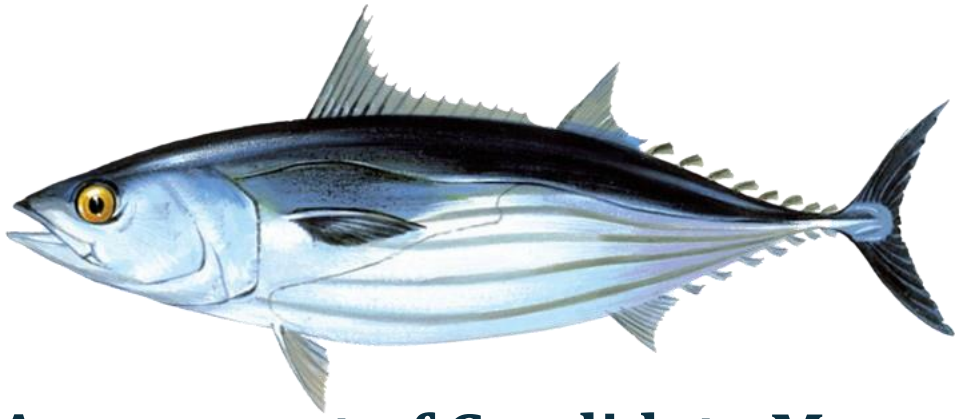


Assessment of Candidate Management Procedures and Harvest Control Rules for the Western Atlantic Skipjack Tuna

Rodrigo Sant'Ana & Bruno Mourato

Presentation Outline

1. SKJ-W MSE Timeline
2. Stock assessment structure -> Operating models
3. Review of the progress of the SKJ-W MSE
   - MSE Structure
   - New indices available
   - Results
     - Reference case
     - Robustness tests – TAC implementation error
4. Discussions and feedback

Timeline

2020

- A Demonstration MSE framework for Western Skipjack tuna (SCRS/2020/140)

2021

- Building Capacity on MSE Methods: from concepts to practice (JCAP-2/ICCAT Project)

2022

Beginning of SKJ-W MSE development

- Western Atlantic skipjack tuna MSE: RCM (SCRS/2022/097);
- Western Atlantic skipjack tuna stock assessment (SCRS/2022/098);
- Operating model conditioning based on the Stock Synthesis model (SCRS/2022/180);
- COMM adopted conceptual Management Objectives (Res. 22-02);

2023

- MSE training workshops;
- SCRS discussion and testing CMPs based on Management Objectives;
- COMM intersessional meeting – update progress;
- SCRS incorporation of COMM feedbacks;
- SCRS CMPs;

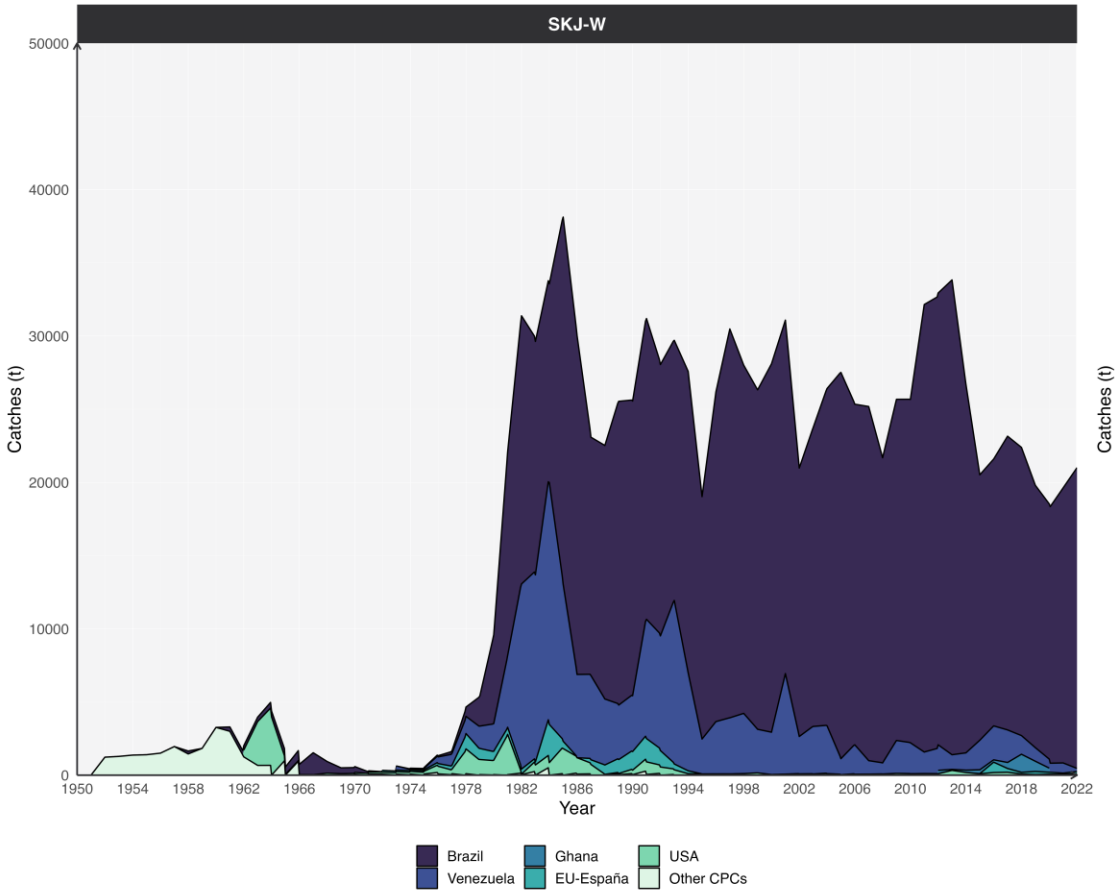
2024

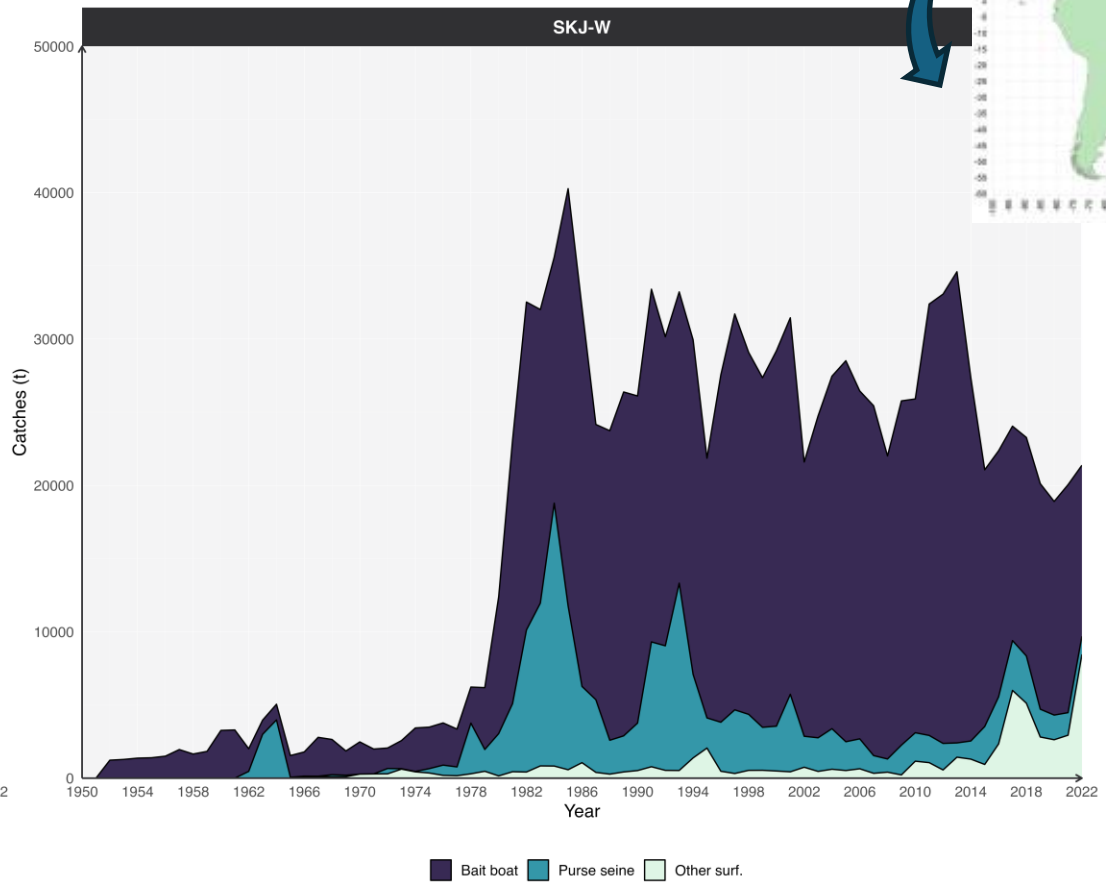
- Development of a new workplan for 2024;
- Present the workplan to SCRS and PA1;
- Implement the workplan;
- Present the results to SCRS;
- MSE training workshop;
- ...

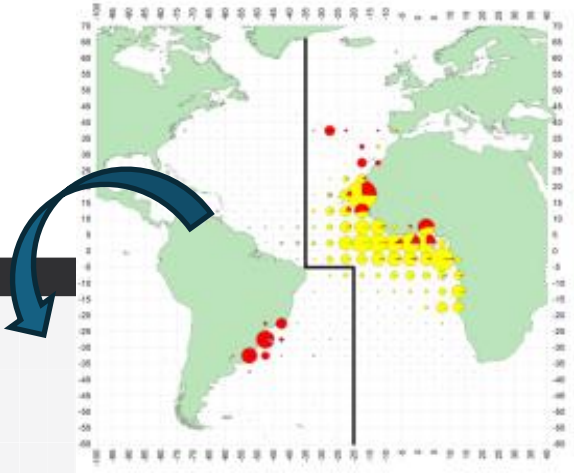
2025+

- Develop exceptional circusntance protocol;
- Develop climate change scenarios;

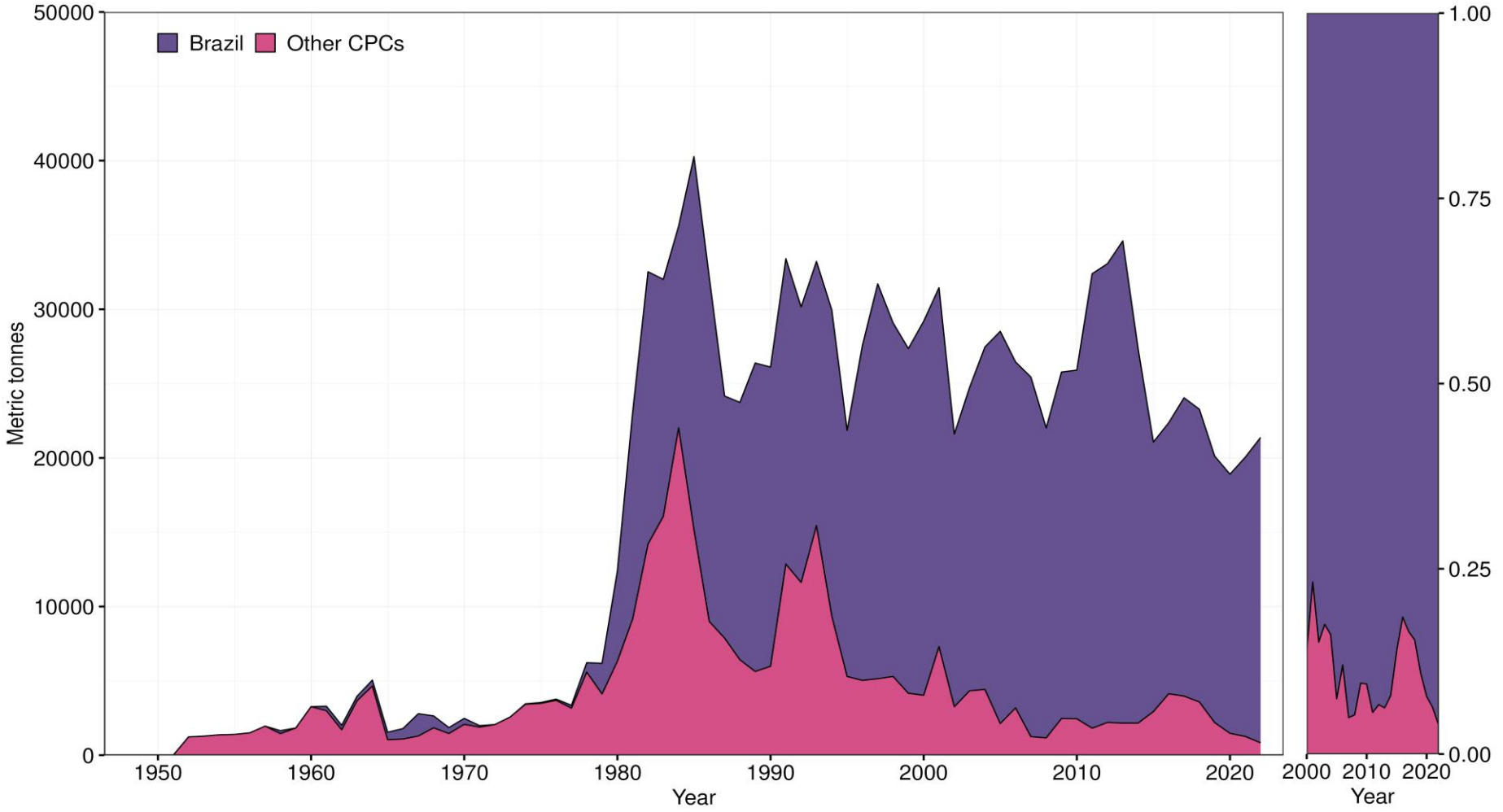
Stock Structure and Assessment

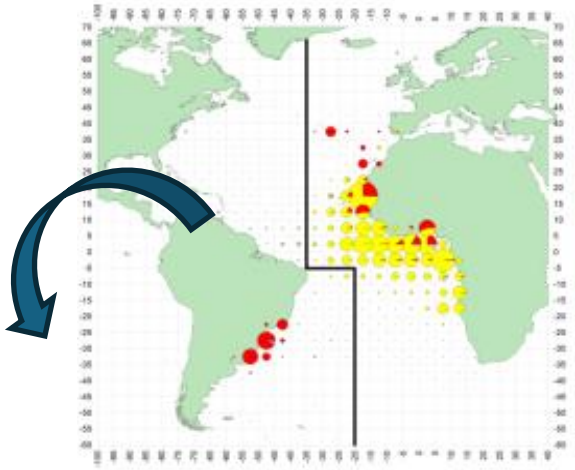






Stock Structure and Assessment



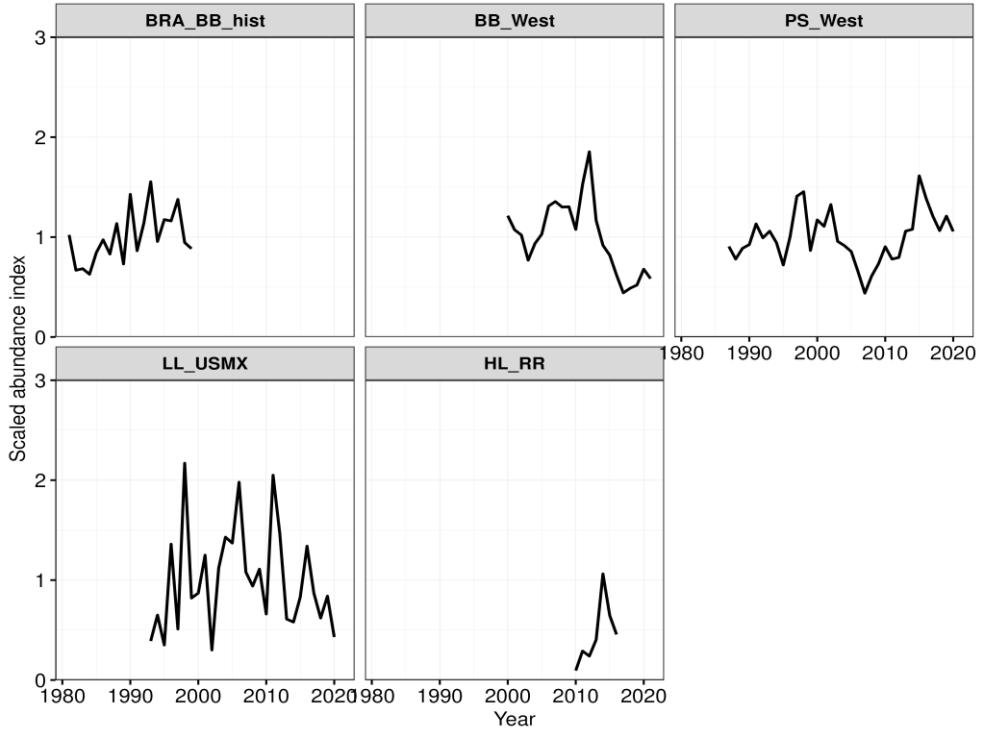


Stock Assessment

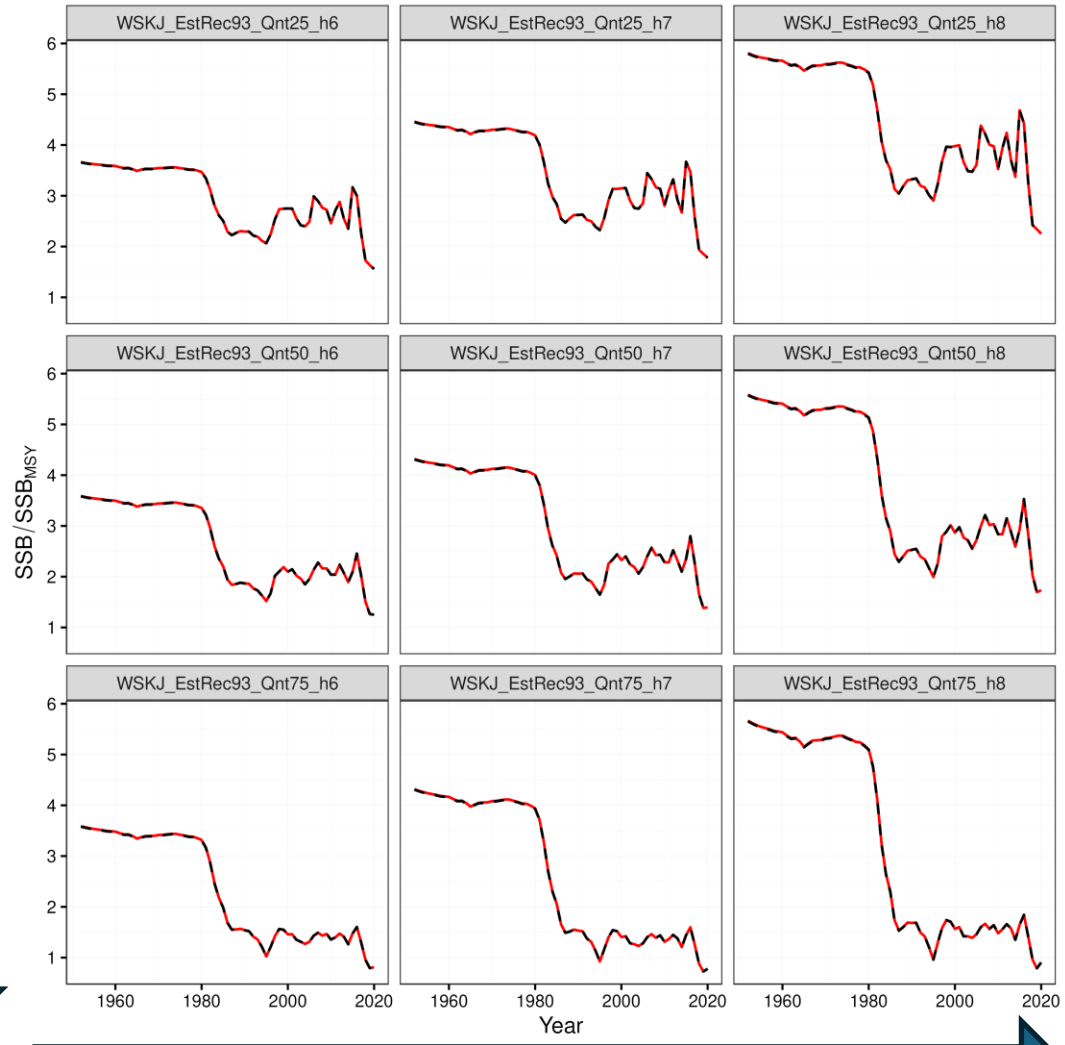
Stock Assessment Uncertainty Grid	Key uncertainty	Option 1	Option 2	Option 3
	Recruitment (steepness, h)	0.6	0.7	0.8
	Growth vector	25	50	75

General structure of the W-SKJ SA:

- Five indices were used in the assessment;
- Uncertainty grid with two key axis with three levels each were used;
- The 2021 and 2022 catch in the projection are fixed at **18,859 t**, equivalent to the 2020 reported catch.



Stock Structure and Assessment



ATLANTIC SKIPJACK SUMMARY	
	Western Atlantic
Maximum Sustainable Yield (MSY)[1]	35,277 t (28,444 – 46,340 t)
Yield for 2020 at the Stock Assessment	18,183 t
Current yield for 2022	21,383 t
Relative Biomass (B_{2020}/B_{MSY})[2]	1.60 (0.90 – 2.87)
Relative Fishing Mortality (F_{2020}/F_{MSY})	0.41 (0.19 – 0.89)
Stock Status (2020)	
Overfished:	No
Overfishing:	No

[1] Median and 95% confidence interval estimated from the joint uncertainty grid.
[2] Median and 95% confidence interval based on 90,000 iterations of the multivariate lognormal (MVLN) approximation for Stock Synthesis and 90,000 Markov chain Monte Carlo (MCMC) iterations for JABBA.

Probability $F<=F_{MSY}$ and $SSB>=SSB_{MSY}$

TAC (1000s mt)	2023	2024	2025	2026	2027	2028
16	99%	100%	100%	100%	100%	100%
18	99%	100%	100%	100%	100%	100%
20	99%	100%	100%	100%	100%	100%
22	99%	99%	100%	100%	100%	100%
24	99%	99%	99%	99%	100%	100%
26	98%	98%	98%	99%	99%	99%
28	97%	97%	97%	97%	97%	97%
30	96%	95%	94%	93%	93%	92%
32	94%	92%	91%	89%	87%	85%
33	93%	91%	88%	86%	83%	80%
34	92%	89%	86%	82%	79%	75%
35	91%	87%	83%	78%	74%	70%
36	90%	85%	80%	75%	70%	65%
38	88%	81%	74%	67%	61%	56%
40	85%	76%	67%	59%	53%	48%

Operating Models Structure

Stock Assessment Uncertainty Grid	Key uncertainty	Op. 1	Op. 2	Op. 3
	Recruitment (steepness, h)	0.6	0.7	0.8
	Growth vector	25	50	75

	Operating model	Growth vector	Steepness	SigmaR	Scenario
Reference	OM 1	25th	0.6	0.4	Perfect TAC implementation
	OM 2	50th			
	OM 3	75th			
	OM 4	25th	0.7		
	OM 5	50th			
	OM 6	75th			
	OM 7	25th	0.8		
	OM 8	50th			
	OM 9	75th			

Robustness Test

- Robustness test 01 – 10% overage TAC error implementation
  - Robustness test 02 – 20% overage TAC error implementation
    - *Robustness test 03 – Climate change scenario based on answers of the growth parameter*

PA1 Decisions for the SKJ-W MSE

Management objectives

- ***Performance indicator probabilities:***
  - *Status:* The stock should have a 70% or greater probability of remaining in the Kobe green quadrant over the 30-year projection;
  - *Safety:* The probability of the stock being below the Blim should not be greater than 10% over the 30-year projection.
  - *Stability:* Fluctuations in TAC should be less than 20%. Reductions in TAC larger than 20% are allowed when required to rebuild the biomass.
- ***Tuning objectives:***
  - *Maximize yield at the limit of PGK70%.*

Res. 22-02
First Intersessional Meeting of Panel 1 in February 2024

For reference

- Short: 1-3 years
- Medium: 4-10 years
- Long: 11-30 years
- All: 1-30 years

Management Objectives (Res. 22-02)	*Proposed Corresponding Performance Metric Statistics*
Status The stock should have a 70% or greater probability of occurring in the green quadrant of the Kobe matrix using a 30-year projection period as determined by the SCRS.	**PGK_{short}**: Probability of being in the Kobe green quadrant (i.e., $SSB \geq SSB_{MSY}$ and $F < F_{MSY}$) in year 1-3 **PGK_{medium}**: Probability of being in the Kobe green quadrant (i.e., $SSB \geq SSB_{MSY}$ and $F < F_{MSY}$) in year 4-10 **PGK_{long}**: Probability of being in the Kobe green quadrant (i.e., $SSB \geq SSB_{MSY}$ and $F < F_{MSY}$) over years 11-30 **PGK**: Probability of being in the Kobe green quadrant (i.e., $SSB \geq SSB_{MSY}$ and $F < F_{MSY}$) over years 1-30 **POF**: Probability of $F > F_{MSY}$ over years 1-30 **PNOF**: Probability of $F < F_{MSY}$ over years 1-30
Safety There should be no greater than 10% probability of the stock falling below B_{LIM} ($0.4*B_{MSY}$) at any point during the 30-year projection period.	**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**: Probability of breaching the limit reference point (i.e., $SSB < 0.4*SSB_{MSY}$) over years 1-30 **$nLRP_{short}$**: Probability of not breaching the limit reference point (i.e., $SSB < 0.4*SSB_{MSY}$) over years 1-3 **$nLRP_{medium}$**: Probability of not breaching the limit reference point (i.e., $SSB < 0.4*SSB_{MSY}$) over years 4-10 **$nLRP_{long}$**: Probability of not breaching the limit reference point (i.e., $SSB < 0.4*SSB_{MSY}$) over years 11-30 **nLRP**: Probability of not 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 20% 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

Candidate Management Procedures

Relative FMSY Reference MPs:

- *FMSYref*
- *FMSYref75*
- *FMSYref110*

Empirical index-based MP:

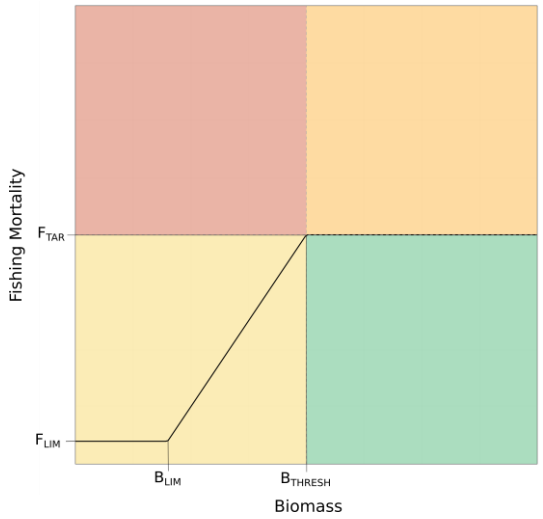
- *Iratio*
  - *IR_01* - TAC is adjusted asymmetrically c(0.2, 0.25)
  - *IR_02* - TAC is adjusted symmetrically c(0.2, 0.2)
  - *IR_03* – TAC without adjustment
- *CE*
  - *CE_01* - TAC is adjusted asymmetrically c(0.2, 0.25)
  - *CE_02* - TAC is adjusted symmetrically c(0.2, 0.2)
  - *CE_03* - TAC without adjustment

Candidate Management Procedures

Model-based MP:

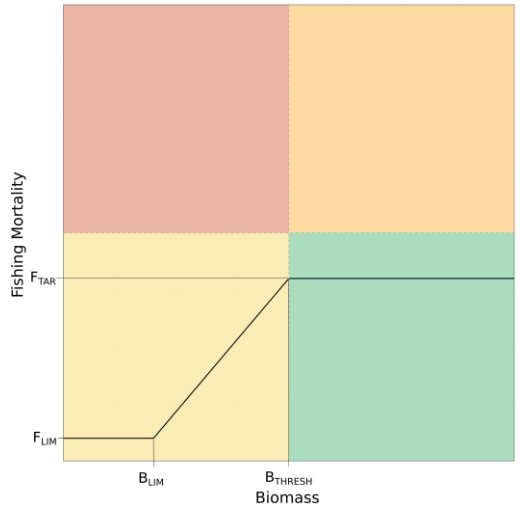
FMSY, if ≥ BMSY :

- Surplus production model (*SP_01*)
- State-space surplus production model (*SP_02*)



80% FMSY, if ≥ BMSY :

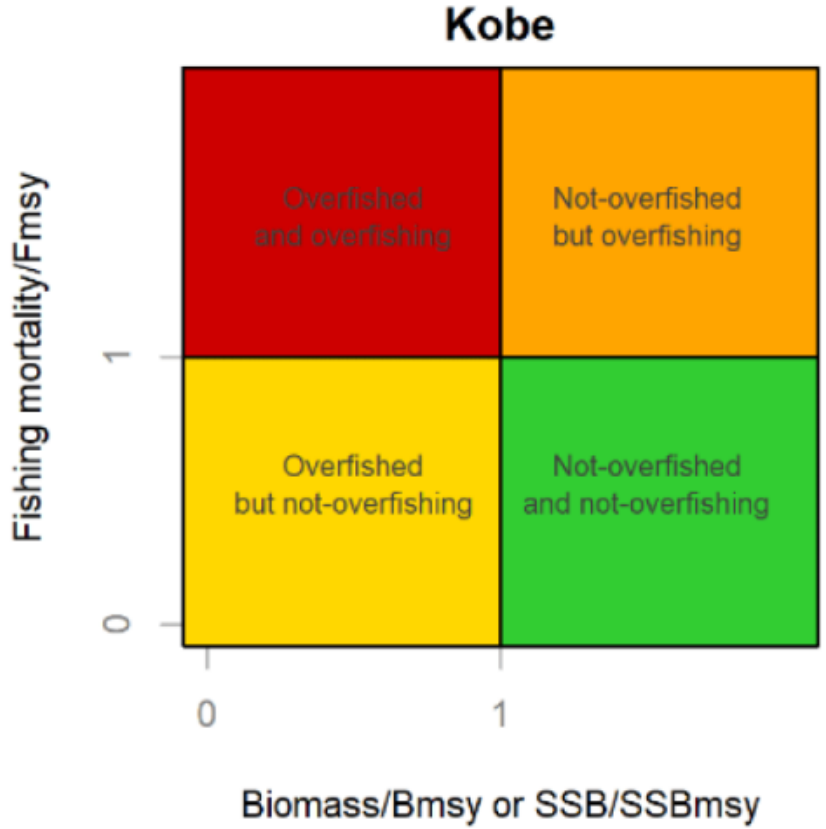
- Surplus production model (*SP_03*)
- State-space surplus production model (*SP_04*)



CMP Tuning

Concept:

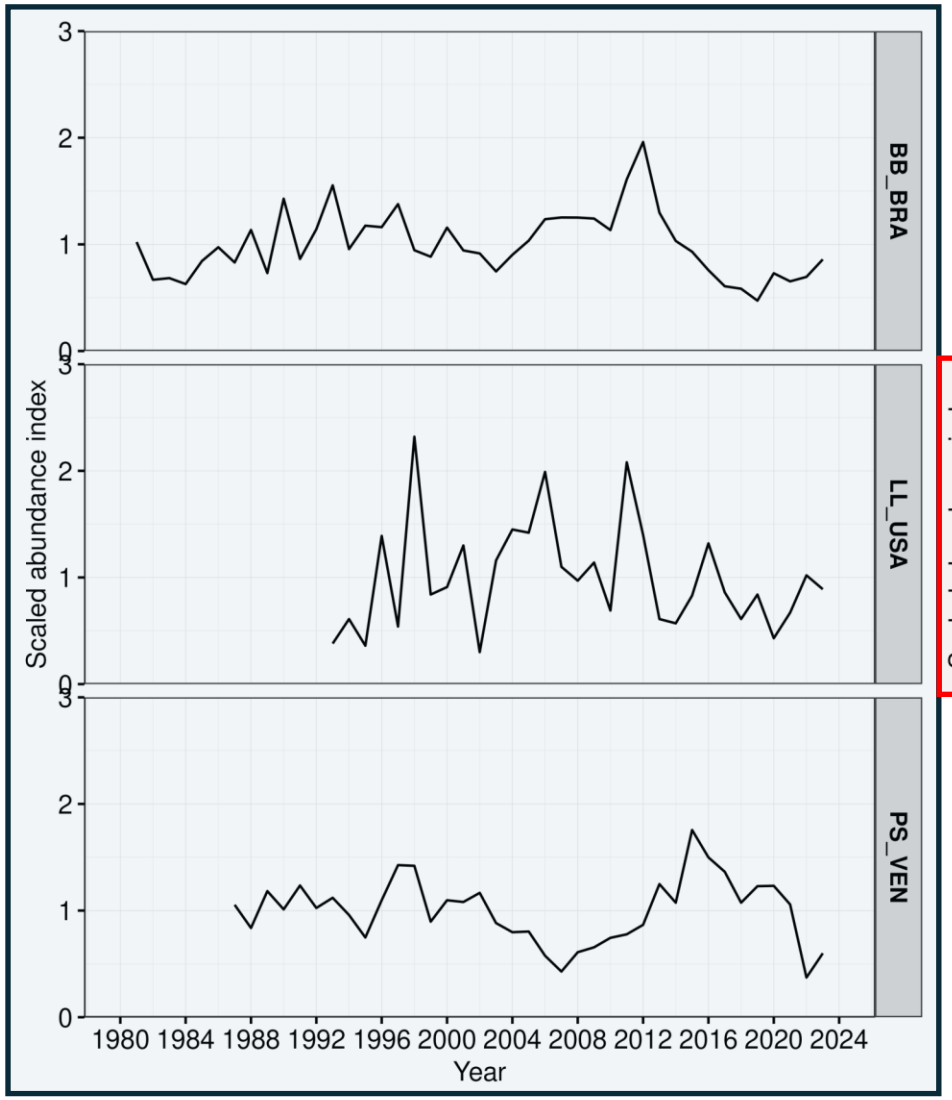
- Maximize potential yield, and;
- Maintaining the probability of the stock remaining in the green quadrant of Kobe plot with at least a 70% probability.

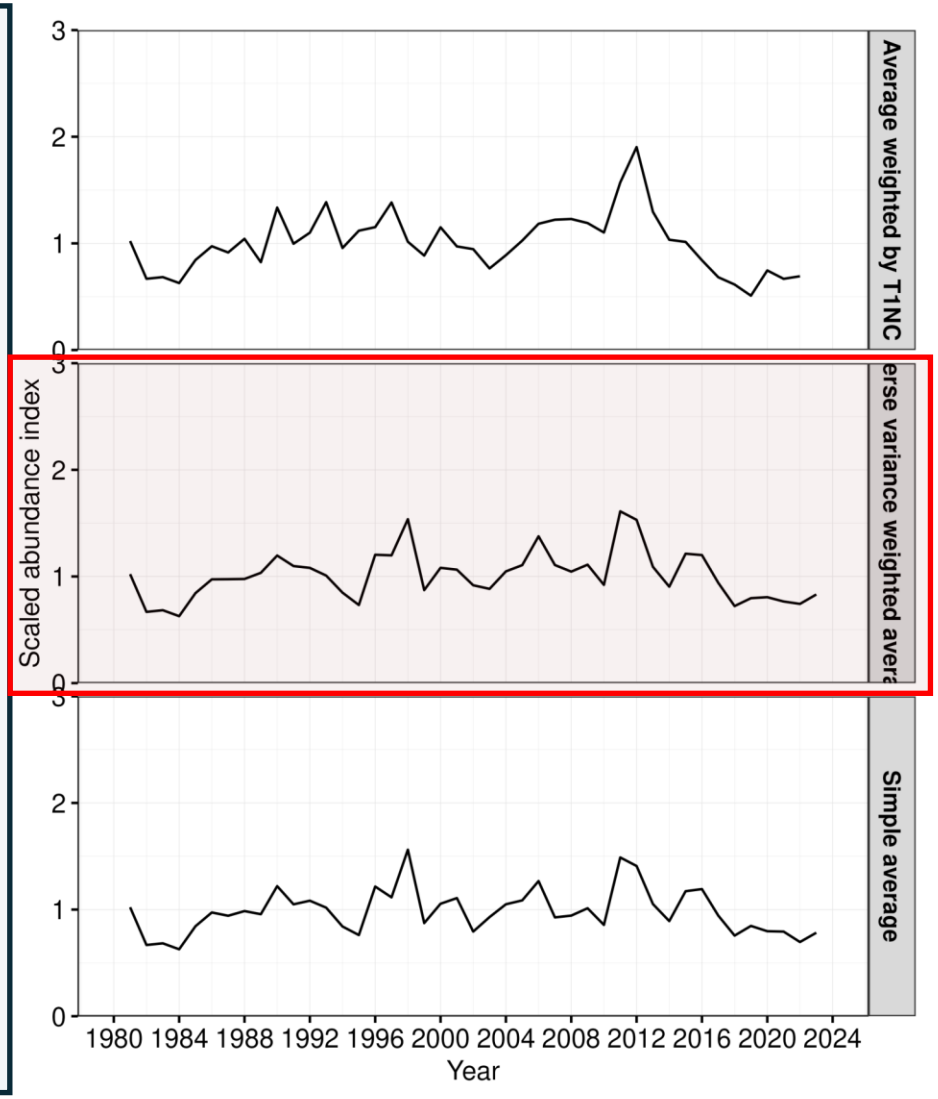


Merino et al. *Sustainability* **2020**, *12*(19), 8245; https://doi.org/10.3390/su12198245

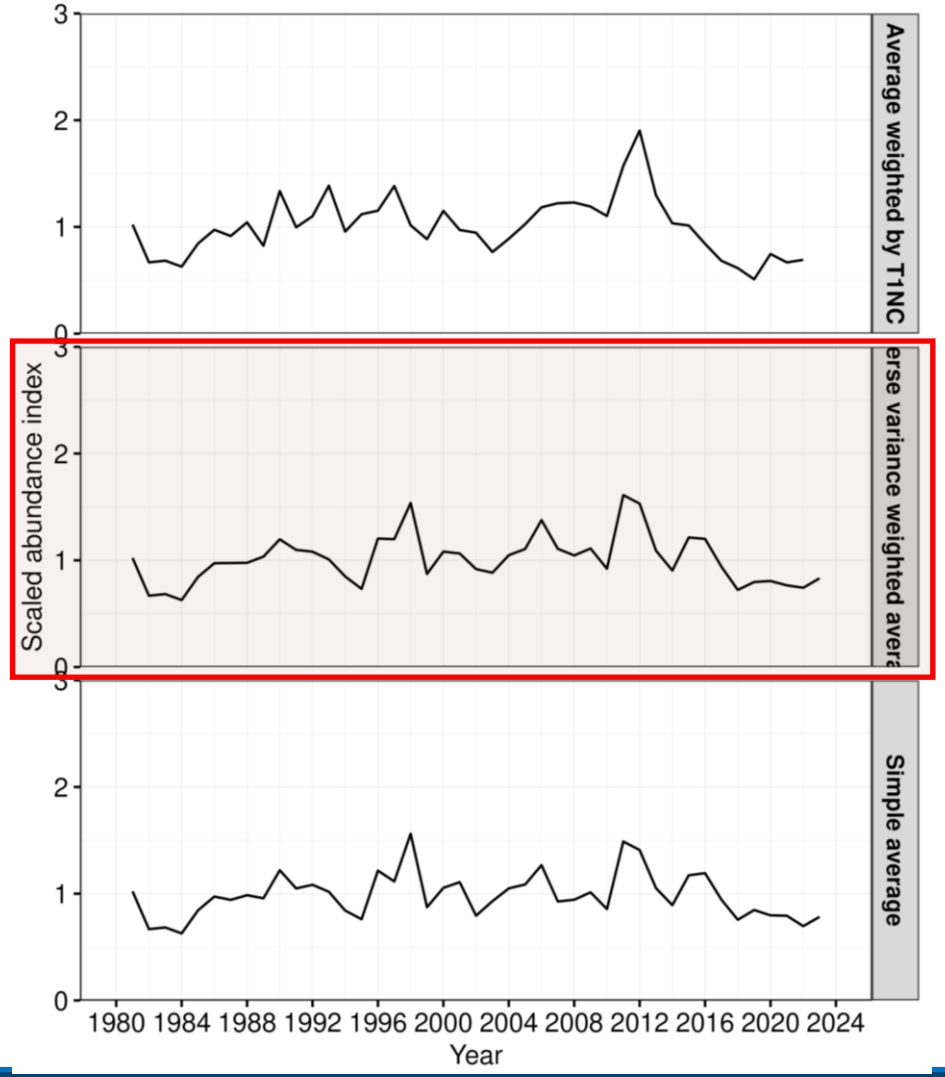
New data available

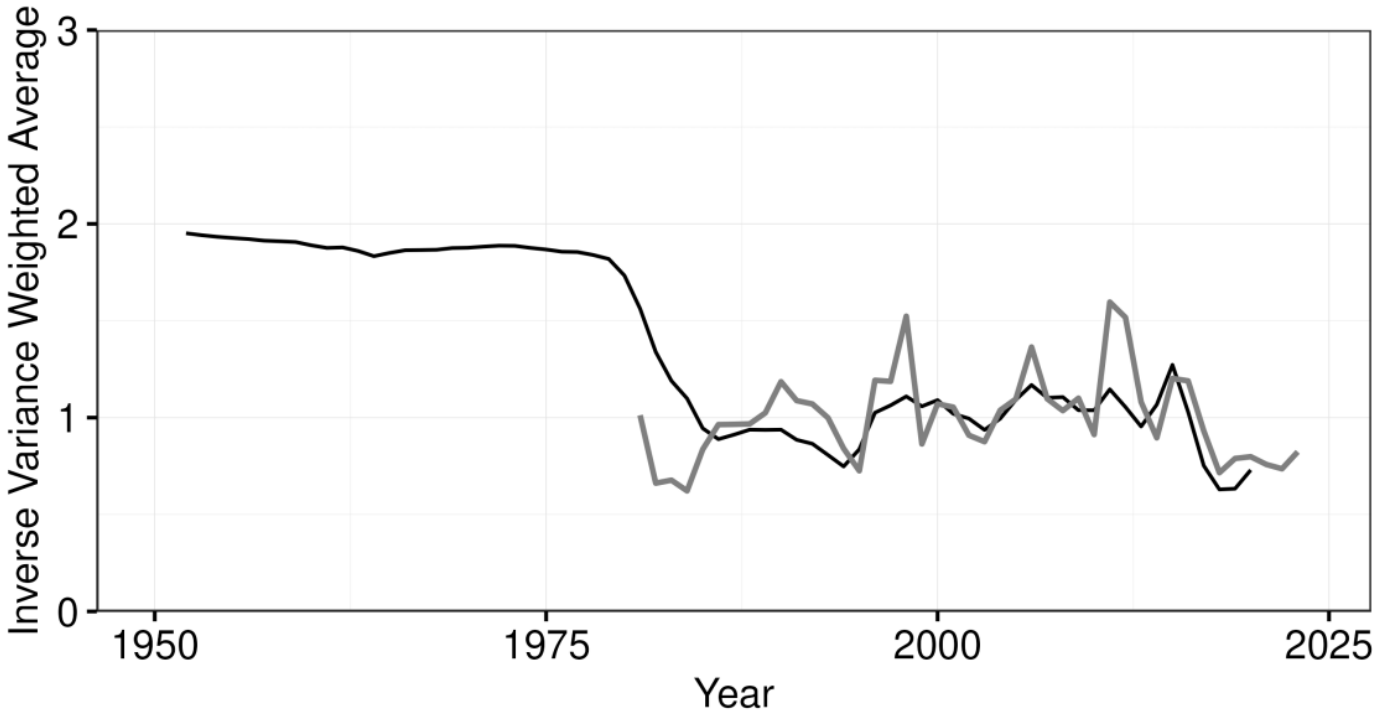
- All catches and indices were updated up to 2022;
- Catches
  - 2021 – 20.048 t
  - 2022 – 21.377 t
- Combined index for MPs
  - Simple average;
  - Average weighted by T1NC;
  - Inverse variance weighted average.

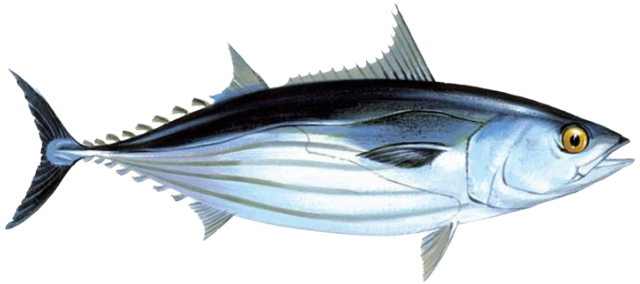




New indices available







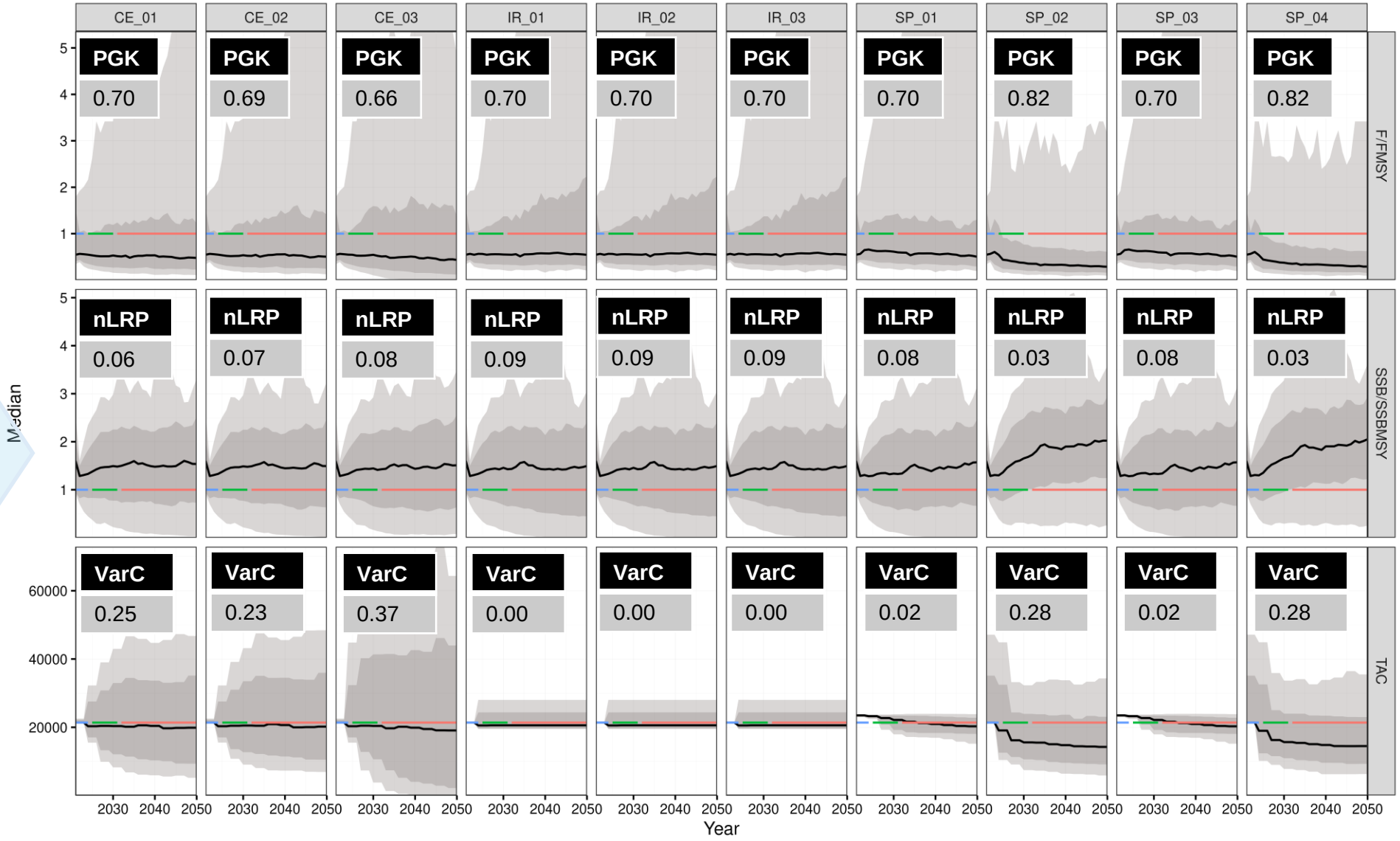
Results – Reference Case

Results

Trajectories

- F/F_{MSY}
- SSB/SSB_{MSY}
- TAC

Reference OM Grid



Results

CMP Performance Quilt Plot:

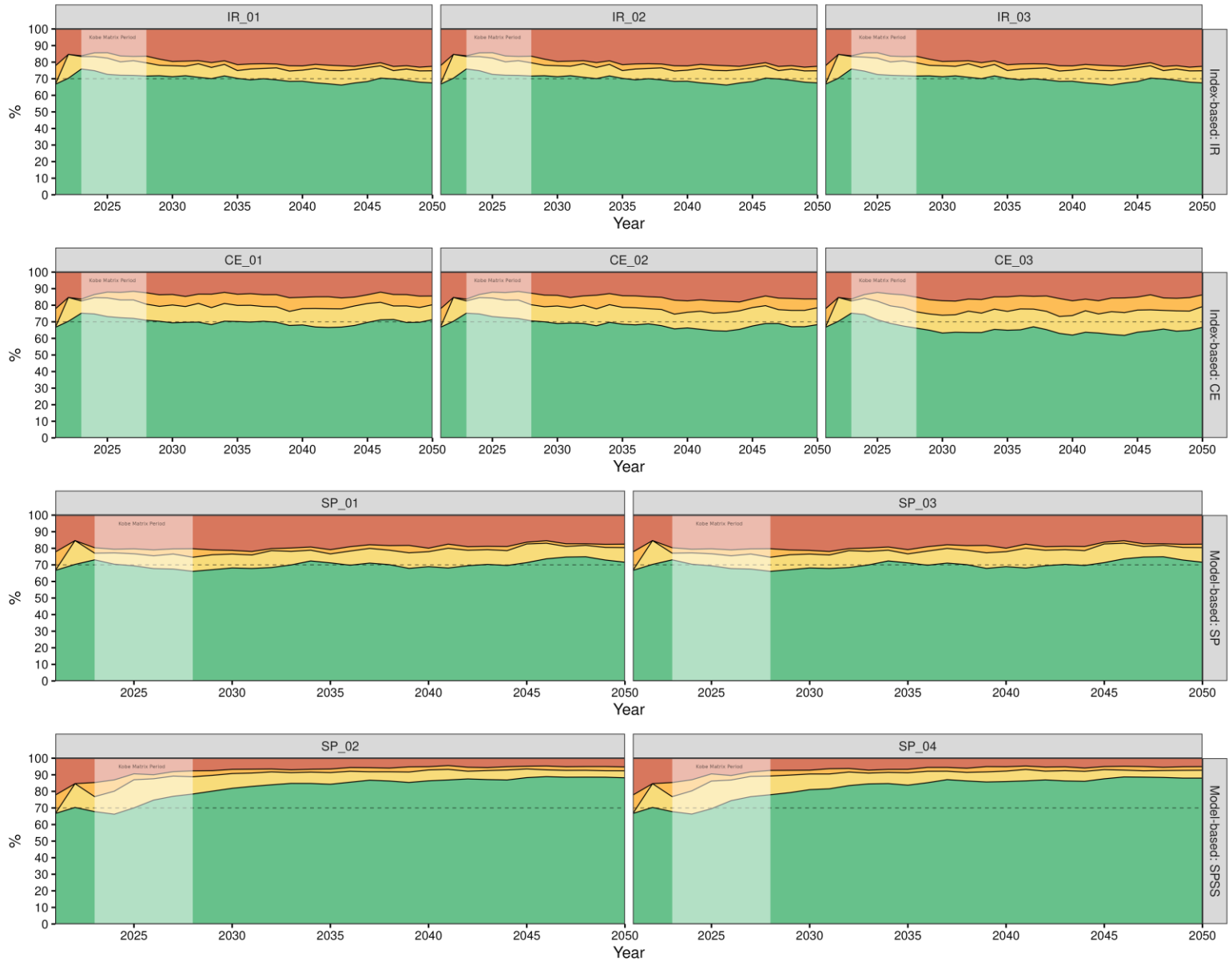
Reference OM Grid

MP	AvC_short	AvC_med	AvC_long	PGK_short	PGK_med	PGK_long	PGK	PNOF	nLRP_short	nLRP_med	nLRP_long	nLRP	VarCmedium	VarClong	VarC
IR_01	20581	21096	20065	0.71	0.72	0.69	0.70	0.77	1.00	0.96	0.88	0.91	0.01	0.00	0.00
IR_02	20581	21096	20065	0.71	0.72	0.69	0.70	0.77	1.00	0.96	0.88	0.91	0.01	0.00	0.00
IR_03	20581	21106	20061	0.71	0.72	0.69	0.70	0.77	1.00	0.96	0.88	0.91	0.01	0.00	0.00
CE_01	20677	20609	20324	0.71	0.72	0.69	0.70	0.80	1.00	0.96	0.92	0.94	0.22	0.31	0.25
CE_02	20677	20712	20641	0.71	0.72	0.67	0.69	0.79	1.00	0.96	0.91	0.93	0.21	0.29	0.23
CE_03	20677	21571	20189	0.71	0.68	0.64	0.66	0.77	1.00	0.95	0.90	0.92	0.34	0.53	0.37
SP_01	21616	22142	19716	0.70	0.68	0.71	0.70	0.78	1.00	0.94	0.89	0.92	0.04	0.02	0.02
SP_02	21395	17649	15658	0.68	0.75	0.87	0.82	0.90	1.00	0.96	0.96	0.97	0.31	0.26	0.28
SP_03	21616	22142	19716	0.70	0.68	0.71	0.70	0.78	1.00	0.94	0.89	0.92	0.04	0.02	0.02
SP_04	21395	17695	15771	0.68	0.75	0.86	0.82	0.89	1.00	0.96	0.96	0.97	0.31	0.26	0.28

Results

CMP Performance Timeseries Kobe plot:

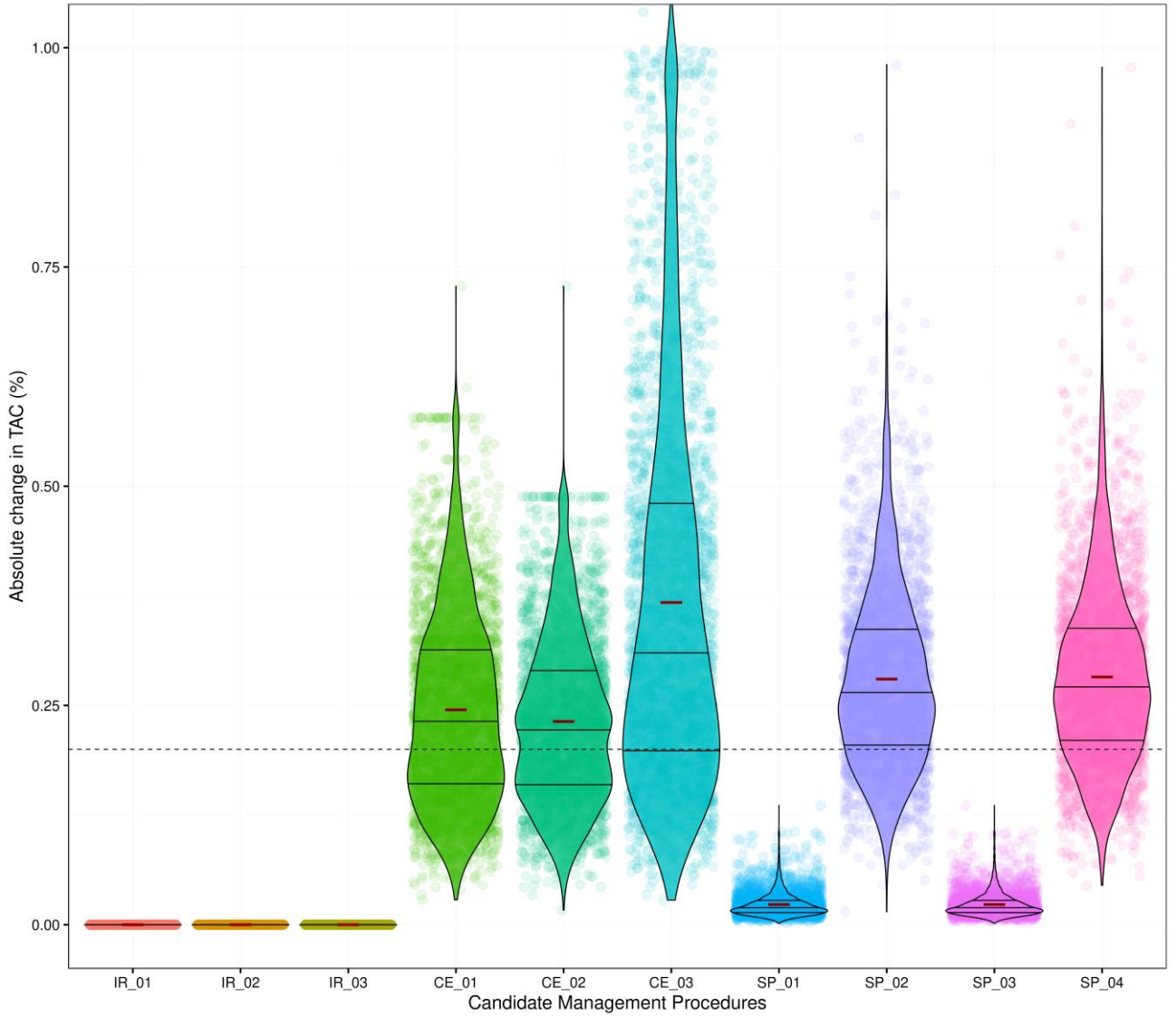
Reference OM Grid



Results

CMP Performance Violin plot:

Reference OM Grid



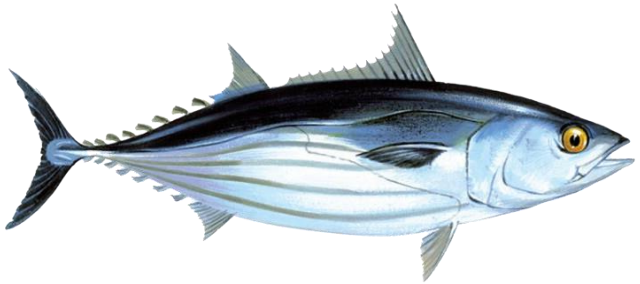
Results

CMP Performance TAC1:

Reference OM Grid

CMP	TAC1
CE_01	20,559.79
CE_02	20,559.79
CE_03	20,559.79
IR_01	20,000.11
IR_02	20,000.11
IR_03	20,000.11
SP_01	23,891.52
SP_02	15,378.83
SP_03	23,891.52
SP_04	15,332.60

TAC for the first management cycle

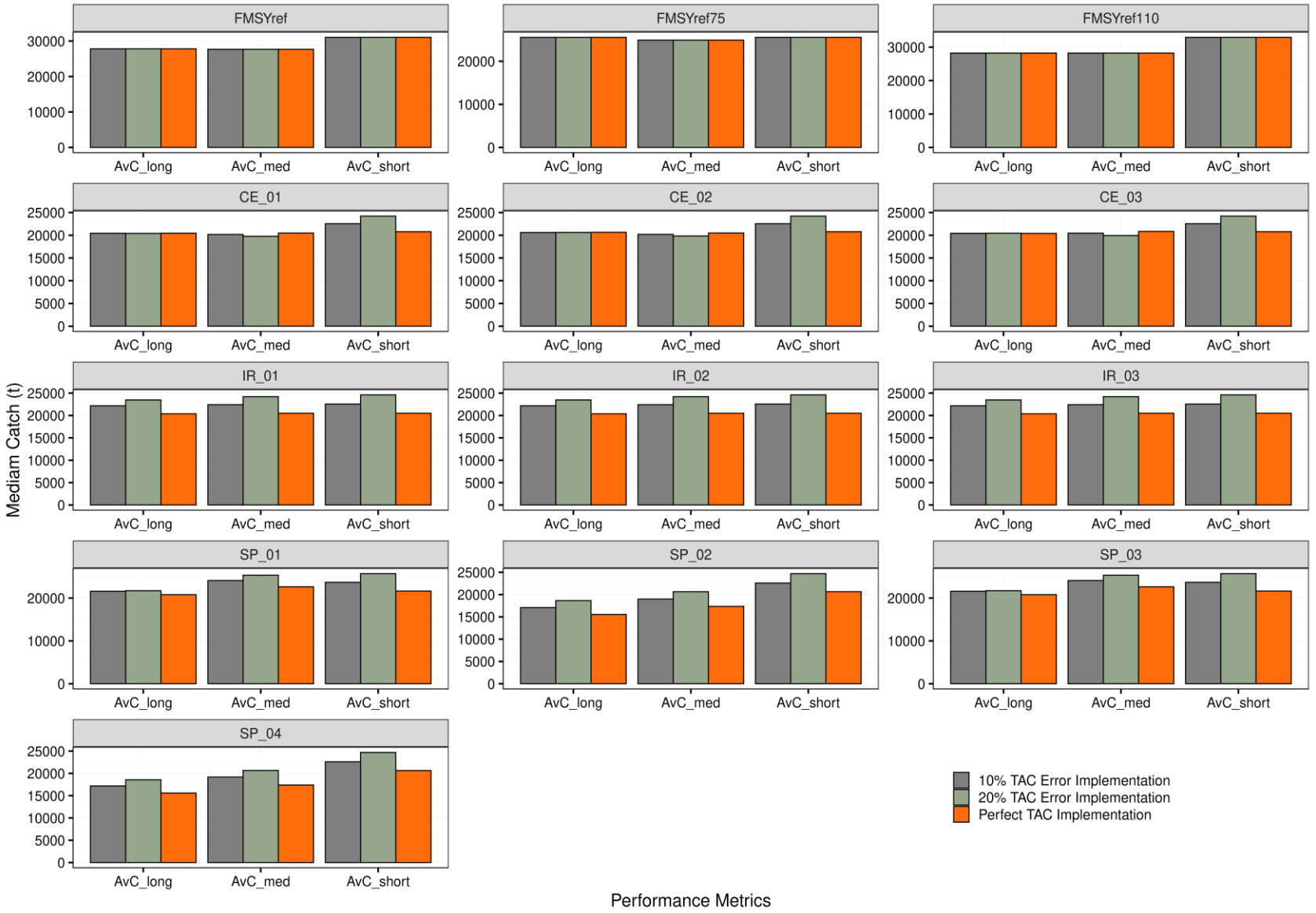


Results – Robustness

Results

Robustness test:

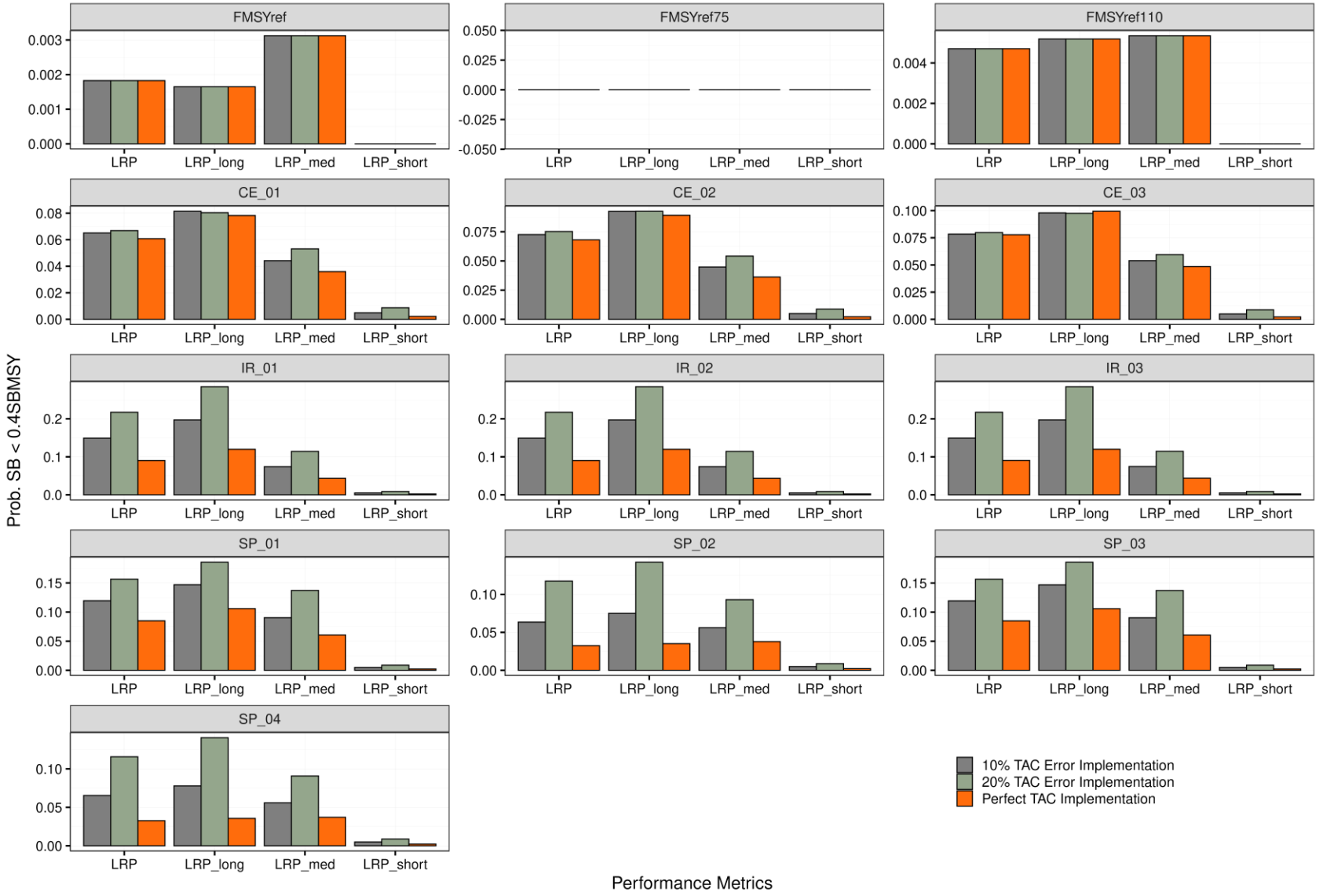
Yield - AvC



Results

Robustness test:

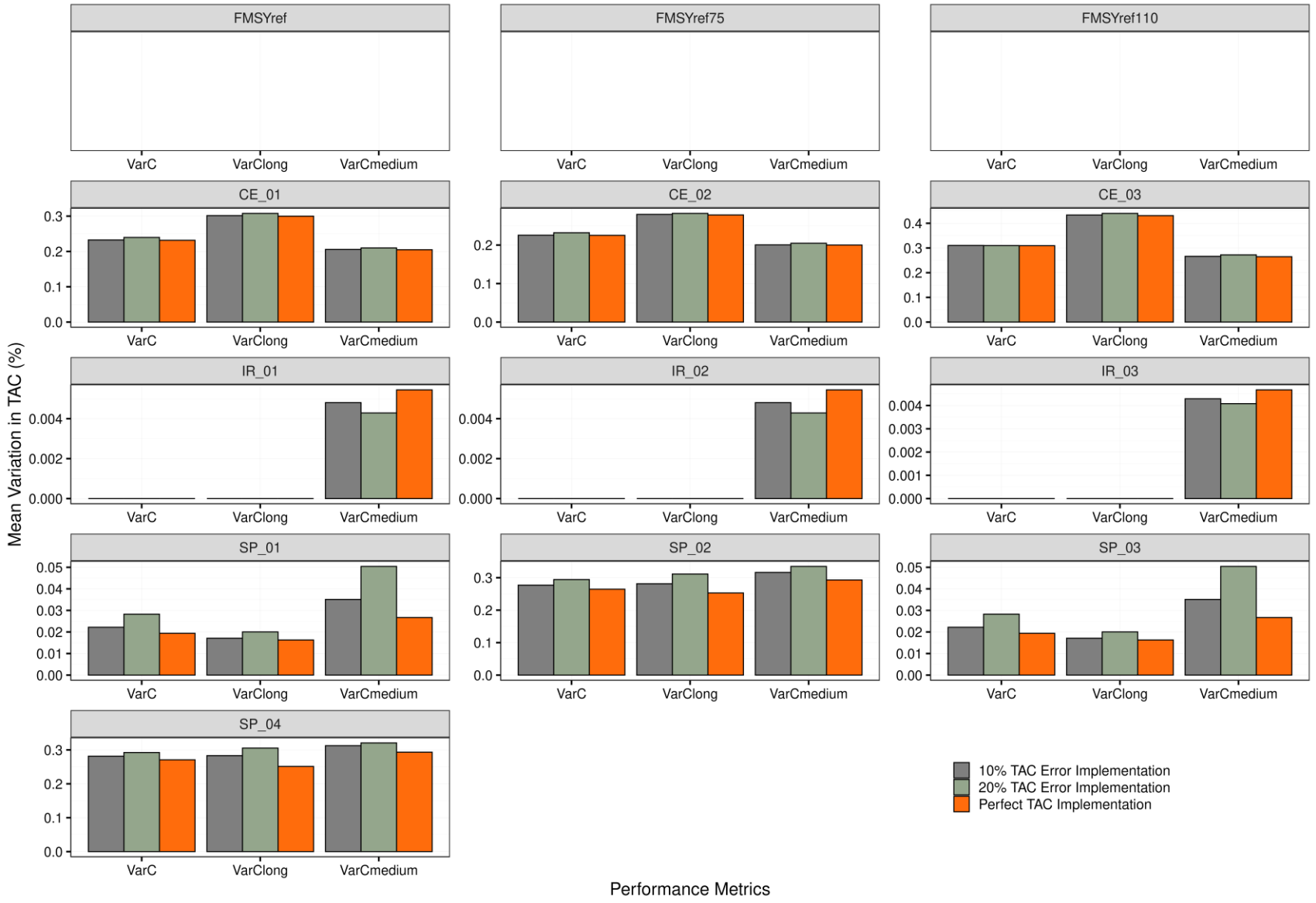
Safety - LRP



Results

Robustness test:

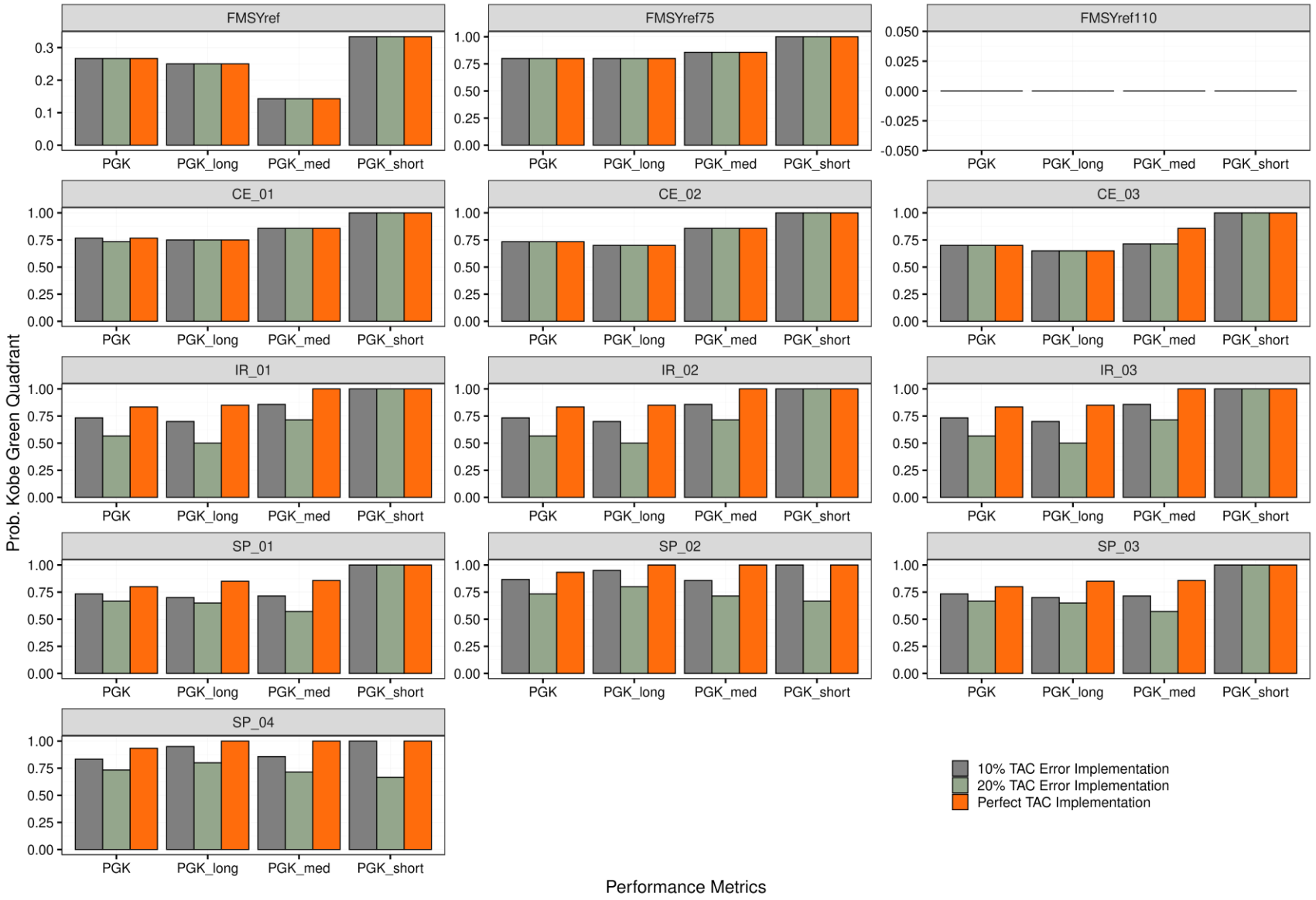
Stability - VarC



Results

Robustness test:

Status - PGK



Results

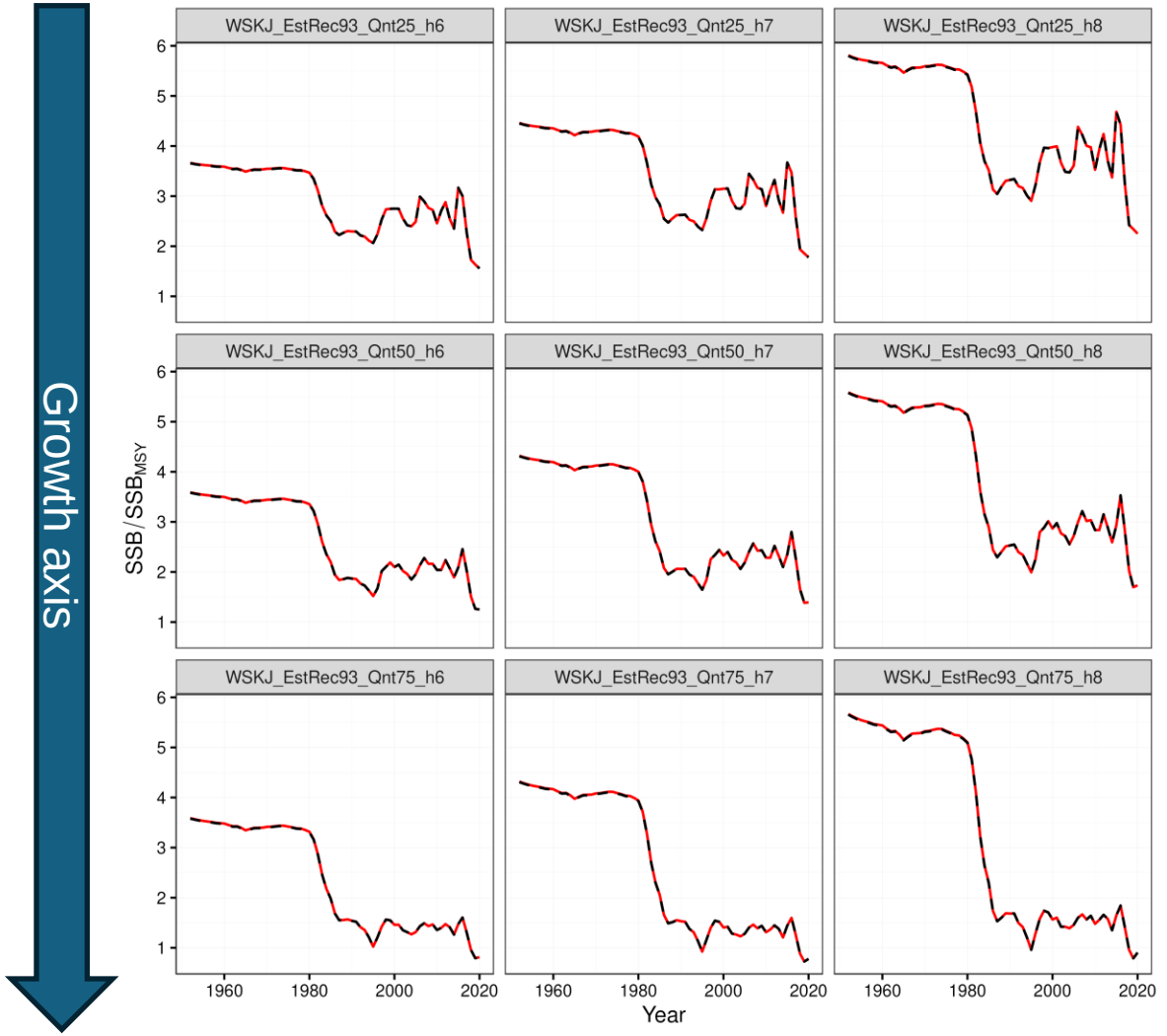
- *Based on answers of the growth parameter* - Unfortunately, not yet implemented

Robustness test:

Climatic Change Scenarios

But, to think about it, the uncertainty grid used in stock assessment, as well as in operating models, already seeks to reflect potential changes/variations in growth patterns.

What could be one of the expected factors for the effects of climate change

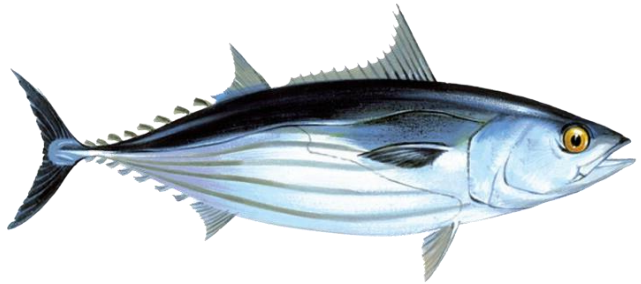


More info...

GitHub https://github.com/rodrigosantana/ICCAT_MSE_WSKJ_2024

All W-SKJ MSE was developed using openMSE framework

openMSE
www.openmse.com



THANK YOU