THIRD INTERSESSIONAL MEETING OF PANEL 4 ON NORTH ATLANTIC SWORDFISH MSE

10 – 11 October 2023

Resources: **Swordfish MSE website**

Swordfish MSE results

ICCAT CICTA CICAA

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

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

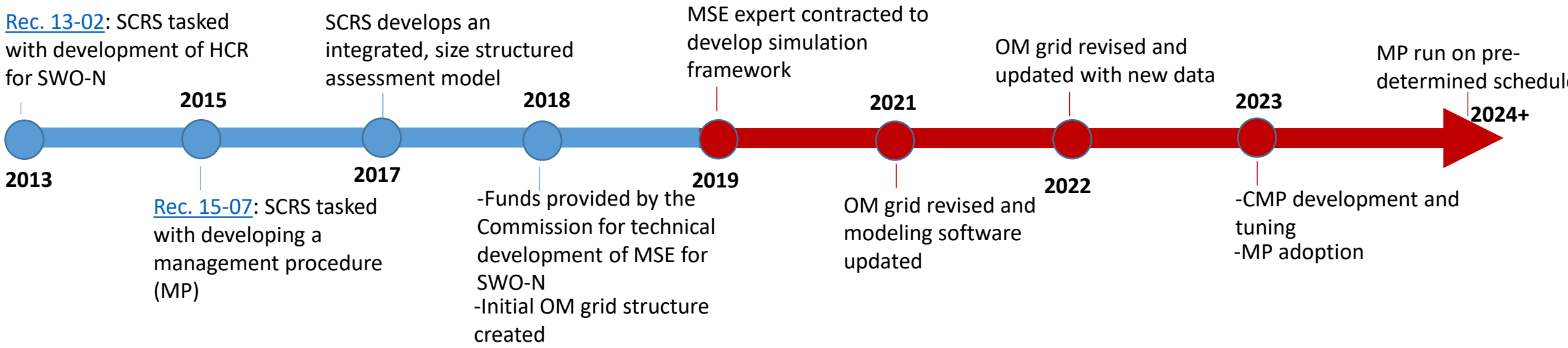
Agenda

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

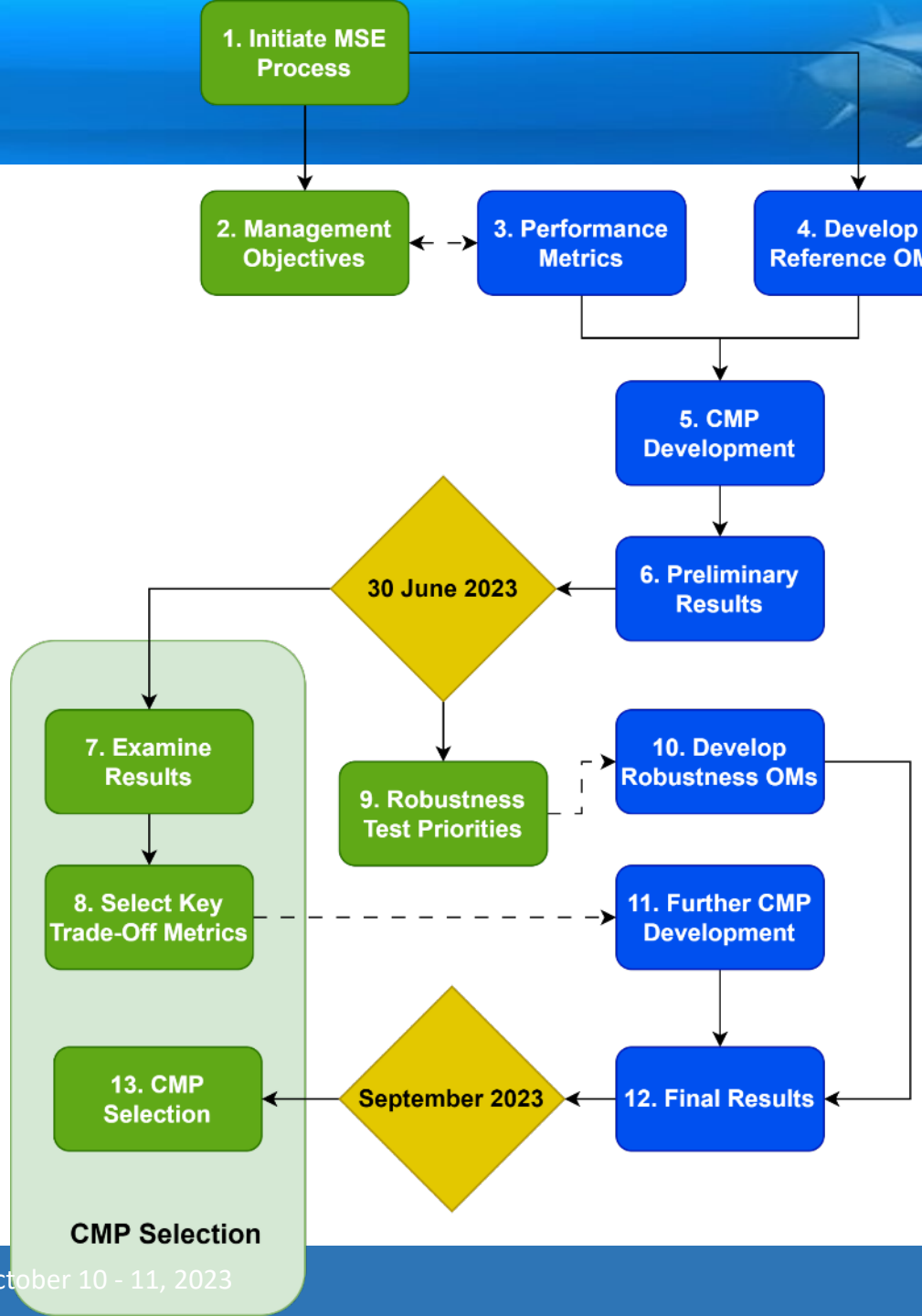
SWO-N MSE development



MSE Process: Selection of Management Procedure (MP)

Managers

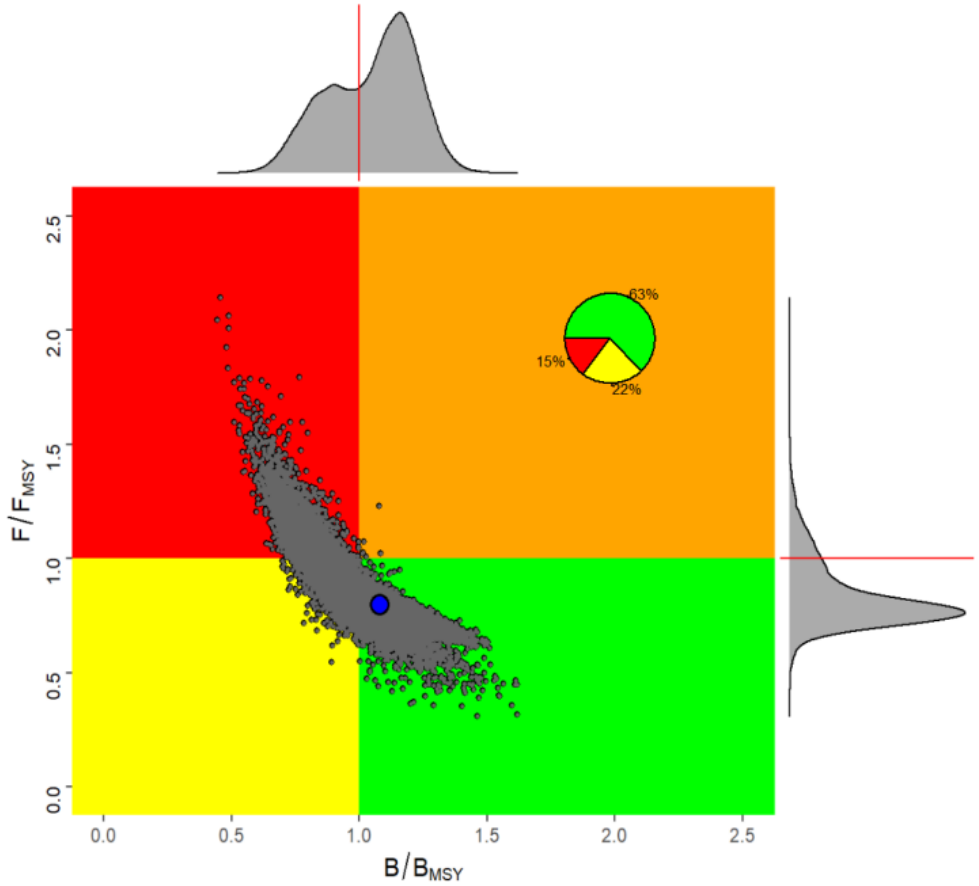
Science



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

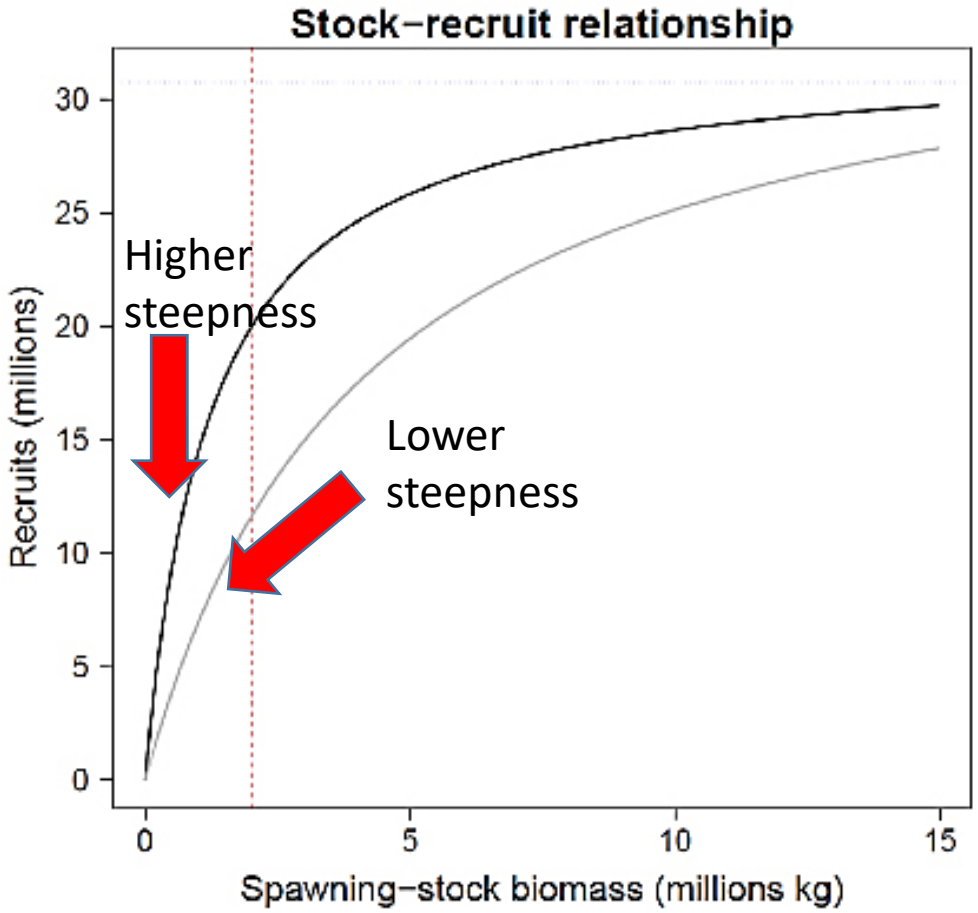
Variable	*Stock assessment base case model*	*Operating model grid*		
Steepness	0.88	0.69	0.8	0.88
Natural mortality	0.2	0.1	0.2	0.3

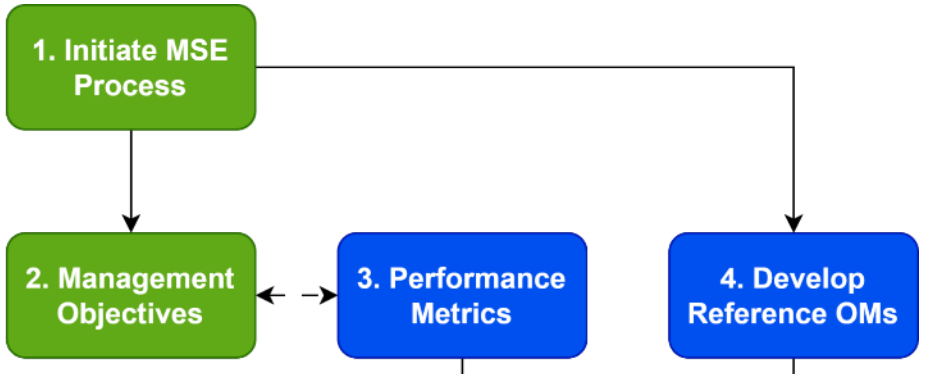
Operating model grid

- Core uncertainty: stock productivity

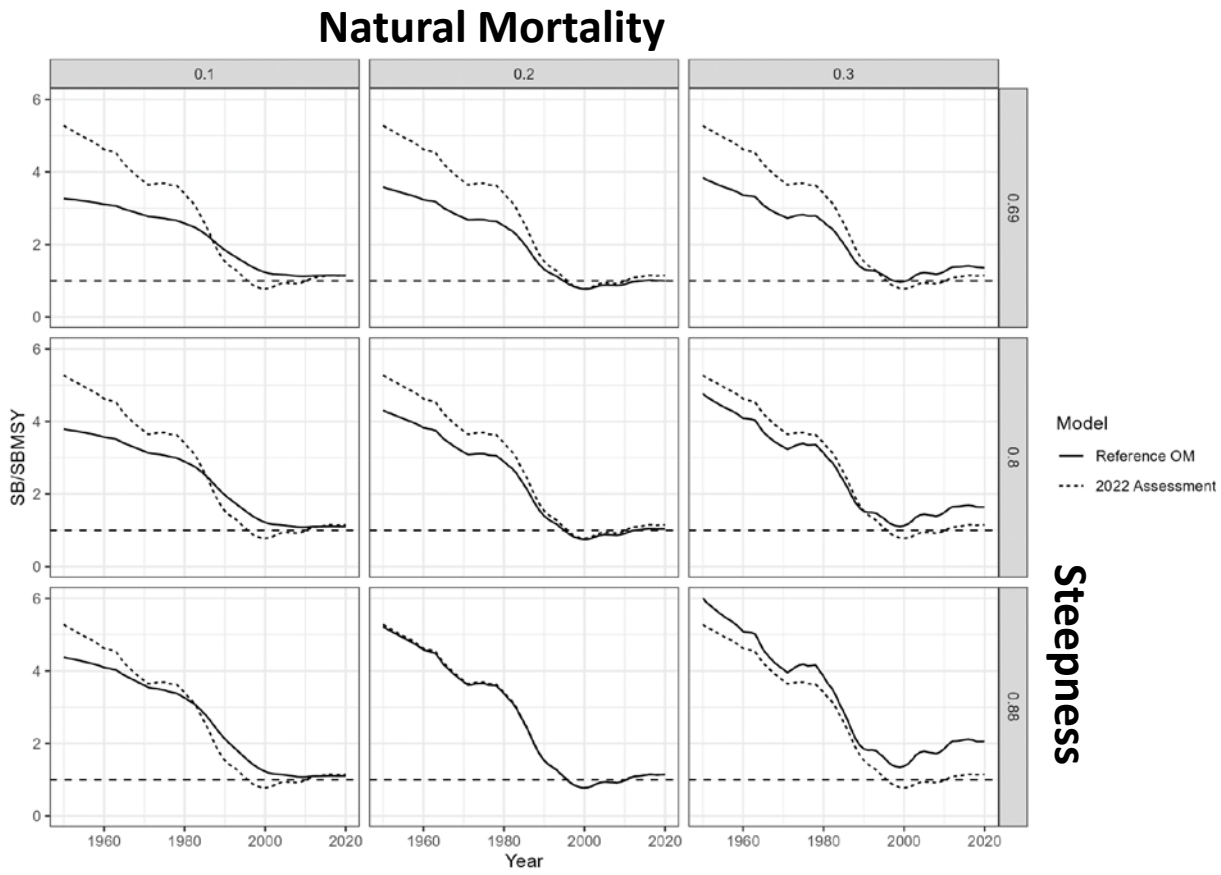
  - Ability to recovery from low abundance levels

  - Natural mortality (death rate in the population)





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

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

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
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1. Safety

   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

   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)

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)

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

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

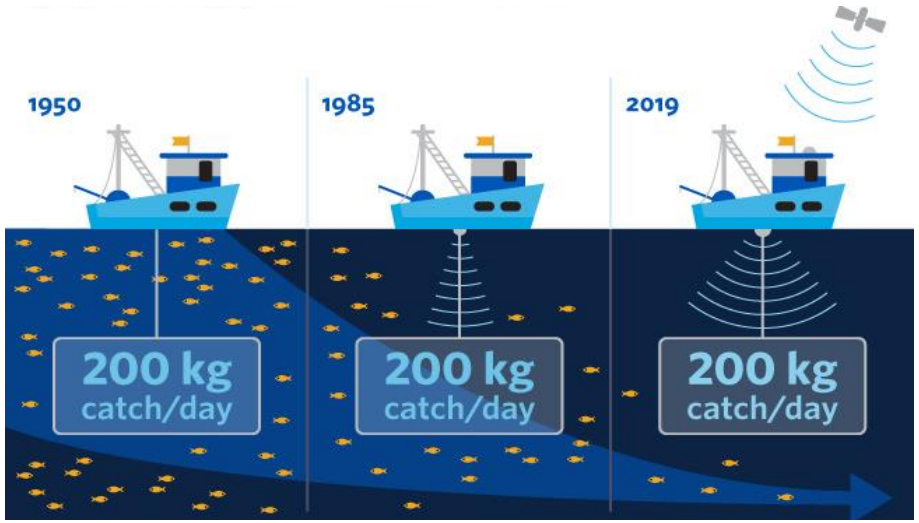
Robustness tests

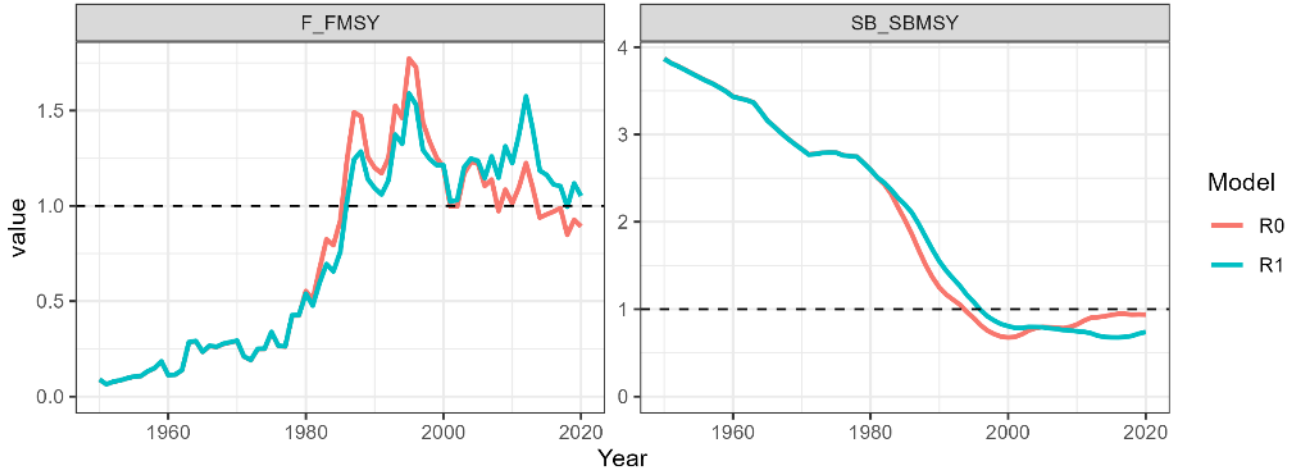
- Plausible but less likely scenarios / stress tests for CMPs

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

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





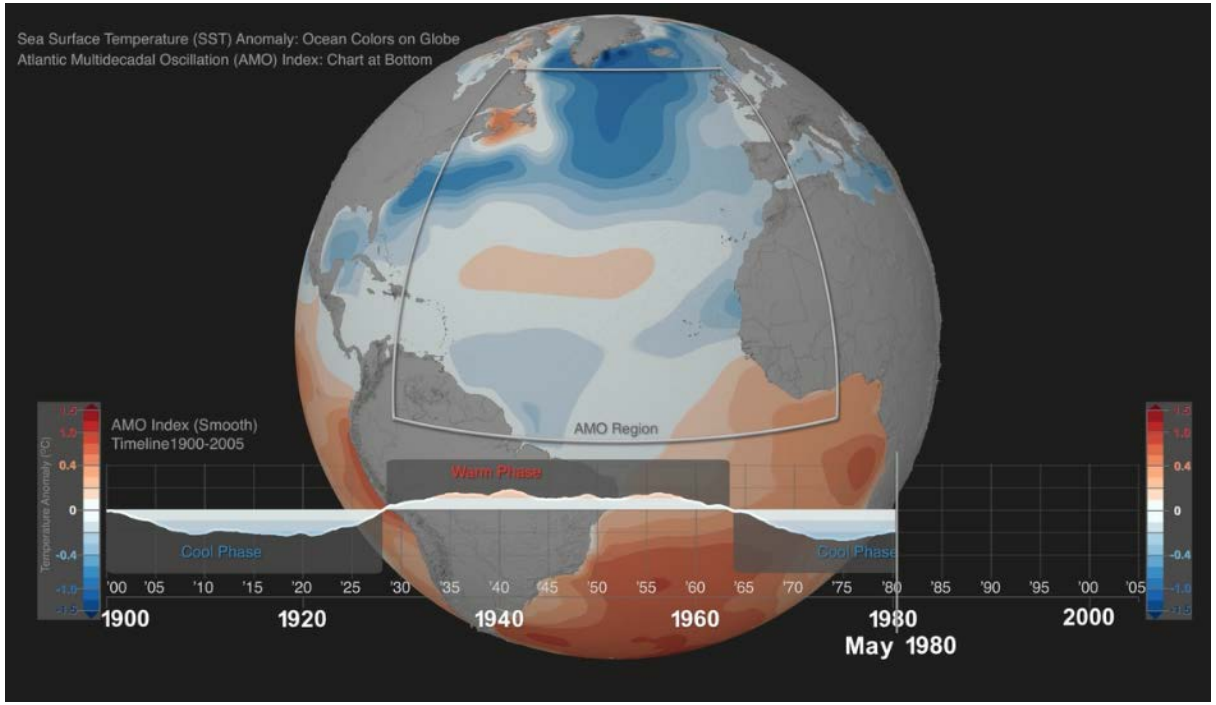
R3 – Climate change

- 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

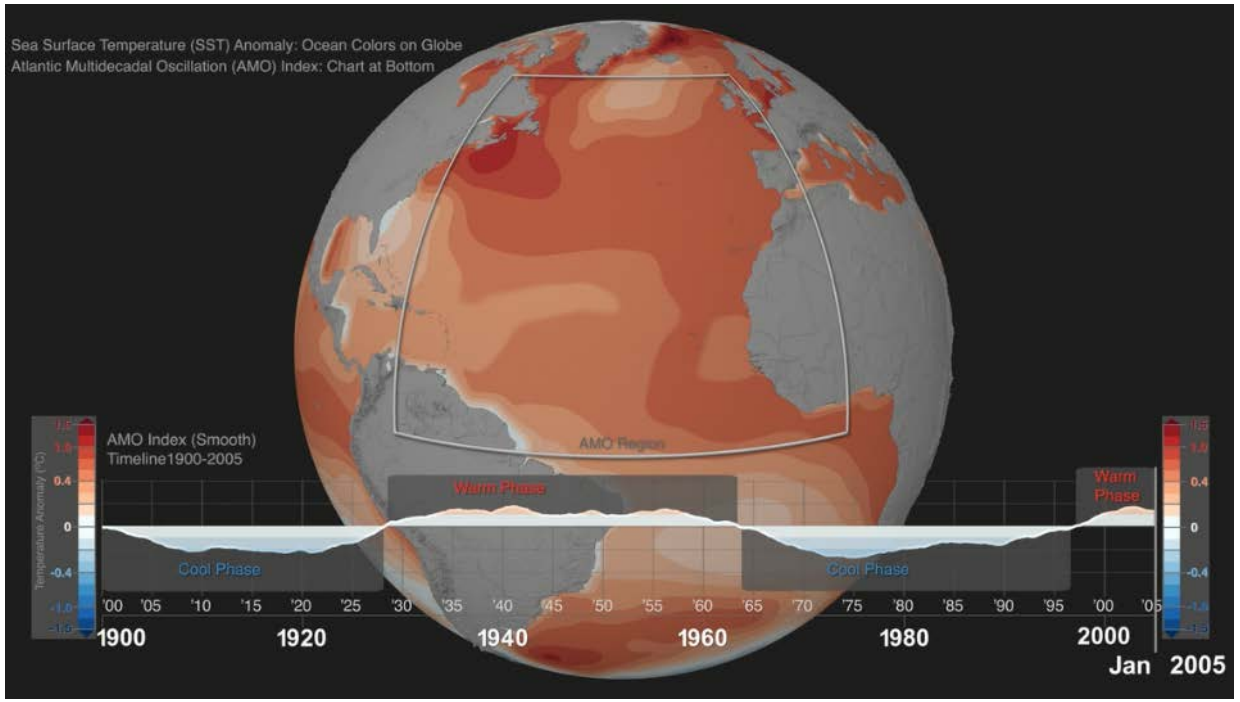
Atlantic Multidecadal Oscillation (AMO)

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

1980

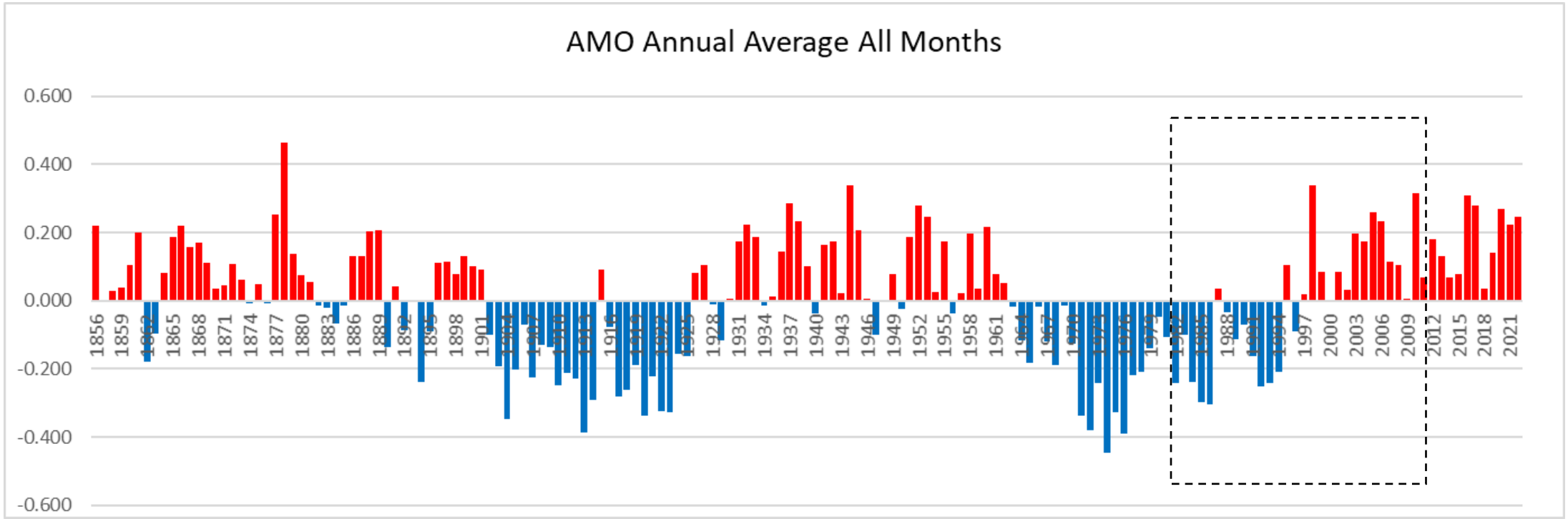


2005



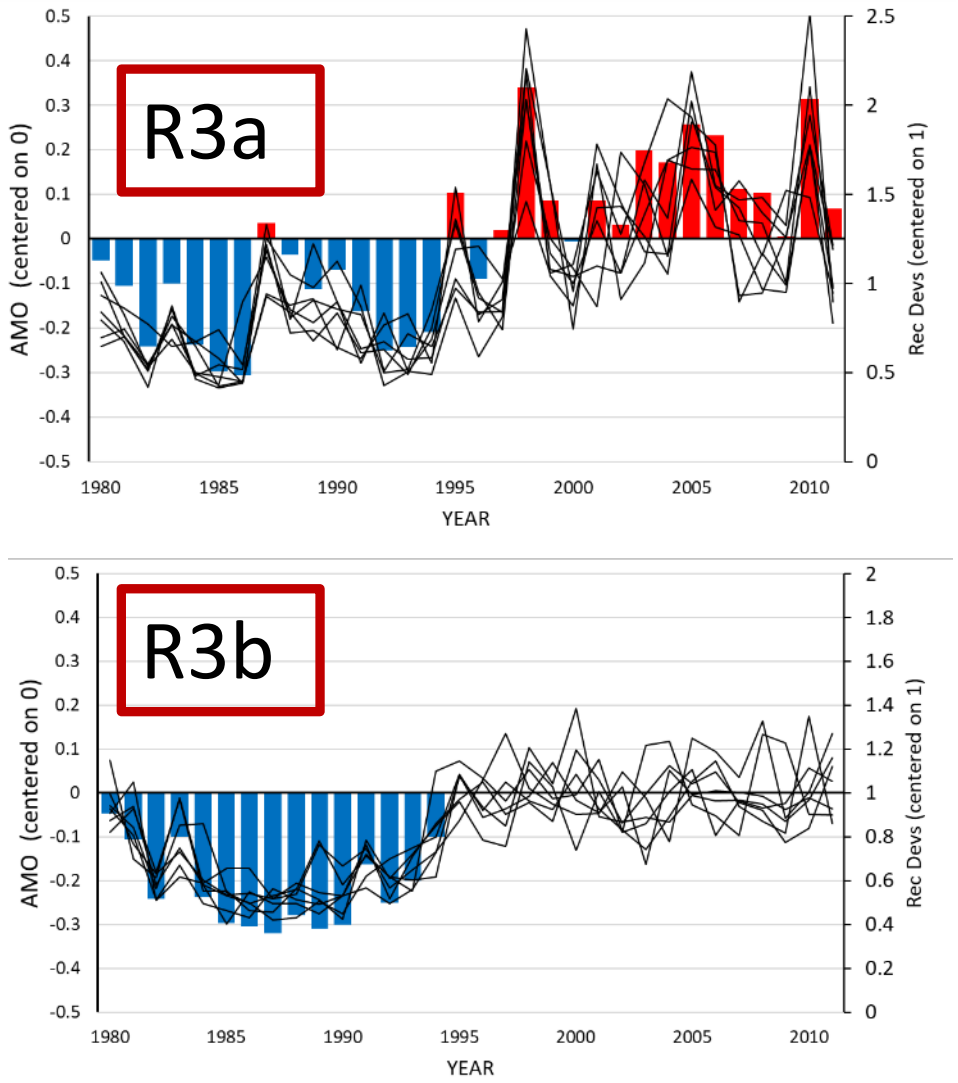
Atlantic Multidecadal Oscillation (AMO)

- 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).

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**

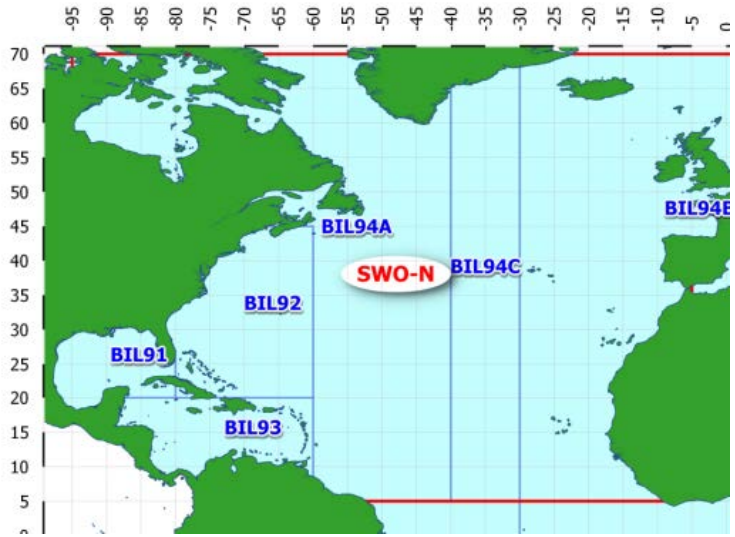
-Index ratio decision rule sets TAC

- **Model based**

-Assessment model output sets TAC

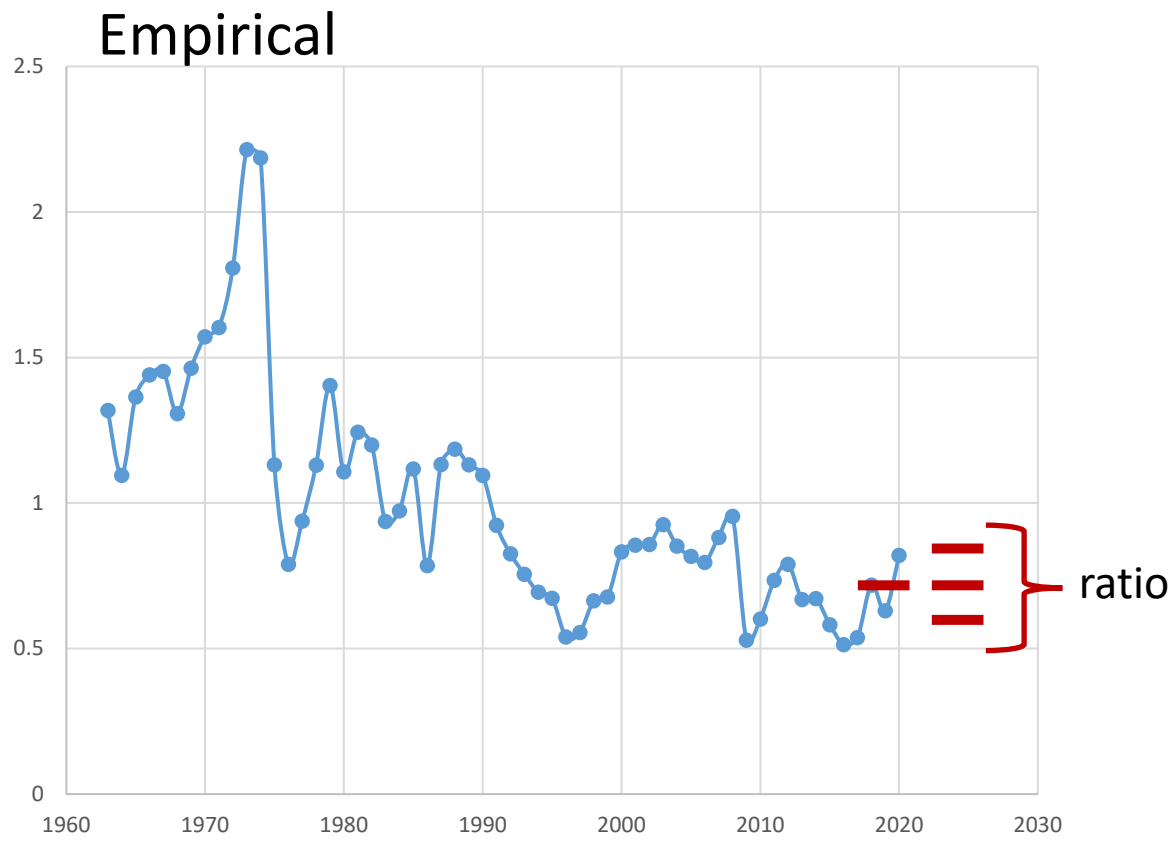
TAC

Whole of ATL-N



CMP development

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



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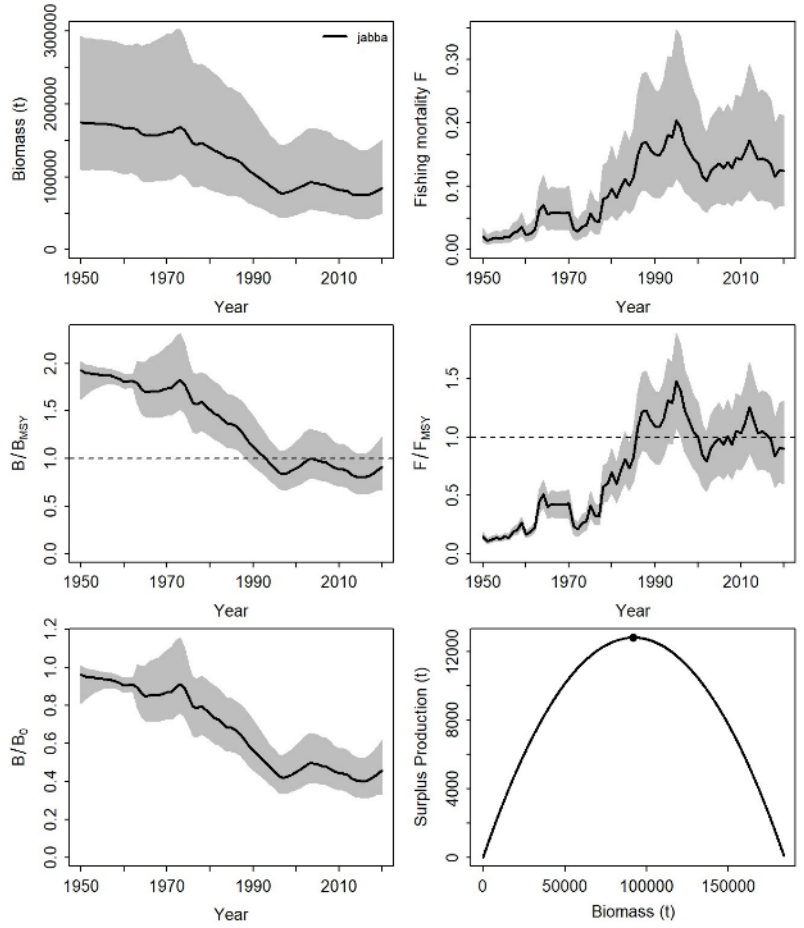
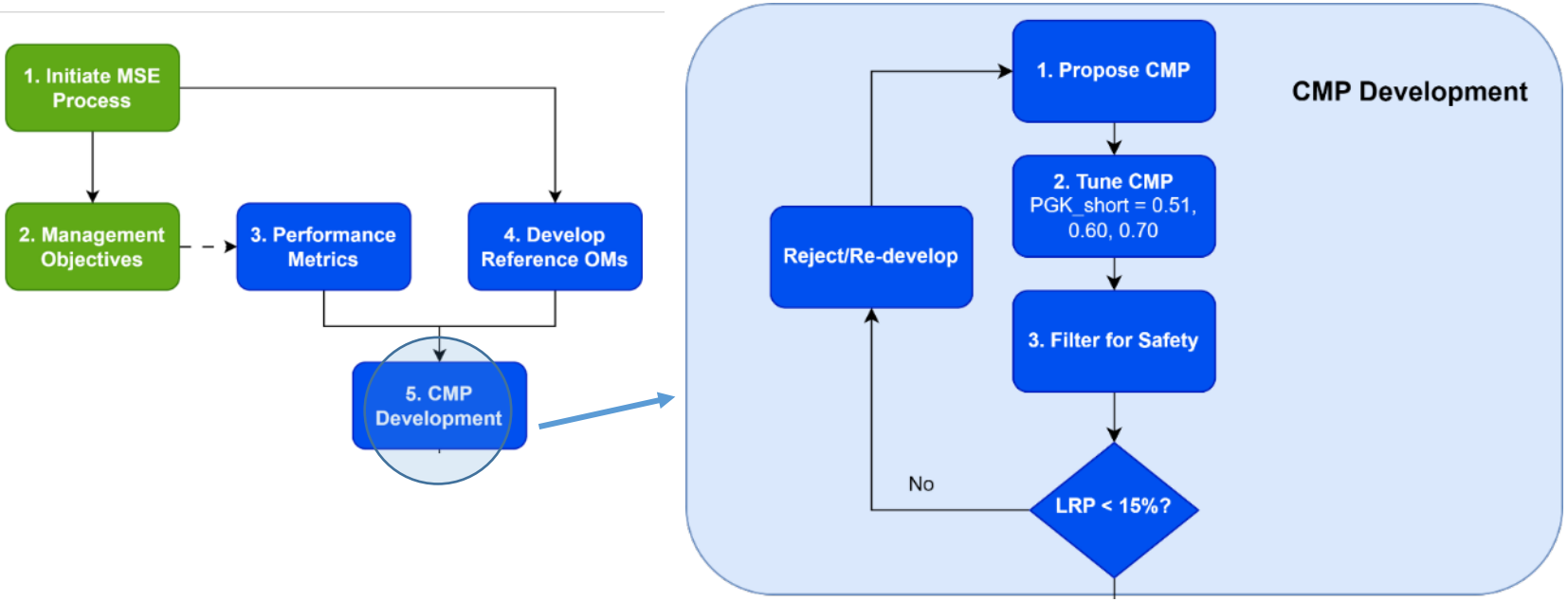
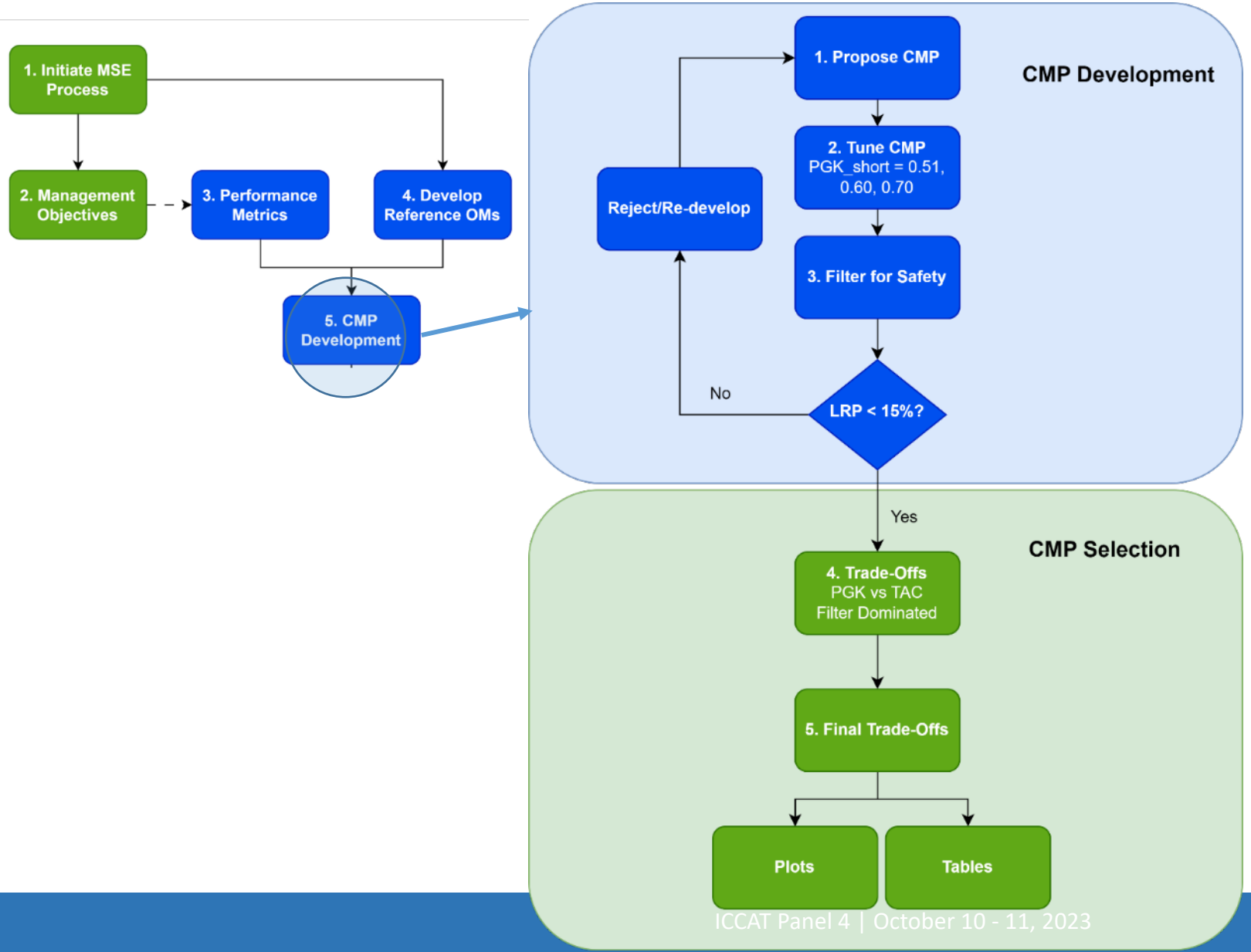
- Empirical and model-based approaches

Model-based



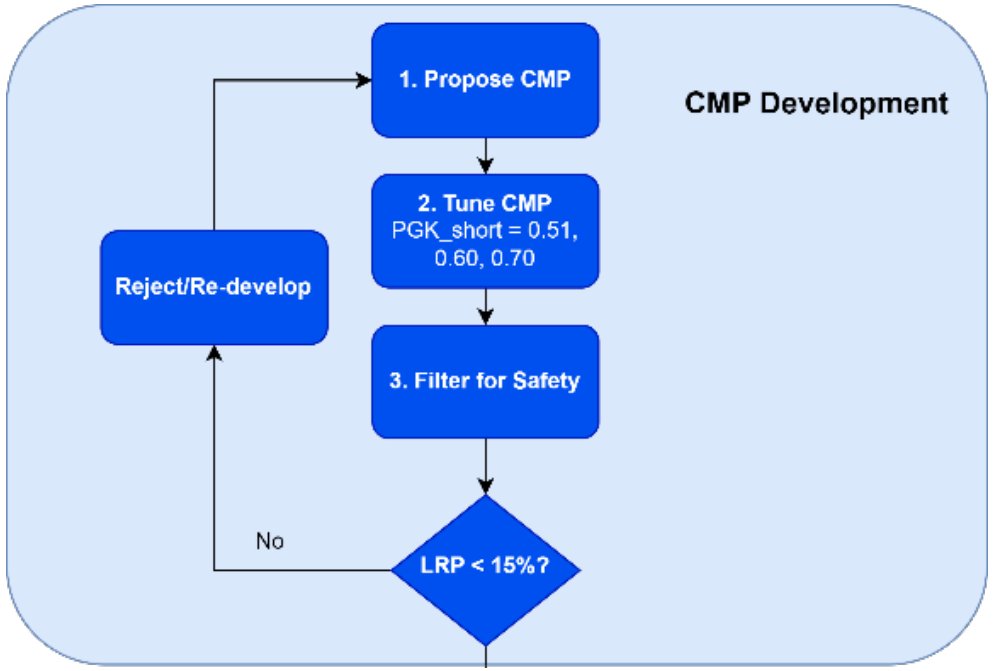


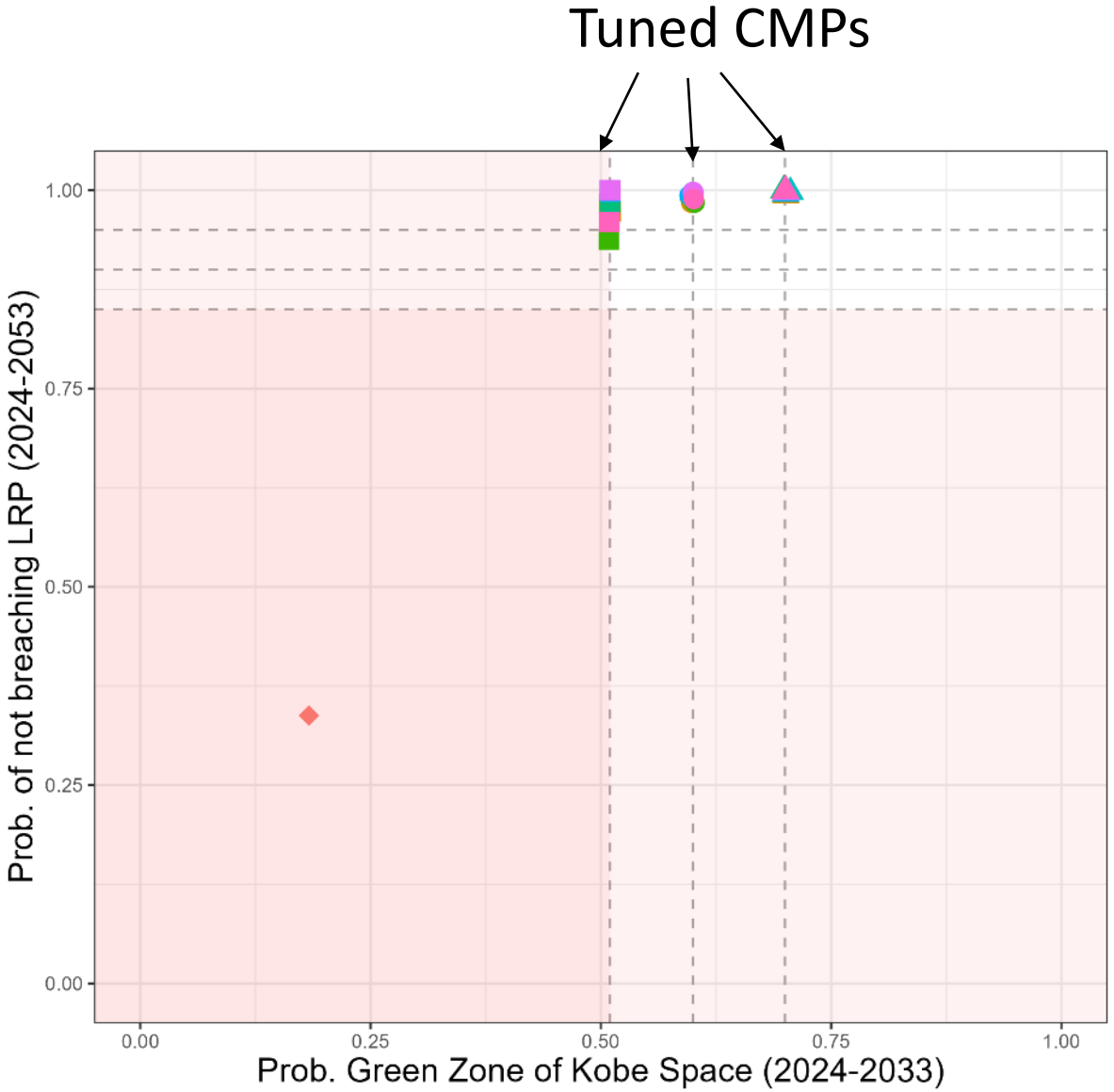
1. Propose CMP
2. Tune CMP to PGK_short: 51, 60, 70%
3. Filter for Safety: LRP ≤ 15%



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

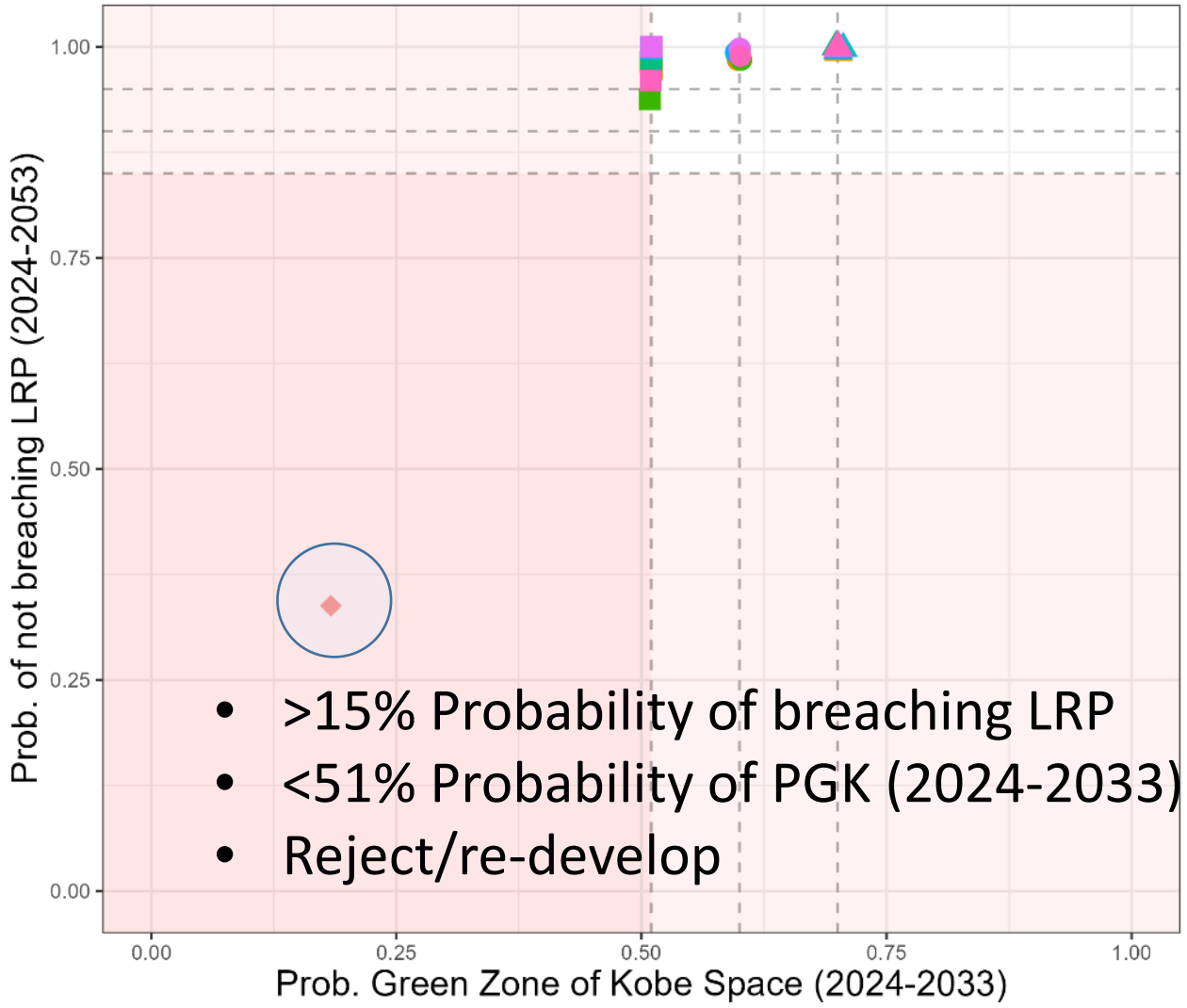
Tune CMP to PGK_short: 51, 60, 70%





Filter for Safety: LRP ≤ 15%

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



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.

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

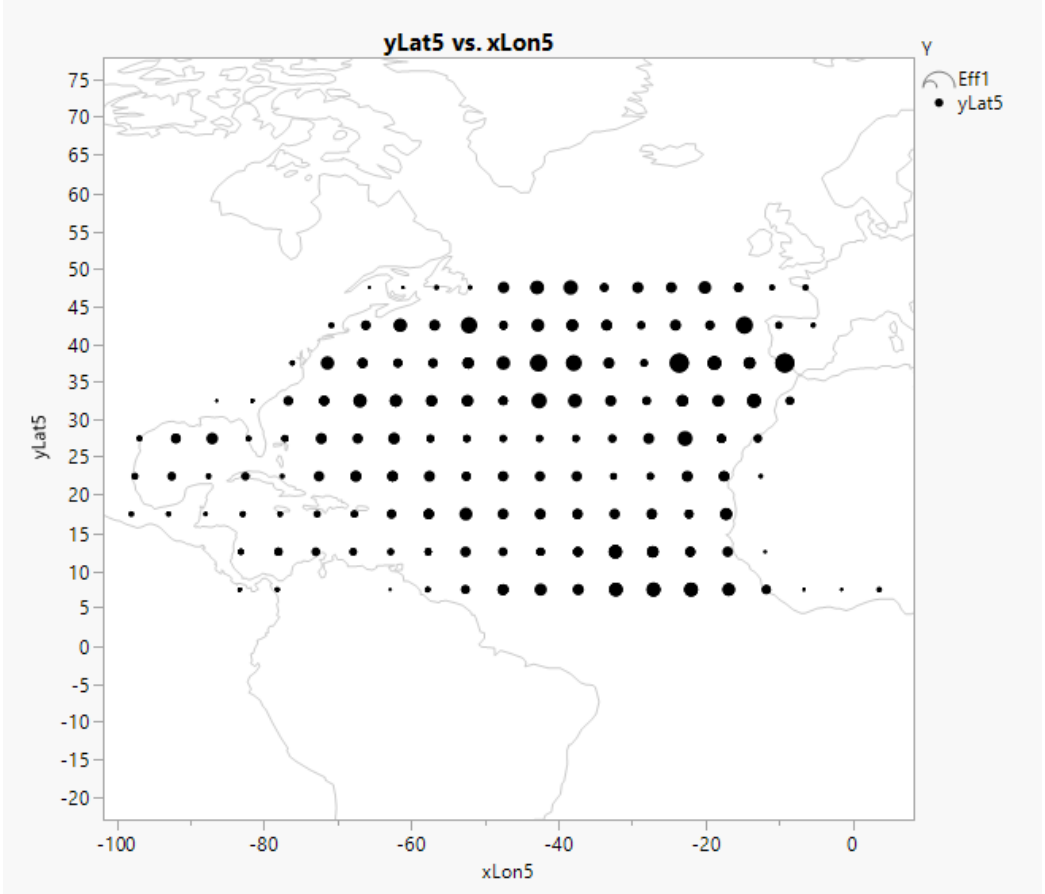
- SPSSFox
  - Surplus production model
  - Data inputs: NACI; landings
  - TAC change is scaled based on estimated stock biomass relative to biomass at MSY
  - 25% limit on TAC change between management cycles

CMP summary

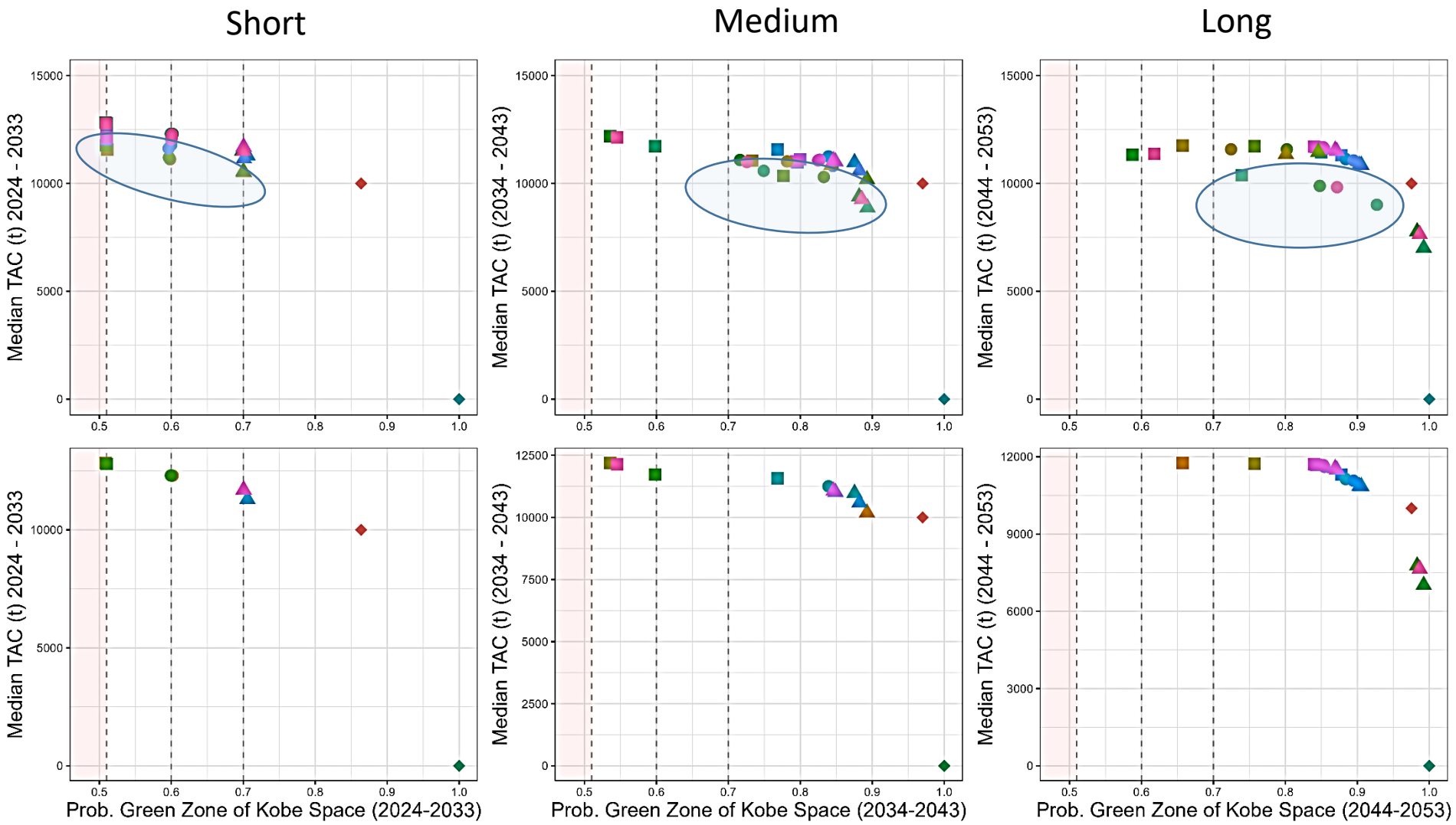
	CE	FX4	MCC5	MCC7	SPSSFox
Type	Empirical	Empirical	Empirical	Empirical	Model
TAC change cap	+/-25%	No cap (built-in stability rules)	No cap (built-in stability rules)	No cap (built-in stability rules)	+/-25%
Steps	NA	10	4	7	NA
Minimum TAC	0.1*reference historical exploitation	75% of base TAC (~8800 t – 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



Dominated CMPs: worse performance with respect to multiple PMs

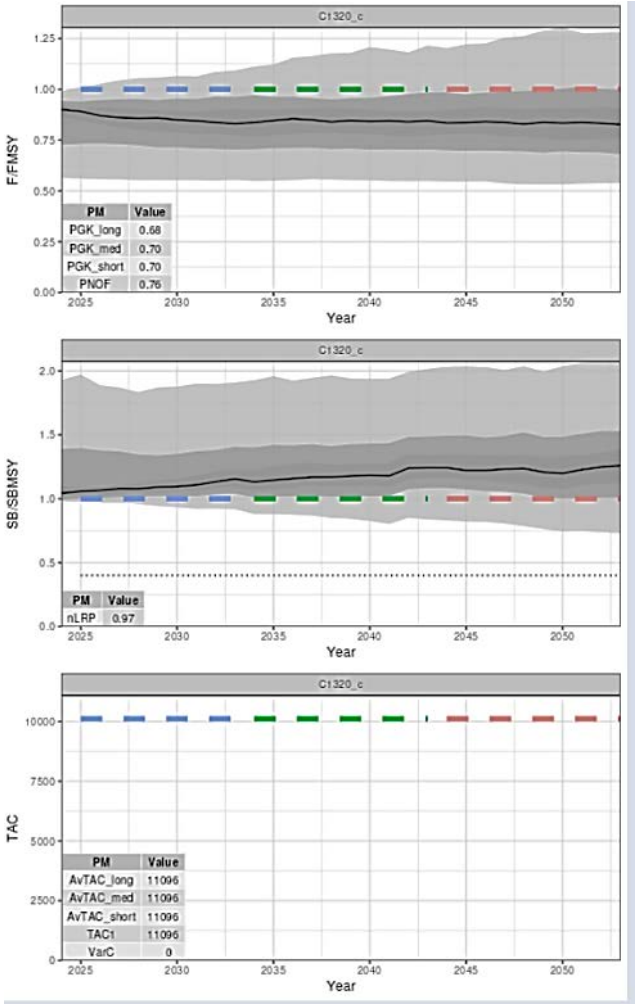


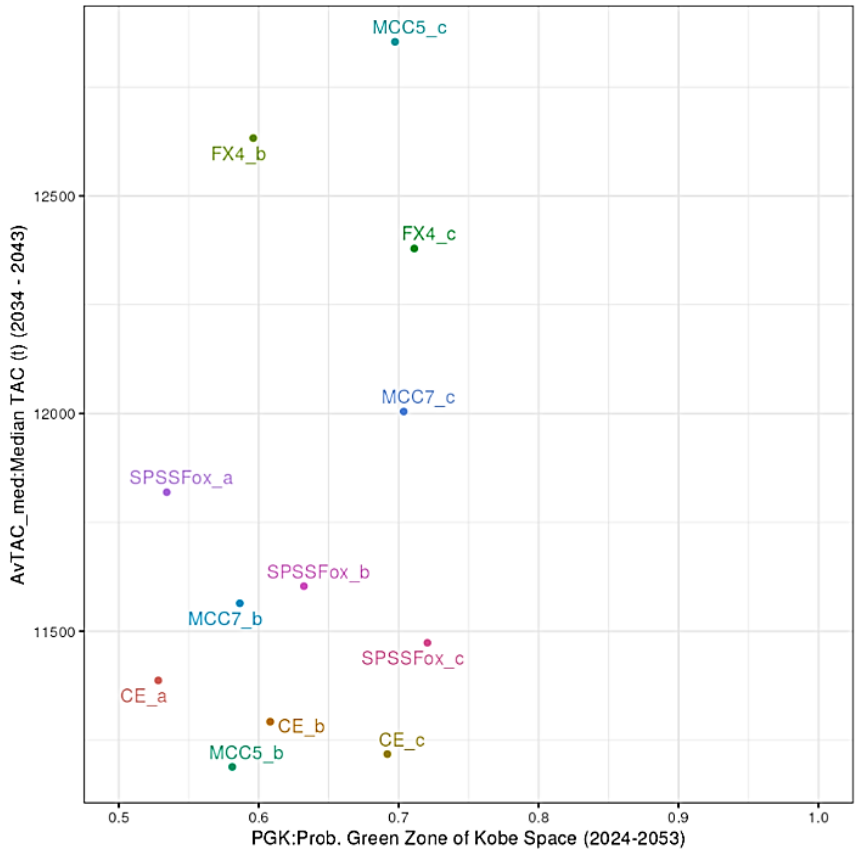
All CMPs

Non-Dominated CMPs

CMP results

SWOMSE Shiny tool

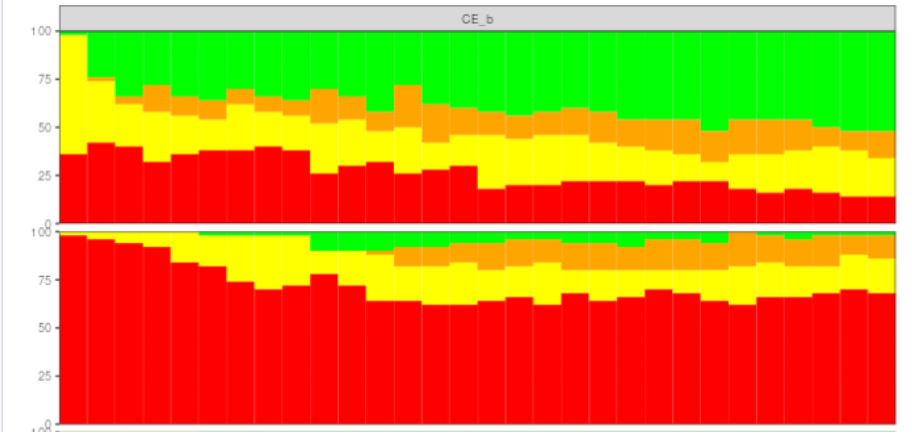




	MP	AvTAC_long	AvTAC_med	AvTAC_short	nLRP	PGK
1	CE_a	11660	11390	13450	0.96	0.53
2	CE_b	11650	11290	12770	0.97	0.61
3	CE_c	11560	11220	12160	0.98	0.69
4	FX4_a	12230	12870	13520	0.99	0.49
5	FX4_b	12320	12630	12940	0.99	0.6
6	FX4_c	12080	12380	12380	1	0.71
7	MCC5_a	11710	11710	14050	0.97	0.48
8	MCC5_b	11190	11190	13430	0.99	0.58

Kobe Time Plots

C1320 | CE | EA1 | FX1 | FX2 | GSC2 | MCC2 | MCC4 | MCC5 | MCC7 | SPSS | SPSSFox

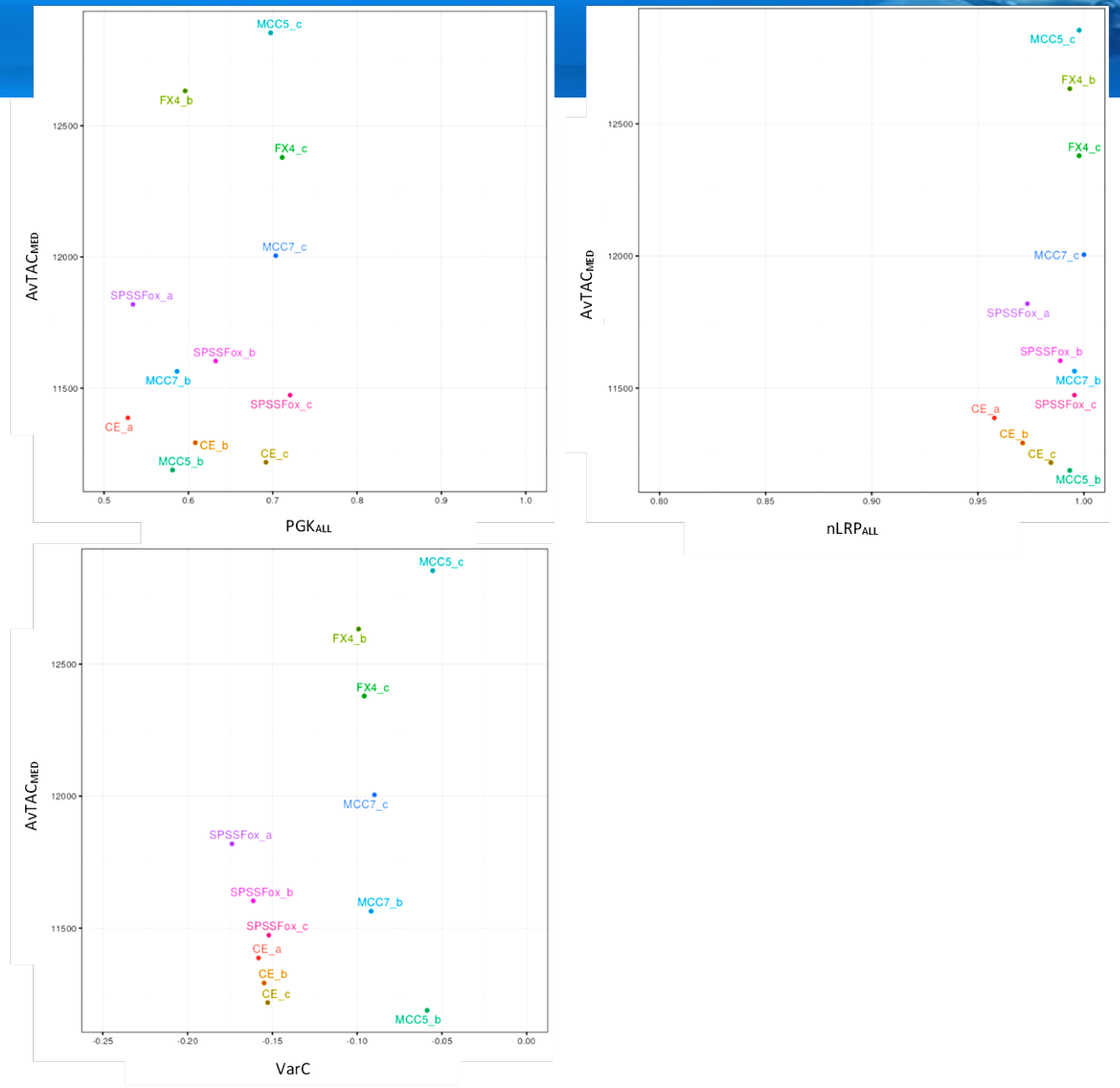


CMP results – quilt plot

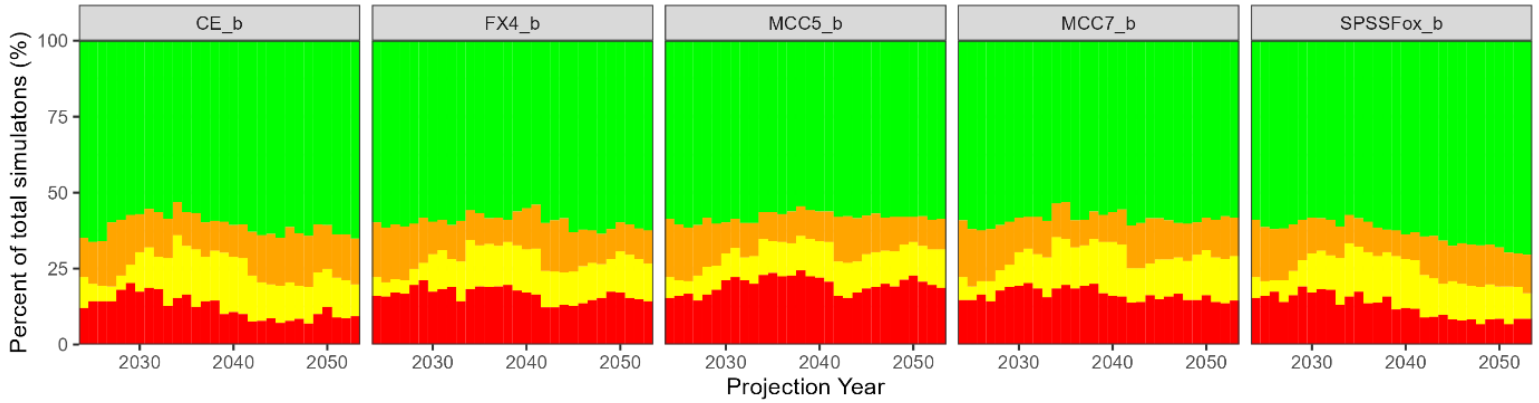
	MP	AvTAC_long	AvTAC_med	AvTAC_short	nLRP	PGK	PGK_med	PGK_short	PNOF	TAC1	VarC
1	CE_a	11660	11390	13450	0.96	0.53	0.51	0.51	0.68	13460	0.16
2	CE_b	11650	11290	12770	0.97	0.61	0.59	0.6	0.74	12860	0.15
3	CE_c	11560	11220	12160	0.98	0.69	0.68	0.7	0.79	12250	0.15
4	FX4_a	12230	12870	13520	0.99	0.49	0.47	0.51	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

Trade-offs

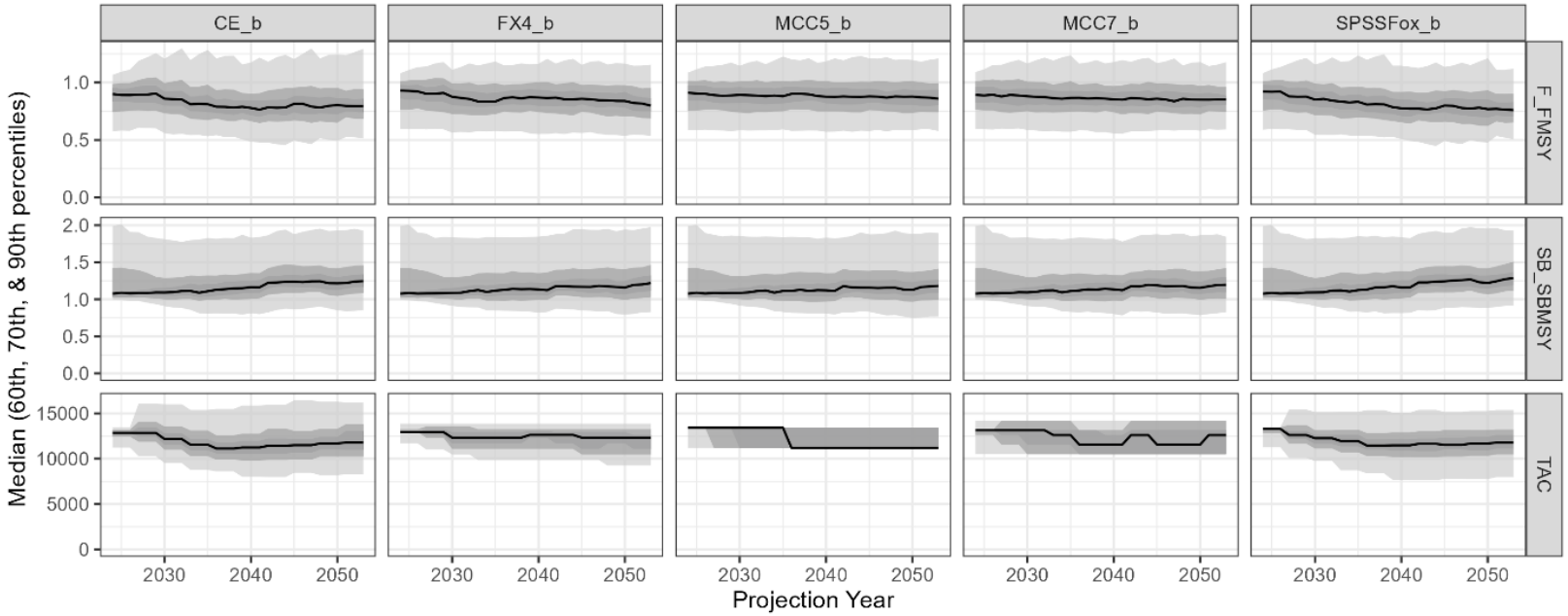
- Tradeoffs among status, safety, stability, yield



Kobe time plots

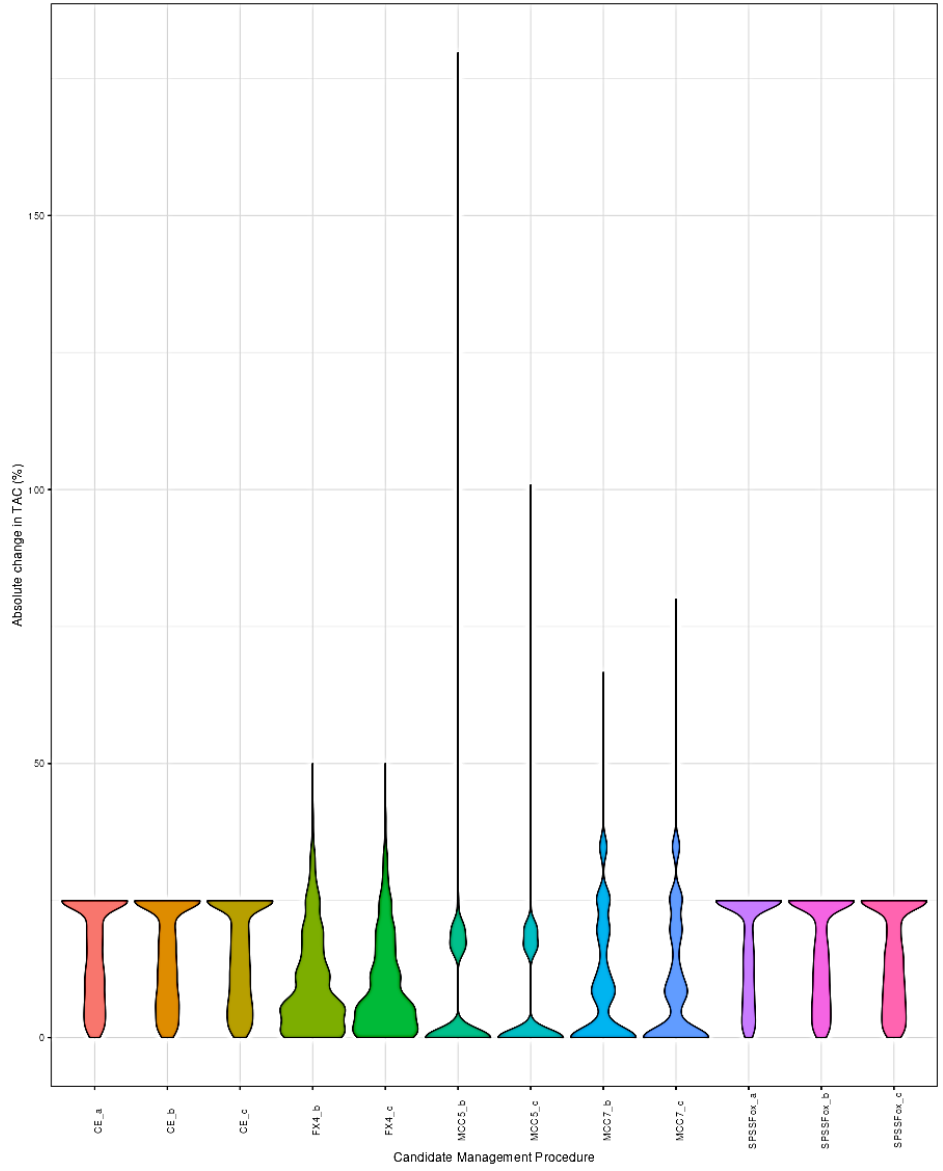


Trajectory plots



Violin plots

- Variability in TAC between management cycles



CMP results demonstration

Agenda

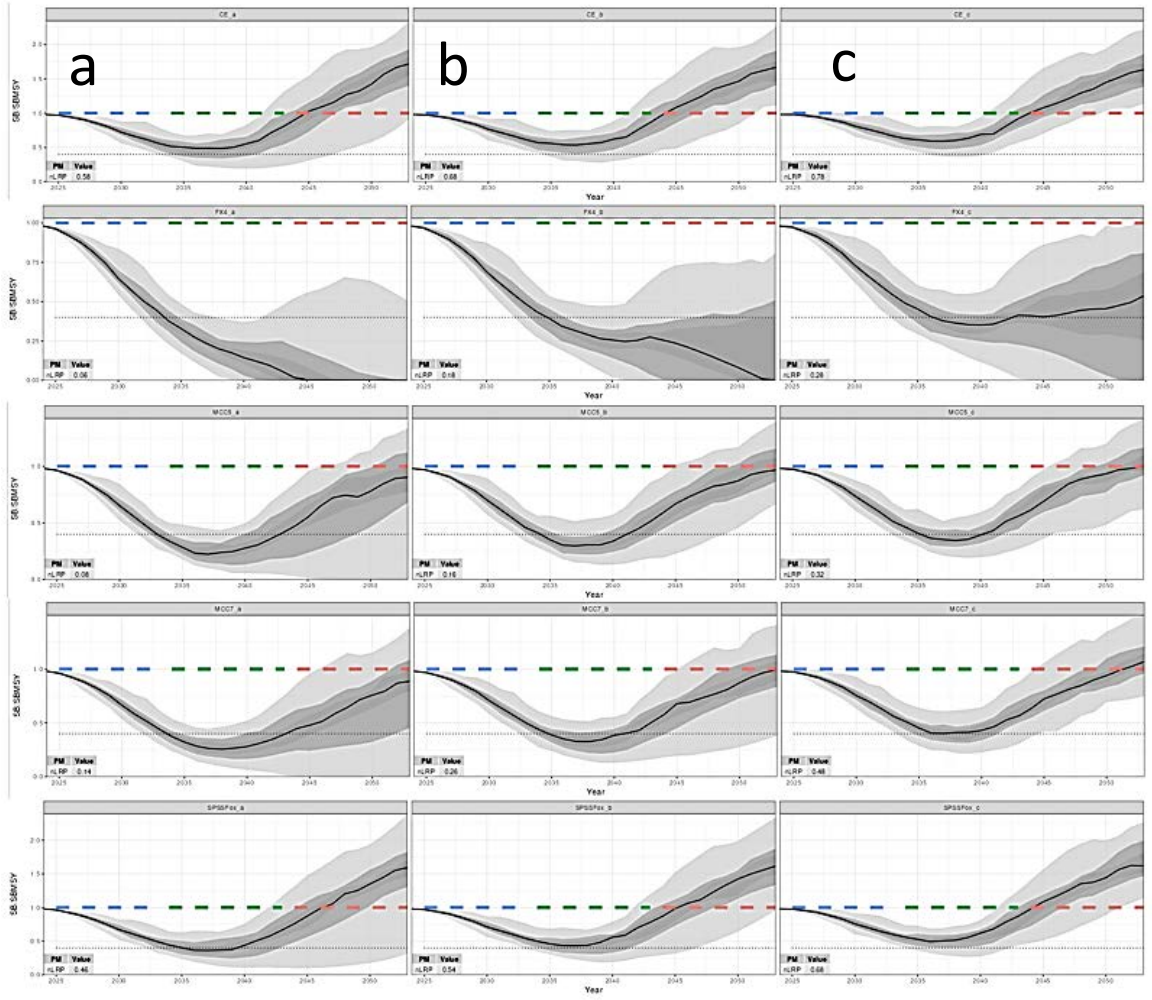
7. Robustness tests
8. Key decisions anticipated to be taken by PA4
- Selection of recommended Management Procedures (MPs)
    a. Final operational management objectives
    b. Final MP type
    c. Final MP specifications
        i. Management cycle
        ii. Minimum TAC change
    d. MP implementation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

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)



CE

FX4

MCC5

MCC7

SPSSFox

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

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  d. MP implementation schedule
9. Development of a management measure

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

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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

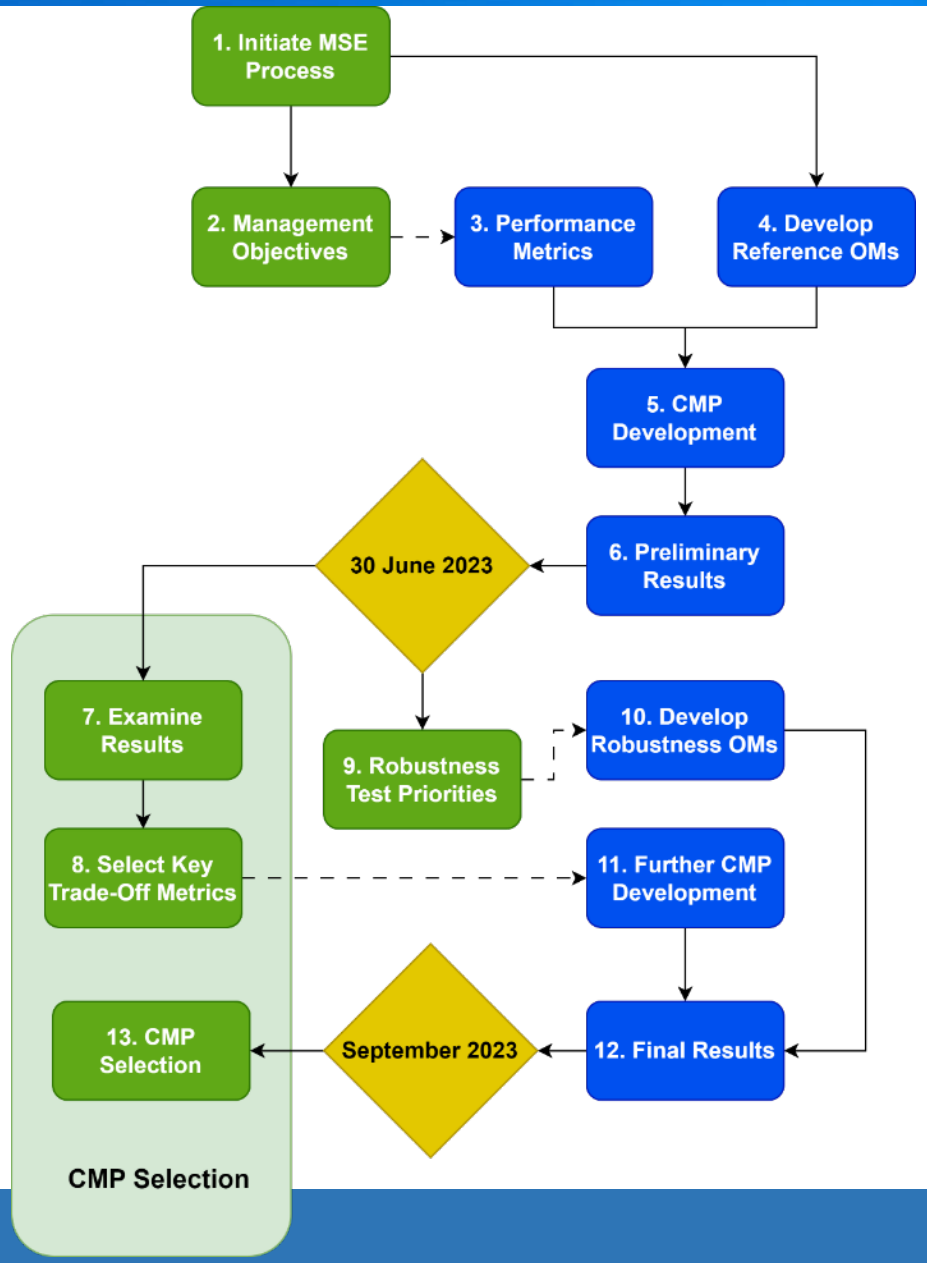
- Climate change
  - CMP performance over longer time scales
  - Variability in biological and environmental parameters
  - Spatial shifts: estimates of abundance, selectivity
  - MSE review periods

- 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)



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)

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

This work is funded by the ICCAT Science Envelope and by special contributions from ICCAT CPCs

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