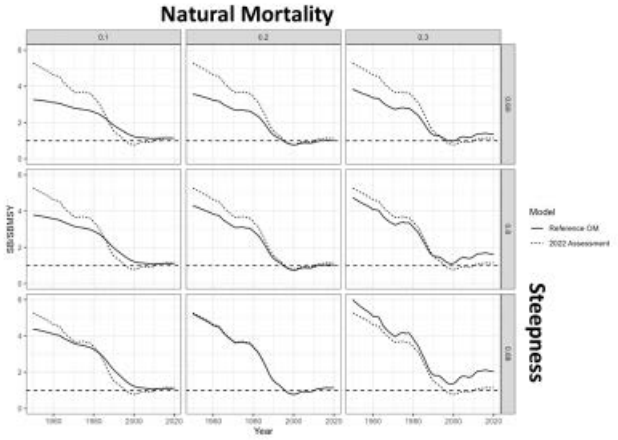
1. MSE process initiated
2. Management Objectives stated
3. Develop Performance Metrics
4. Develop Reference OMs



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Management objectives

Objectives fall into 4 categories:

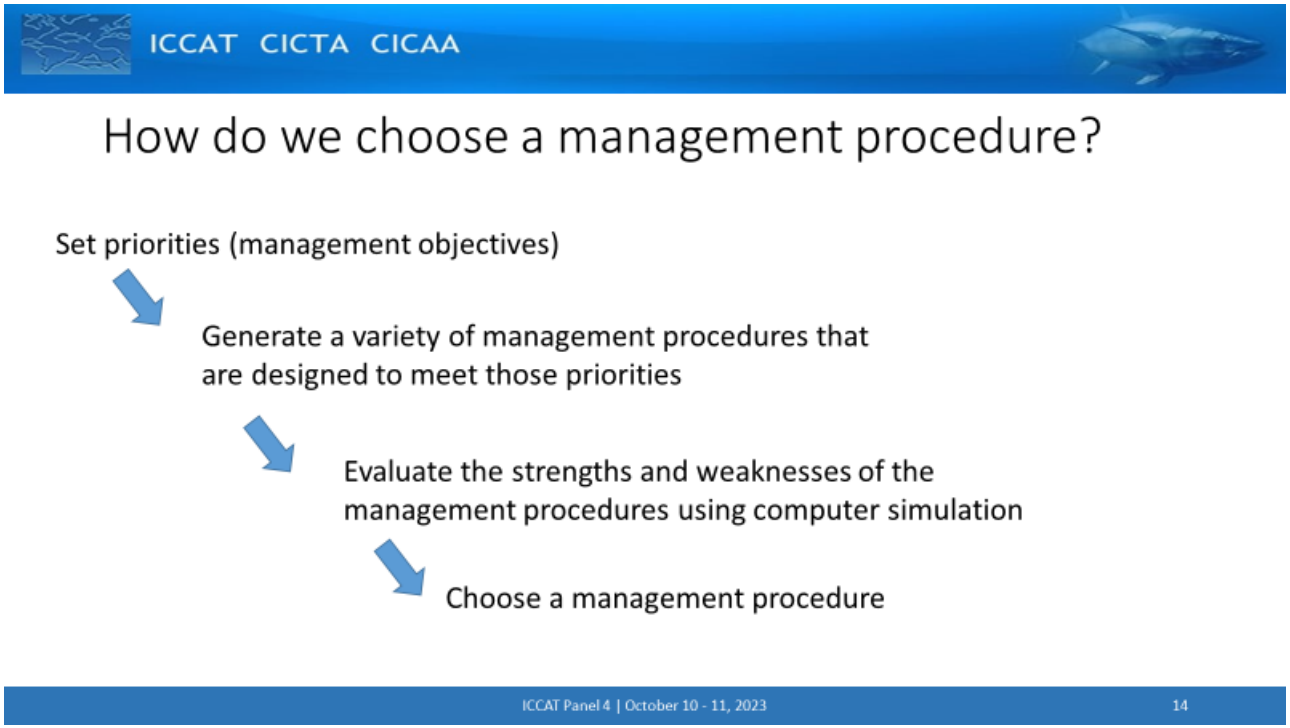
19-14	SWO
RESOLUTION BY ICCAT ON DEVELOPMENT OF INITIAL MANAGEMENT OBJECTIVES FOR NORTH ATLANTIC SWORDFISH	

1. Safety [15%, 10%, 5%]
   E.g. "There should be a [__]% or less probability of the stock falling below B_{LIM} at any point during the 30-year evaluation period."

2. Stock status [51%, 60%, 70%]
   E.g. The stock should have a greater than [__]% probability of occurring in the green quadrant of the Kobe matrix

3. Stability [25% / no cap]
   E.g. Any increase or decrease in TAC between management periods should be less than [__]%

4. Yield
   E.g. Maximize overall catch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How do we choose a management procedure?
Set priorities (management objectives)
Generate a variety of management procedures that are designed to meet those priorities
Evaluate the strengths and weaknesses of the management procedures using computer simulation
Choose a management procedure
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Tuning objective

- Tuning CMPs to achieve a performance metric standard
- Tuning allows comparison among CMPs
- NSWO tuning objectives: 51%, 60%, 70% PGK_{short}

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Performance metrics

- Test performance of CMPs against pre-determined objectives
  - Time frame
  - Specific measurement

  - E.g. Probability of overfishing in years 1 – 10

Management objectives

Objectives fall into 4 categories:

19-14	SWO
RESOLUTION BY ICCAT ON DEVELOPMENT OF INITIAL MANAGEMENT OBJECTIVES FOR NORTH ATLANTIC SWORDFISH	

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2. Stock status
   E.g. The stock should have a greater than [__]% probability of occurring in the green quadrant of the Kobe matrix

3. Stability
   E.g. Any increase or decrease in TAC between management periods should be less than [__]%

4. Yield
   E.g. Maximize overall catch

Performance metrics – Safety

Name	***Description***
LRP_short	Probability of breaching the limit reference point (SB<0.4SB$_{MSY}$) in any of the first 10 years (2024-2033)
LRP_med	Probability of breaching the limit reference point (SB<0.4SB$_{MSY}$) in any of years 11-20 (2034-2043)
LRP_long	Probability of breaching the limit reference point (SB<0.4SB$_{MSY}$) in any of years 21-30 (2044-2053)
LRP	Probability of breaching the limit reference point (SB<0.4SB$_{MSY}$) in any year (2024-2053)

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Performance metrics – Status

Name	***Description***
PGK_short	Probability of being in Green Zone of Kobe Space (SB>SB_{MSY} & F<F_{MSY}) in years 1-10 (2024-2033)
PGK_med	Probability of being in Green Zone of Kobe Space (SB>SB_{MSY} & F<F_{MSY}) in years 11-20 (2034-2043)
PGK_long	Probability of being in Green Zone of Kobe Space (SB>SB_{MSY} & F<F_{MSY}) in years 21-30 (2044-2053)
PGK	Probability of being in Green Zone of Kobe Space (SB>SB_{MSY} & F<F_{MSY}) over all years (2024-2053)
PGK_30	Probability of being in Green Zone of Kobe Space (SB>SB_{MSY} & F<F_{MSY}) in year 30 (2053)
POF	Probability of Overfishing (F>F_{MSY}) over all years (2024-2053)
PNOF	Probability of Not Overfishing (F<F_{MSY}) over all years (2024-2053)

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Performance metrics – Stability

Name	***Description***
VarC	Mean variation in TAC (%) between management cycles over all years and simulations

Performance metrics – Yield

Name	***Description***
TAC1	TAC (t) in the first implementation year (2024)
AvTAC_short	Median TAC (t) over years 1-10 (2024-2033)
AvTAC_med	Median TAC (t) over years 11-20 (2034-2043)
AvTAC_long	Median TAC (t) over years 21-30 (2044-2053)

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- Robustness operating models
  - Other potentially important uncertainties or scenarios
  - May be considered less plausible
  - "Stress tests"

Robustness operating models

Test	*Purpose*	*Uncertainty type*	*Analysis requirements*
1. Lower steepness	Evaluate sensitivity to stock with low resilience	Conditioning	Low
2. Higher recruitment variability	Evaluate sensitivity to higher variability in recruitment process error	Conditioning	Low
3. Exclude length composition data	Evaluate impact of only using indices of abundance in OM conditioning (i.e. do not include catch at length data in the model fitting)	Conditioning	Low
4/5. Catchability in historical and projection periods	Evaluate impact of an increase in catchability that was not accounted for in the standardization of the indices of abundance	Conditioning/projection	Low
6. a) Climate Change recruitment	Evaluate impact of systematic pattern in recruitment deviations in projection periods; a proxy for impact of Climate Change on productivity	Projection	Medium
6. b) Climate Change alternative scenarios	Investigate impacts of Climate Change on stock biology, distribution; fishing fleets	Projection/management	High
7. Implementation error	Evaluate impact of illegal, unreported, or unregulated (IUU) catches	Management	Medium
8. Size limit	Evaluate impact of different size limits, including removing all size regulations	Management	Medium
9. Alternative management cycles	Evaluate the impact of a longer management cycle	Management	Low

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Robustness tests

- Plausible but less likely scenarios / stress tests for CMPs

Test name	*Category*	*Description*
R1	Catchability	1 percent annual increase catchability, that is not accounted for in the standardization of the indices of abundance (historical & projection)
R2	Catchability	1 percent annual increase catchability, that is not accounted for in the standardization of the indices of abundance (historical only)
R3a	Climate Change	Climate Change impacts on recruitment deviations (positive and negative)
R3b	Climate Change	Climate Change impacts on recruitment deviations (negative)
R4	Implementation error	10% overage in TAC due to IUU
R5	Size limit	Test effect of removal of minimum size limit
Additional tests	TAC change minimum threshold	Test performance of CMPs when no TAC change if TAC update is <200 t difference
	Management cycle	Compare effect of 3 year vs 4 year MP implementation length

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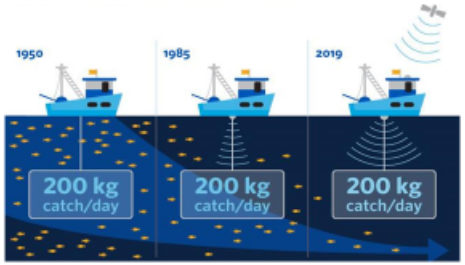
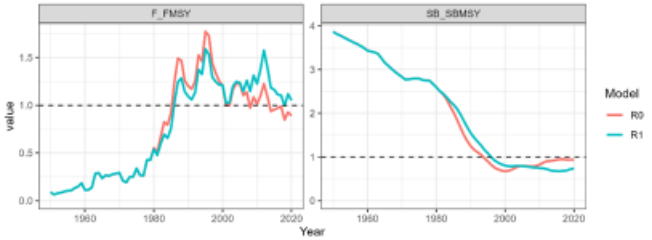
Catchability

- Assuming 'effort creep' and hyperstability in indices
- R1: 1% increase in catchability in historical and projection periods
- R2: 1% increase in catchability in historical period





R3 – Climate change

- Climate change may have varying effects on different features of the stock, such as
  - Distribution
  - Reproduction
  - Growth
- Complex scenarios require long term work plan
- Tests CMP ability to react to periods of low (50%) recruitment

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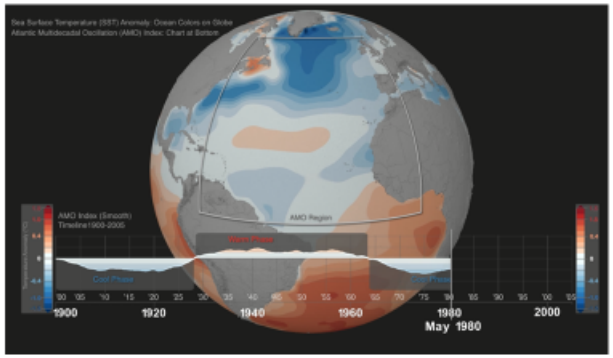
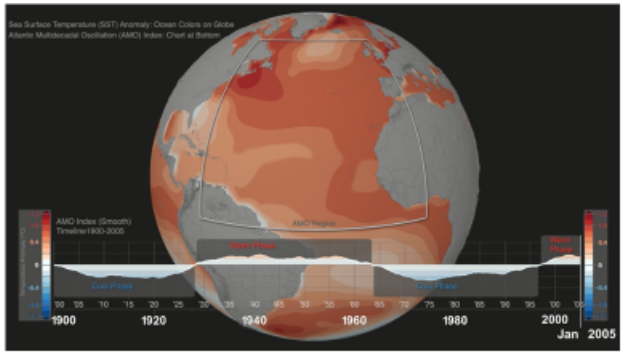
Atlantic Multidecadal Oscillation (AMO)

- The Atlantic Multidecadal Oscillation (AMO) is an indicator of long-duration changes in the sea surface temperature of the North Atlantic Ocean

1980



2005



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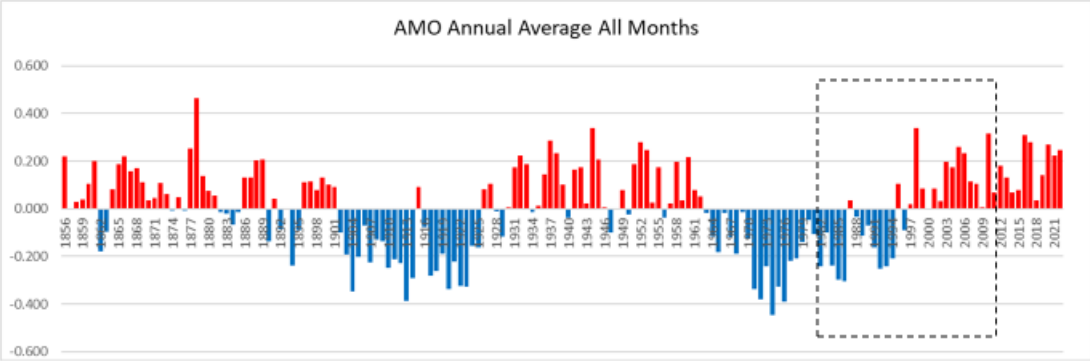
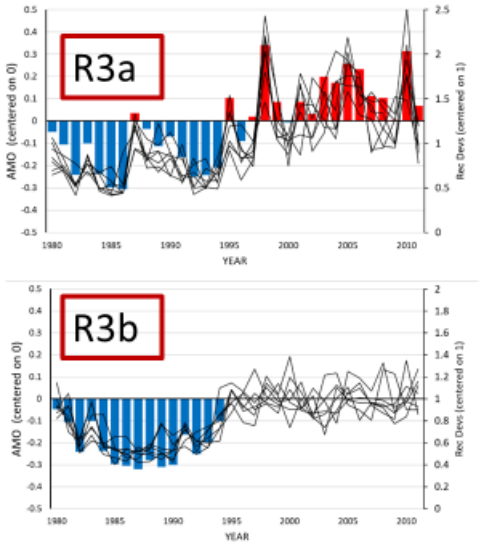
Atlantic Multidecadal Oscillation (AMO)

- We considered a 32 time period that started and continued with 16 years of negative deviations and continued for 16 years of positive deviations. We are not postulating that the AMO is driving recruitment deviations, only that the trend is something we have actually observed in nature



Two Scenarios Considered

- We considered two climate change scenarios
- The first was a cyclical trend represented by the AMO trend
- The second was a period of negative deviations followed by a period of neutral deviations.
- Deviations were inflated by a factor of 2x to simulate climate change possibly increasing the magnitude of recruitment deviations.



R4 – Implementation error / IUU

- Catches assumed to be 10% higher than the TAC

- Catches are assumed to be unreported (i.e., the observed catch provided to the CMPs is equal to the TAC, which is ~90% of the actual removals).

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R5 – Minimum size limit

- **Rec. 90-02**: minimum size limit requiring that swordfish less than 25 kg (or 125 cm lower jaw fork length, LJFL) not be retained in ICCAT fisheries in the Atlantic (with a 15% tolerance in the landed catch).
- Supplemented by **Rec. 95-10**: alternative minimum size limit of 119 cm LJFL (or 15 kg) with no tolerance in the landed catch.

- **Res. 19-14**

"In the development of the operating models, the Commission would like the SCRS to allow for the evaluation of minimum size limits as strategies to achieve management objectives"

- Robustness test allows for feedback to the Commission on effects of retaining minimum size limit (120 cm) versus removal of the minimum size limit in the projection period

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Additional tests

- Minimum Total Allowable Catch (TAC) change
  - TAC change threshold below which there is a roll-over in TAC

- Management cycle length
  - Current assumption: MP in effect for 3 years at a time
  - Compare to 4 year cycle length

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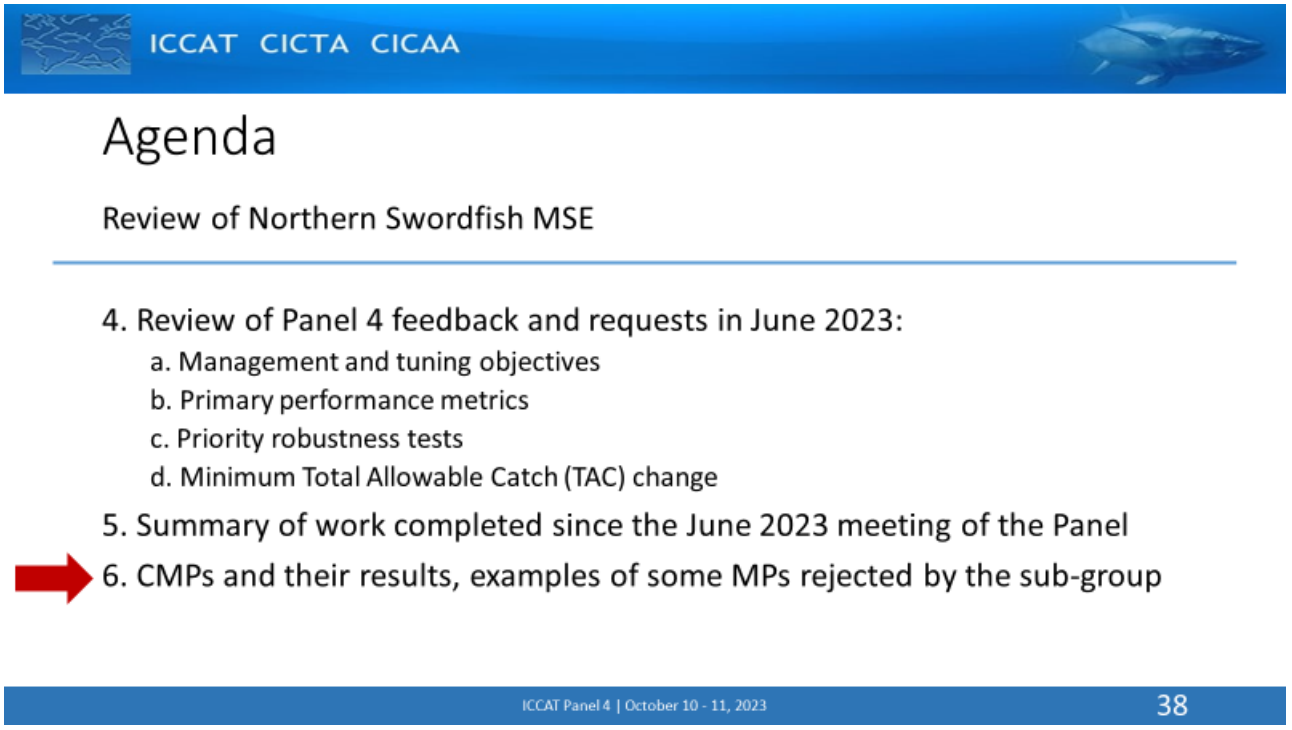
Summary of work completed

- CMP development
- Robustness tests
- Communications tools
  - Interactive website
- Updating the combined data index
- SCRS review and approval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CMP specifications

CMPs

- **Empirical**

-Index ratio decision rule sets TAC

- **Model based**

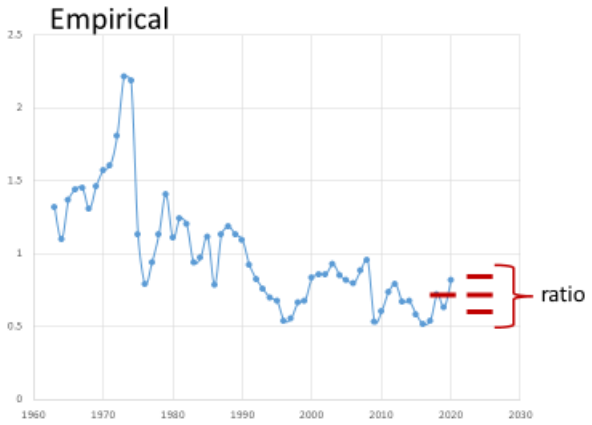
-Assessment model output sets TAC

TAC

Whole of ATL-N

CMP development

- Collaborative process among core technical team
- Empirical and model-based approaches



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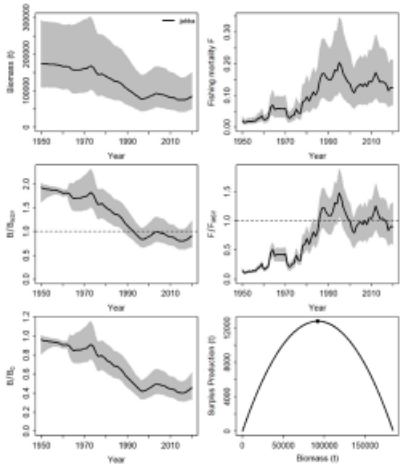
CMP development

- Collaborative process among core technical team
- Empirical and model-based approaches

Model-based



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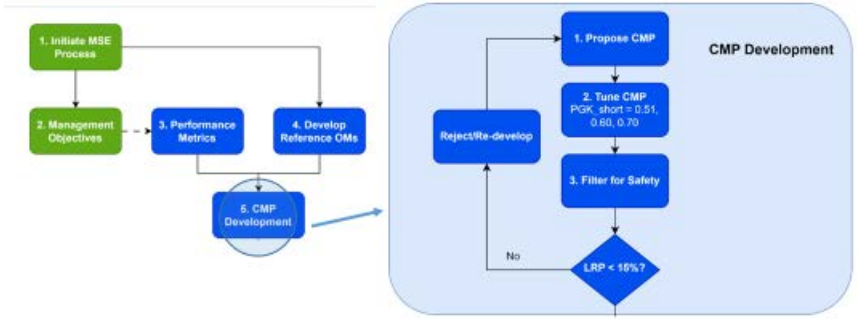
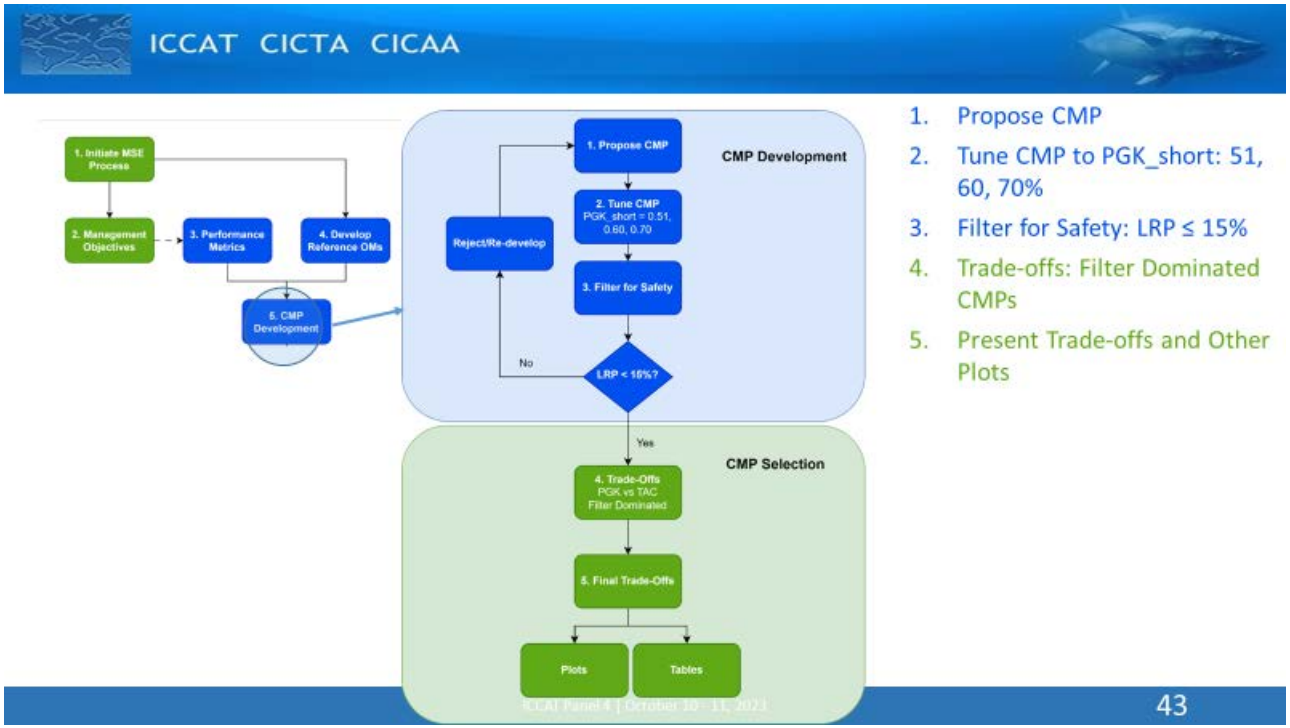


1. Propose CMP
2. Tune CMP to PGK_short: 51, 60, 70%
3. Filter for Safety: LRP ≤ 15%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1. Initiate MSE Process
2. Management Objectives
3. Performance Metrics
4. Develop Reference OMs
5. CMP Development
CMP Development
1. Propose CMP
2. Tune CMP
PGK_short = 0.51, 0.60, 0.70
3. Filter for Safety
LRP < 15%?
No
Reject/Re-develop
Yes
CMP Selection
4. Trade-Offs
PGK vs TAC
Filter Dominated
5. Final Trade-Offs
Plots
Tables
1. Propose CMP
2. Tune CMP to PGK_short: 51, 60, 70%
3. Filter for Safety: LRP ≤ 15%
4. Trade-offs: Filter Dominated CMPs
5. Present Trade-offs and Other Plots
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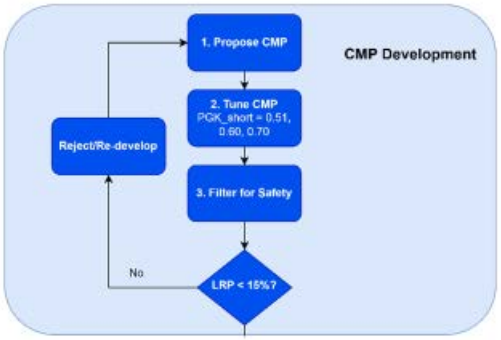
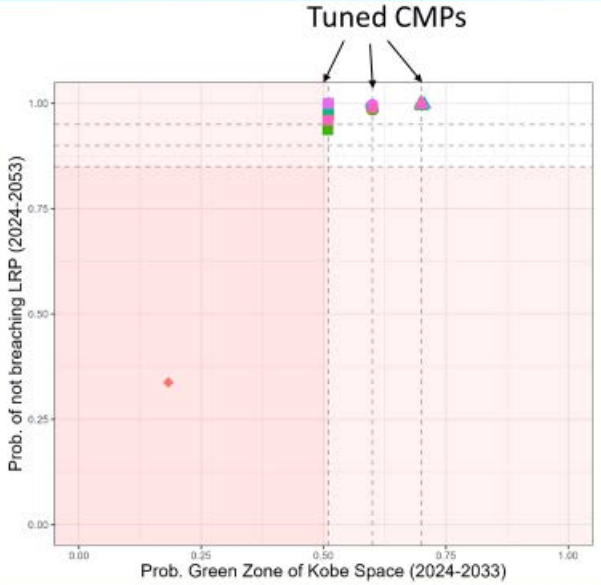
Tune CMP to PGK_short: 51, 60, 70%





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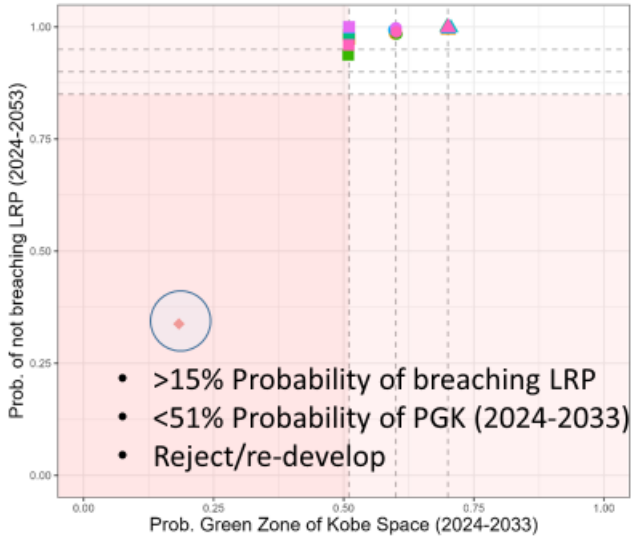
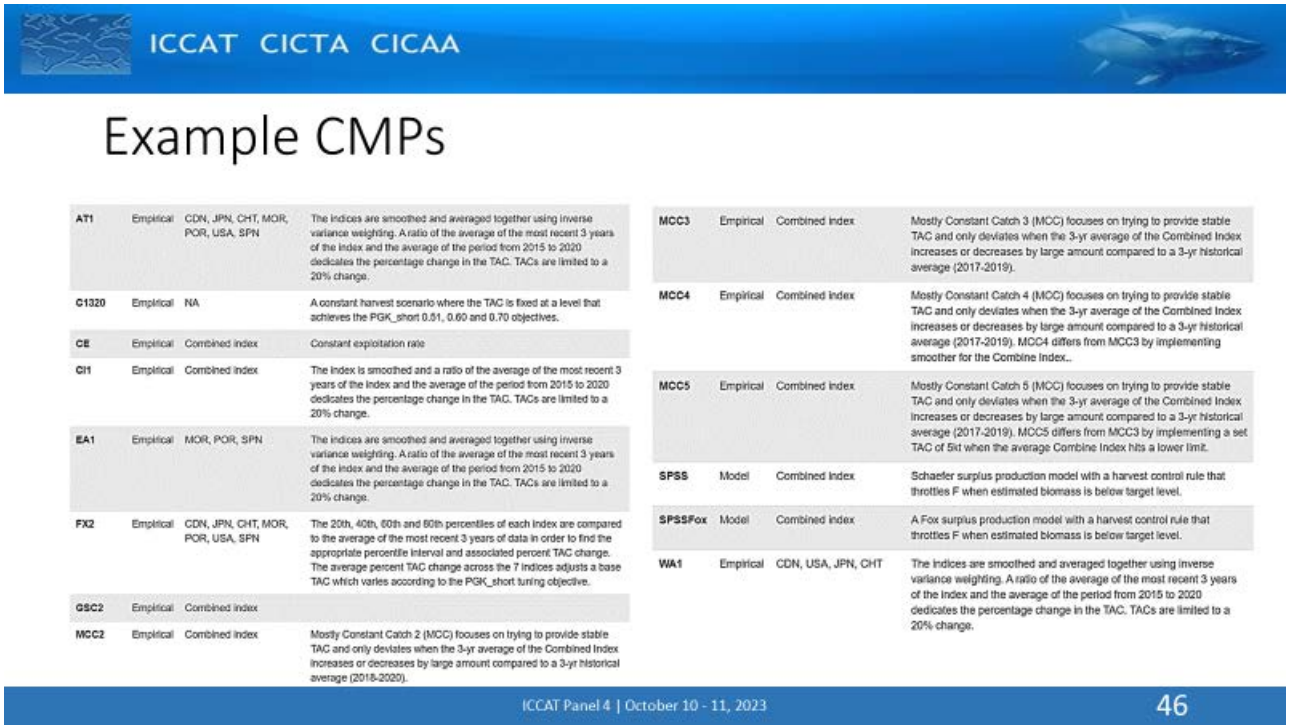
Filter for Safety: LRP ≤ 15%

Proposed CMPs that cannot achieve the tuning targets, or have >15% probability of breaching LRP are rejected/re-developed

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Example CMPs
AT1 Empirical CDN, JPN, CHT, MOR, POR, USA, SPN The indices are smoothed and averaged together using inverse variance weighting. A ratio of the average of the most recent 3 years of the index and the average of the period from 2015 to 2020 dedicates the percentage change in the TAC. TACs are limited to a 20% change.
C1320 Empirical NA A constant harvest scenario where the TAC is fixed at a level that achieves the PGK_short 0.51, 0.60 and 0.70 objectives.
CE Empirical Combined index Constant exploitation rate
CI1 Empirical Combined index The index is smoothed and a ratio of the average of the most recent 3 years of the index and the average of the period from 2015 to 2020 dedicates the percentage change in the TAC. TACs are limited to a 20% change.
EA1 Empirical MOR, POR, SPN The indices are smoothed and averaged together using inverse variance weighting. A ratio of the average of the most recent 3 years of the index and the average of the period from 2015 to 2020 dedicates the percentage change in the TAC. TACs are limited to a 20% change.
FX2 Empirical CDN, JPN, CHT, MOR, POR, USA, SPN The 20th, 40th, 60th and 80th percentiles of each index are compared to the average of the most recent 3 years of data in order to find the appropriate percentile interval and associated percent TAC change. The average percent TAC change across the 7 indices adjusts a base TAC which varies according to the PGK_short tuning objective.
GSC2 Empirical Combined index
MCC2 Empirical Combined index Mostly Constant Catch 2 (MCC) focuses on trying to provide stable TAC and only deviates when the 3-yr average of the Combined Index increases or decreases by large amount compared to a 3-yr historical average (2018-2020).
MCC3 Empirical Combined index Mostly Constant Catch 3 (MCC) focuses on trying to provide stable TAC and only deviates when the 3-yr average of the Combined Index increases or decreases by large amount compared to a 3-yr historical average (2017-2019).
MCC4 Empirical Combined index Mostly Constant Catch 4 (MCC) focuses on trying to provide stable TAC and only deviates when the 3-yr average of the Combined Index increases or decreases by large amount compared to a 3-yr historical average (2017-2019). MCC4 differs from MCC3 by implementing smoother for the Combine Index..
MCC5 Empirical Combined index Mostly Constant Catch 5 (MCC) focuses on trying to provide stable TAC and only deviates when the 3-yr average of the Combined Index increases or decreases by large amount compared to a 3-yr historical average (2017-2019). MCC5 differs from MCC3 by implementing a set TAC of 5kt when the average Combine Index hits a lower limit.
SPSS Model Combined index Schaefer surplus production model with a harvest control rule that throttles F when estimated biomass is below target level.
SPSSFox Model Combined index A Fox surplus production model with a harvest control rule that throttles F when estimated biomass is below target level.
WA1 Empirical CDN, USA, JPN, CHT The indices are smoothed and averaged together using inverse variance weighting. A ratio of the average of the most recent 3 years of the index and the average of the period from 2015 to 2020 dedicates the percentage change in the TAC. TACs are limited to a 20% change.
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Short-listed CMPs

- (very) long list pared down using approved culling process
- Five CMP types
  - One model-based
  - Four empirical
- Three tunings for each CMP
  - a = 51% PGKshort (years 1 – 10)
  - b = 60% PGKshort
  - c = 70% PGKshort
- All meet minimum standards / risk tolerances set by Panel 4

Empirical CMPs

- CE
  - Increases/decreases in the North Atlantic Combined Index (NACI) scale the exploitation rate relative to the 2016 to 2020 historical period
  - Exploitation = ratio of catch over smoothed index values
  - 25% limit on TAC change between management cycles

- FX4
  - Scales the TAC based on increases/decreases in a smoothed NACI
  - Stepped change in TAC (10 levels)
  - No cap on change in TAC between cycles

Empirical CMPs

- MCC5
  - Compares recent 3-year average NACI to historical 3-year average (2017-2019)
  - Smoother applied to NACI
  - The value of the ratio determines whether TAC is:
    - Maintained, or
    - Increased by 20%, or
    - Decreased by either 25% or 50%

- MCC7
  - Same as MCC5 but with more (7) increase/decrease steps

Model based CMP

- SPSSFox
  - Surplus production model
  - Data inputs: NACI; landings
  - TAC change is scaled based on estimated stock biomass relative to biomass at MSY
  - 25% limit on TAC change between management cycles

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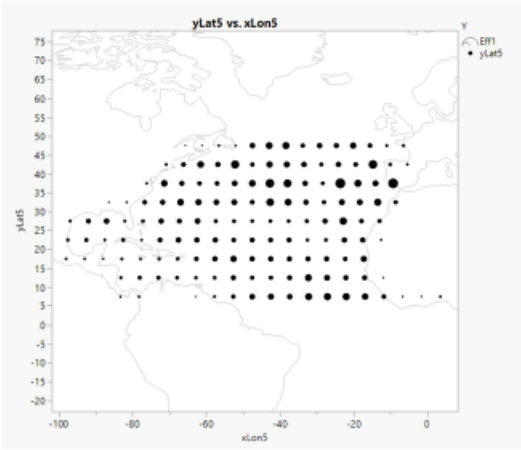
CMP summary

	CE	FX4	MCC5	MCC7	SPSSFox
Type	Empirical	Empirical	Empirical	Empirical	Model
TAC change cap	+/-25%	No cap (built-in stability rules)	No cap (built-in stability rules)	No cap (built-in stability rules)	+/-25%
Steps	NA	10	4	7	NA
Minimum TAC	0.1*reference historical exploitation	75% of base TAC (~8800 t – 9650 t)	4000 t	50% of base TAC (~5000 t – 5500 t)	0.1*E_{MSY}
Reference period	5 most recent data years	Most recent 30 years	2017 – 2019	2017 – 2019	N/A

Rejected CMPs

- CMPs that used CPC generated CPUEs
- CMPs not meeting minimum standards for LRP or PGK
- Dominated CMPs



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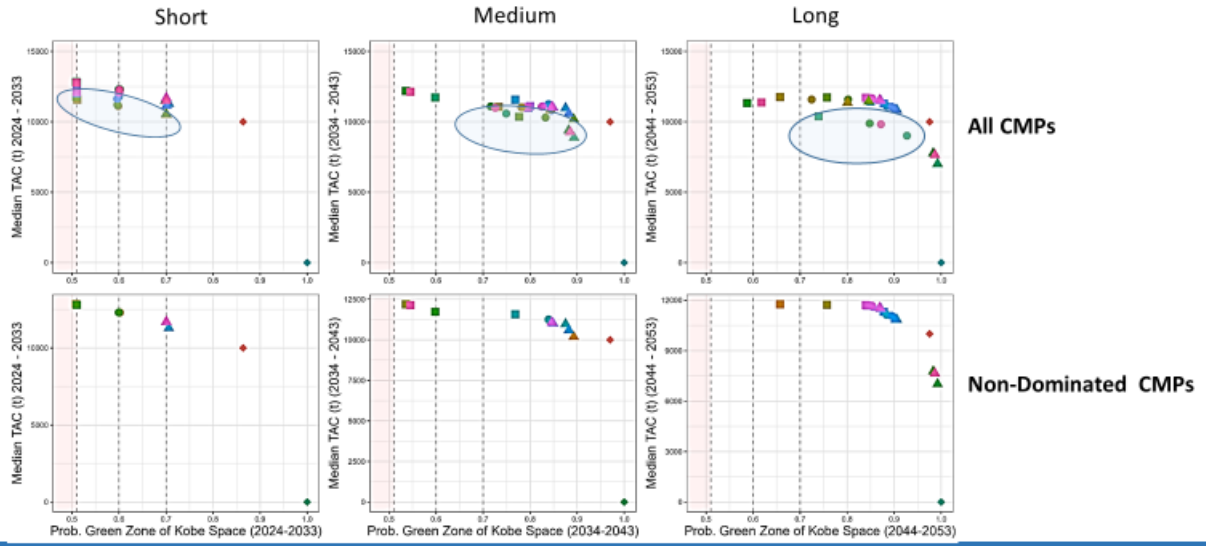
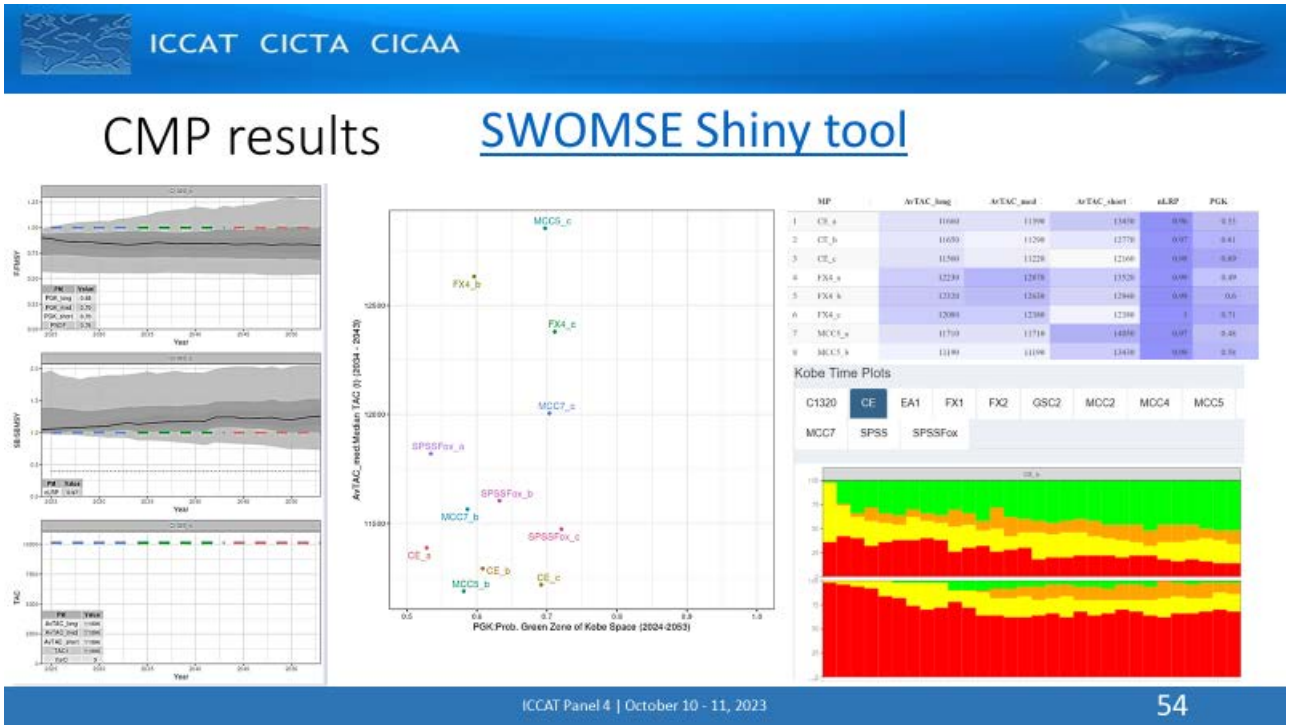
Dominated CMPs: worse performance with respect to multiple PMs



All CMPs

Non-Dominated CMPs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CMP results
SWOMSE Shiny tool
MCC5_c
FX4_b
FX4_c
MCC7_c
SPSSFox_a
SPSSFox_b
MCC7_b
SPSSFox_c
CE_a
CE_b
CE_c
MCC5_b
PGK:Prob. Green Zone of Kobe Space (2024-2053)
Kobe Time Plots
C1320
CE
EA1
FX1
FX2
GSC2
MCC2
MCC4
MCC5
MCC7
SPS5
SPSSFox
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CMP results – quilt plot

	MP	AvTAC_long	AvTAC_med	AvTAC_short	nLRP	PGK	PGK_med	PGK_short	PNOF	TAC1	VarC
1	CE_a	11660	11390	13450	0.96	0.53	0.51	0.51	0.68	13460	0.16
2	CE_b	11650	11290	12770	0.97	0.61	0.59	0.6	0.74	12860	0.15
3	CE_c	11560	11220	12160	0.98	0.69	0.68	0.7	0.79	12250	0.15
4	FX4_a	12230	12870	13520	0.99	0.49	0.47	0.51	0.61	13520	0.1
5	FX4_b	12320	12630	12940	0.99	0.6	0.57	0.6	0.71	12940	0.1
6	FX4_c	12080	12380	12380	1	0.71	0.7	0.7	0.82	12380	0.1
7	MCC5_a	11710	11710	14050	0.97	0.48	0.47	0.51	0.57	14050	0.06
8	MCC5_b	11190	11190	13430	0.99	0.58	0.56	0.6	0.68	13430	0.06
9	MCC5_c	12850	12850	12850	1	0.7	0.68	0.7	0.8	12850	0.06
10	MCC7_a	11030	11030	13780	0.99	0.49	0.48	0.51	0.61	13780	0.09
11	MCC7_b	11560	11560	13140	1	0.59	0.57	0.6	0.71	13140	0.09
12	MCC7_c	12510	12010	12510	1	0.7	0.69	0.7	0.81	12510	0.09
13	SPSSFox_a	11790	11820	13460	0.97	0.53	0.51	0.51	0.67	13460	0.17
14	SPSSFox_b	11680	11600	12750	0.99	0.63	0.62	0.6	0.75	13290	0.16
15	SPSSFox_c	11570	11470	12190	1	0.72	0.7	0.7	0.82	12520	0.15

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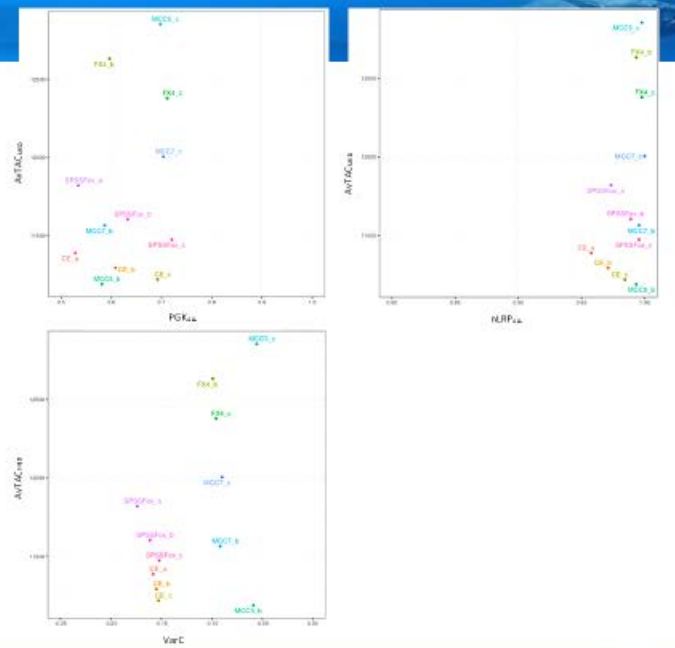
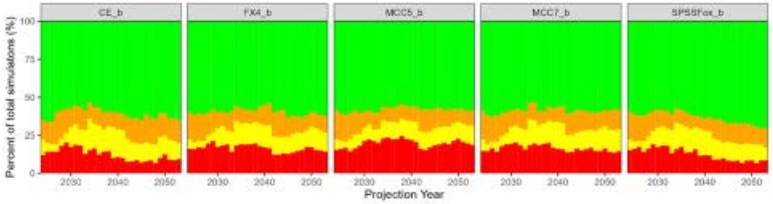
Trade-offs

- Tradeoffs among status, safety, stability, yield



Kobe time plots



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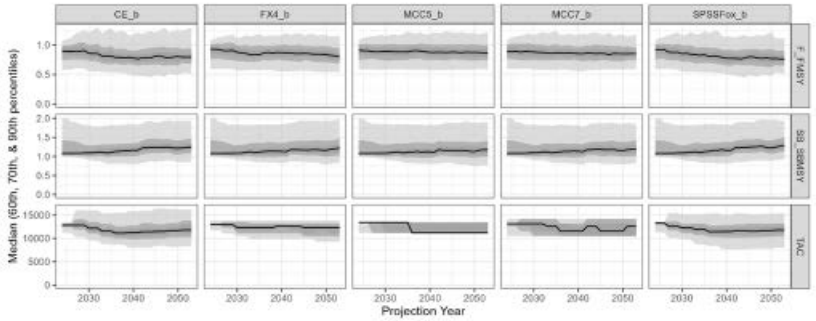
Trajectory plots



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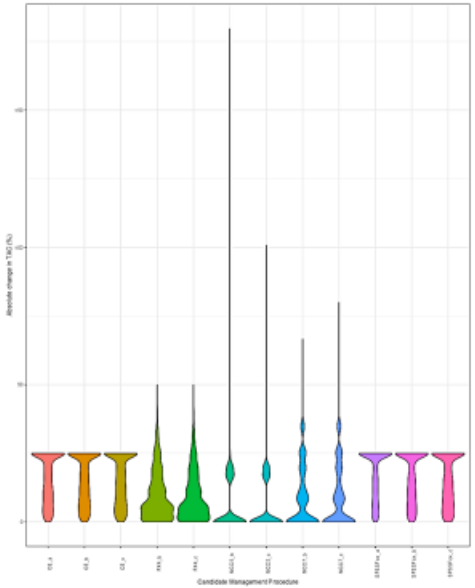
Violin plots

- Variability in TAC between management cycles



CMP results demonstration

Agenda

7. Robustness tests
8. Key decisions anticipated to be taken by PA4
   - Selection of recommended Management Procedures (MPs)
     a. Final operational management objectives
     b. Final MP type
     c. Final MP specifications
        i. Management cycle
        ii. Minimum TAC change
     d. MP implementation schedule
9. Development of a management measure

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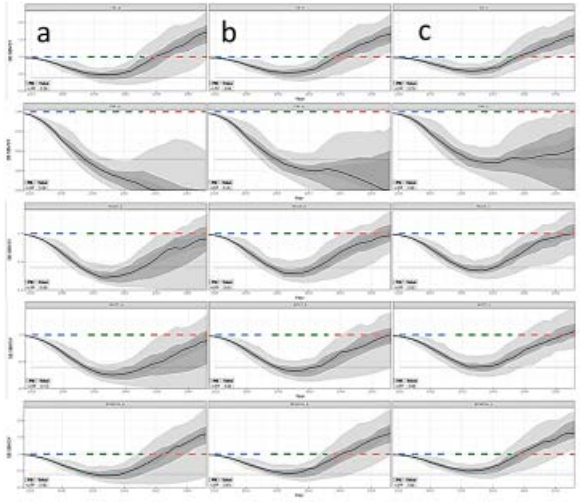
Robustness tests

- Plausible but less likely scenarios / stress tests for CMPs

Test name	*Category*	*Description*
R1	Catchability	1 percent annual increase catchability, that is not accounted for in the standardization of the indices of abundance (historical & projection)
R2	Catchability	1 percent annual increase catchability, that is not accounted for in the standardization of the indices of abundance (historical only)
R3a	Climate Change	Climate Change impacts on recruitment deviations (positive and negative)
R3b	Climate Change	Climate Change impacts on recruitment deviations (negative)
R4	Implementation error	10% overage in TAC due to IUU
R5	Size limit	Test effect of removal of minimum size limit
Additional tests	TAC change minimum threshold	Test performance of CMPs when no TAC change if TAC update is <200 t difference
	Management cycle	Compare effect of 3 year vs 4 year MP implementation length

Robustness scenarios (3b as an example)



R5 Size limit

- Undersized discards are all retained, eliminating an additional source of mortality

- Confounding factor:
  - Fleet dynamics
    - Movement
    - Timing
  - Non-stationarity in selectivity

- Additional work needed

CMP robustness testing

Agenda

7. Robustness tests
8. Key decisions anticipated to be taken by PA4
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Possible MSE implementation schedule

		Activity					*Data inputs*	
Year	Management cycle	MP run	MP advice implemented	Stock assessment	MSE Review	Exceptional circumstances evaluated	Combined index	Exceptional circumstance indicators
2023		x					x	
2024	1		x			x		x
2025	1					x		x
2026	1	x				x	x	x
2027	2		x			x		x
2028	2			x (alternative)		x		x
2029	2	x		x		x	x	x
2030	3		x	x (alternative)		x		x
2031	3					x		x
2032	3	x			x	x	x	x

Agenda

7. Robustness tests
8. Key decisions anticipated to be taken by PA4
- Selection of recommended Management Procedures (MPs)
  a. Final operational management objectives
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  c. Final MP specifications
     i. Management cycle
     ii. Minimum TAC change
  d. MP implementation schedule
9. Development of a management measure

MSE details in a management measure

- Operationalized management objectives

- The chosen MP
  - TAC formulas, relevant reference points and reference time periods
  - harvest control rule (if applicable)
  - management cycle length and implementation schedule
  - minimum TAC change threshold
  - exceptional circumstances protocol*

- Additional work required of the SCRS

Other considerations

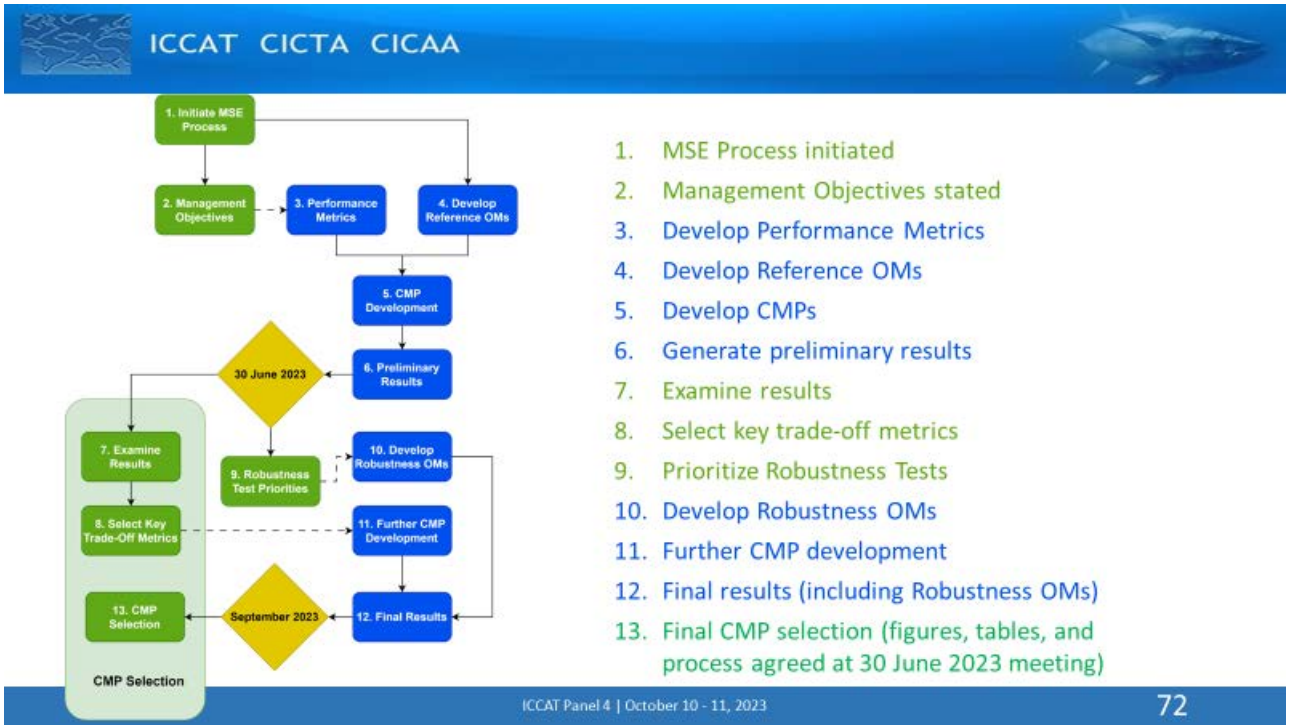
- Climate change
  - CMP performance over longer time scales
  - Variability in biological and environmental parameters
  - Spatial shifts: estimates of abundance, selectivity
  - MSE review periods

- Discarding estimates and reporting

SCRS/PA4 work to continue in 2024

- Exceptional circumstances protocol (see examples from ALB and BFT)

- Additional robustness tests
  - Climate Change (additional tests e.g., distribution, productivity, fleet dynamics)
  - Size limit additional testing (selectivity changes)
  - Lower steepness (0.6)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1. Initiate MSE Process
2. Management Objectives
3. Performance Metrics
4. Develop Reference OMs
5. CMP Development
6. Preliminary Results
30 June 2023
7. Examine Results
8. Select Key Trade-Off Metrics
9. Robustness Test Priorities
10. Develop Robustness OMs
11. Further CMP Development
12. Final Results
September 2023
13. CMP Selection
CMP Selection
1. MSE Process initiated
2. Management Objectives stated
3. Develop Performance Metrics
4. Develop Reference OMs
5. Develop CMPs
6. Generate preliminary results
7. Examine results
8. Select key trade-off metrics
9. Prioritize Robustness Tests
10. Develop Robustness OMs
11. Further CMP development
12. Final results (including Robustness OMs)
13. Final CMP selection (figures, tables, and process agreed at 30 June 2023 meeting)
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Summary

- Final CMP results are available
- Panel 4 is scheduled to select a MP to generate TAC in 2024+
- A variety of CMPs are available, all meeting management objectives
- Interactive website available to weigh trade-offs

Acknowledgements

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The SWO Species Group Coordinator would like to acknowledge the work of the SWO MSE technical team. This dedicated team has worked exceptionally hard to produce this analysis and the content in this presentation