ITEM 5. INTRODUCTION TO MSE

5.1 BRIEF INTRODUCTION OF MANAGEMENT PROCEDURES AND MSE
    5.1.1 BASIC PRINCIPLES
    5.1.2 ROLES OF RESPONSIBILITIES, DIALOGUE TOOLS AND FEEDBACK MECHANISM

5.2 DEMONSTRATION OF MSE CAPACITY BUILDING TOOLS (POLINA LEVONTINE, JANA KLEINEBERG)

5.3 SC PROPOSAL FOR THE STANDARD PRESENTATION OF MSE RESULTS

5.1 BRIEF INTRODUCTION OF MANAGEMENT PROCEDURES AND MSE

TOSHIHIDE KITAKADO (SC CHAIR)

Part I: Overview of MSE with several remarks and caveats to avoid misunderstanding
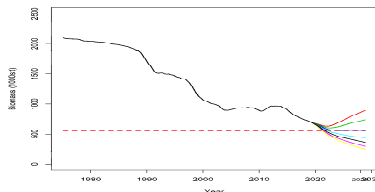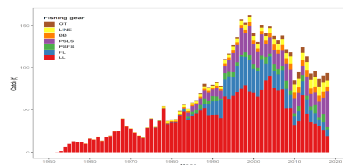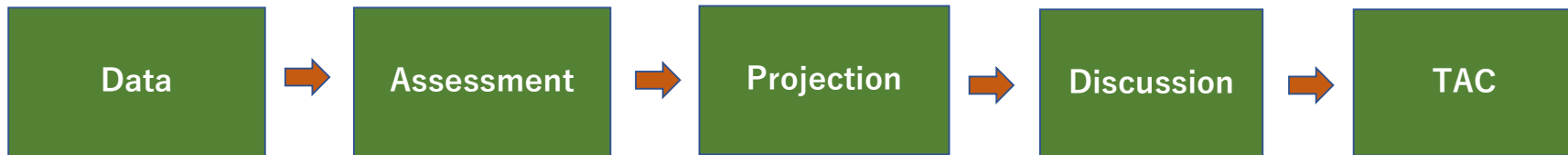Part II: Roles, responsibilities and feedback mechanism

PART I

OVERVIEW OF MSE + "SEVERAL REMARKS AND CAVEATS" TO AVOID MISUNDERSTANDING

- **Management Procedure (MP), Harvest Strategy** - Some **combination** of monitoring data, analysis method, harvest control rule and management measure, which is <u>fully-specified</u> and <u>simulation tested</u> to demonstrate adequately robust performance in the face of plausible uncertainties about stock and fishery dynamics.

- **Management Strategy Evaluation (MSE)** - A **process** whereby the performances of alternative management procedures are <u>tested</u> and <u>compared using stochastic simulations</u> of stock and fishery dynamics against a set of performance statistics developed to **quantify the attainment of management objectives**.

Putting the details aside, let's simply recognize "MSE" as

"an evaluation process of candidate management procedures for achieving stated management objectives through stochastic simulations"

Setting TAC

Stock assessment with constant catch projection approach

Data → Assessment → Projection → Discussion → TAC

Reference point and projection timeframe	Alternative catch projections (relative to the average catch level from YYYY–YYYY) and probability (%) of violating MSY-based target reference points ($B_{targ} = B_{MSY}$; $F_{targ} = F_{MSY}$)								
	60% (catch t)	70% (catch t)	80% (catch t)	90% (catch t)	100% (catch t)	110% (catch t)	120% (catch t)	130% (catch t)	140% (catch t)
$B_{2016} < B_{MSY}$	9	13	19	28	40	53	65	82	86
$F_{2016} > F_{MSY}$	3	6	30	56	81	91	98	99	100

Pre-determined management procedure

Data → Assessment (if needed) → HCR or pre-determined rule → TAC
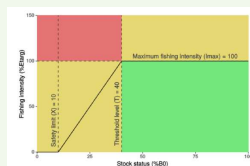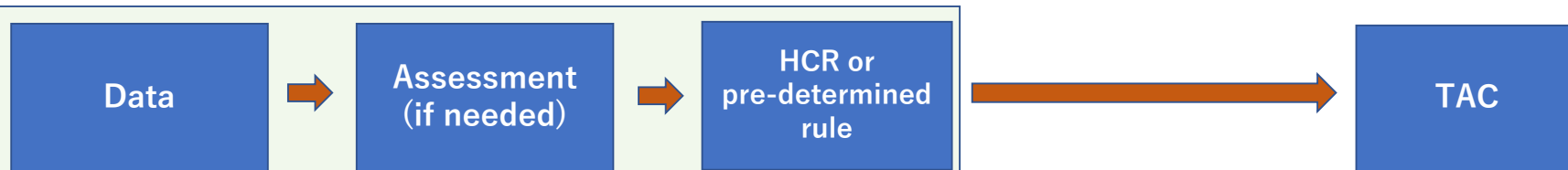
The MSE is a computer simulation framework

● to understand the **expected behavior of "MPs"** if implementing them in an actual fishery

● to find the best way by developing MPs to **robustly meet the pre-determined management objectives** (acceptable trade-off and levels of risk)

● to **select an MP** for implementation in actual fisheries

Merits of MSE

• **Comprehensiveness**, **Transparency** and **Dialogue**

• Consider in advance **uncertainty** in data, model, estimation, projection, implementation etc.

• Ensure a certain level of **robustness** of management performance to uncertainty

• Information is available in advance for some **likely trajectories** and their ranges for biomass, catch, etc. after implementing an MP

SOME MORE DETAILS

MSE Process (not necessarily in this sequence)

1. Identification of **management objectives** and quantifiable **performance measures**

2. Development of a range of **Operating Models (OMs)** to represent the uncertainty in the fishery and population dynamics

3. Development of candidate **Management Procedures (MPs)**

4. **Simulation testing** of candidate MPs with the OMs

5. **Selection of an MP** on the basis of the simulated performance

6. **Implementation of the MP**

- Before implementing an MP, need to test if the MP can work or not for meeting pre-determined management objectives

Management Procedures (MPs)

HCR | Assessment (if needed) | Data, fishery, survey…
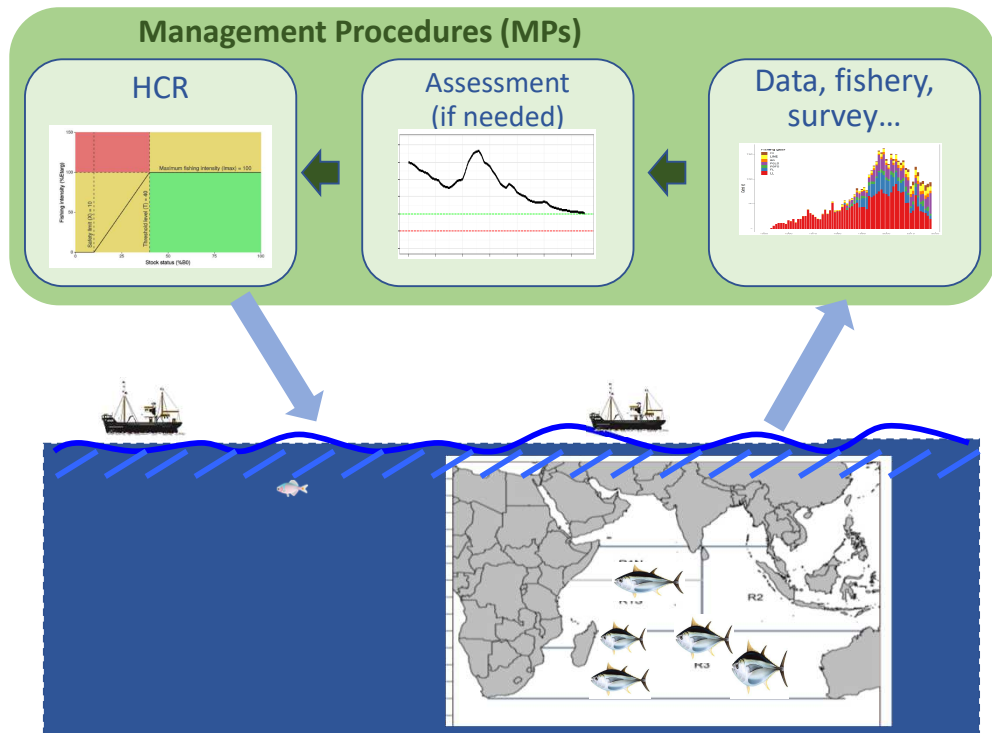
- Several different objectives
- Use of performance measures to see if management objectives are met or not
- High priority issue on safety of population can be reflected in tuning criteria

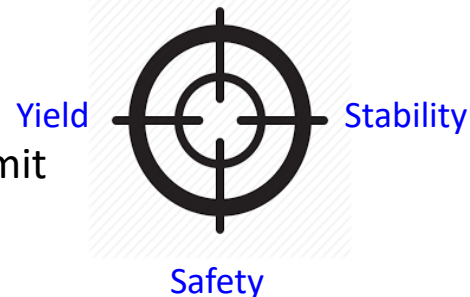| Management objectives | ⬌ | Performance measures |

e.g.

Stock status ⇔ Probability that stock is being in green zone

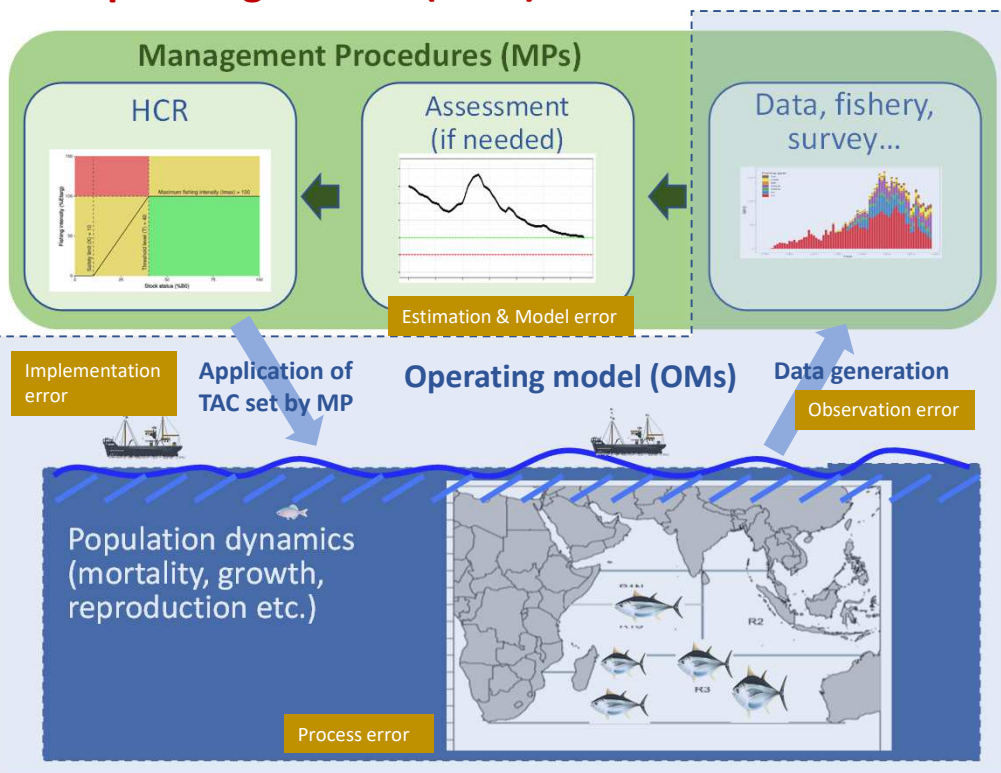Safety ⇔ Probability that stock is breaching the biomass limit


Stock status

Yield   Stability

Safety

For testing MPs, we need **"virtual population"** and **"virtual fishery following an MP"**

⇒ **Operating models (OMs)**

- OMs generate data used in MPs

- OMs can account for the impact of catch on the stock

- OMs are primarily based on the stock assessment, but should not be completely equal to the assessment models

- Consider several key uncertainties in parameters, and other kinds of uncertainties to evaluate the **robustness** of candidate Management Procedures

Food and Agriculture Organization
of the United Nations

iotc ctoi

Conduct **comprehensive simulation** to evaluate the performance of MPs using OMs
(trajectories, performance measures, and their trade-off)

MSE IN NUTSHELL

Food and Agriculture Organization of the United Nations

iotc ctoi
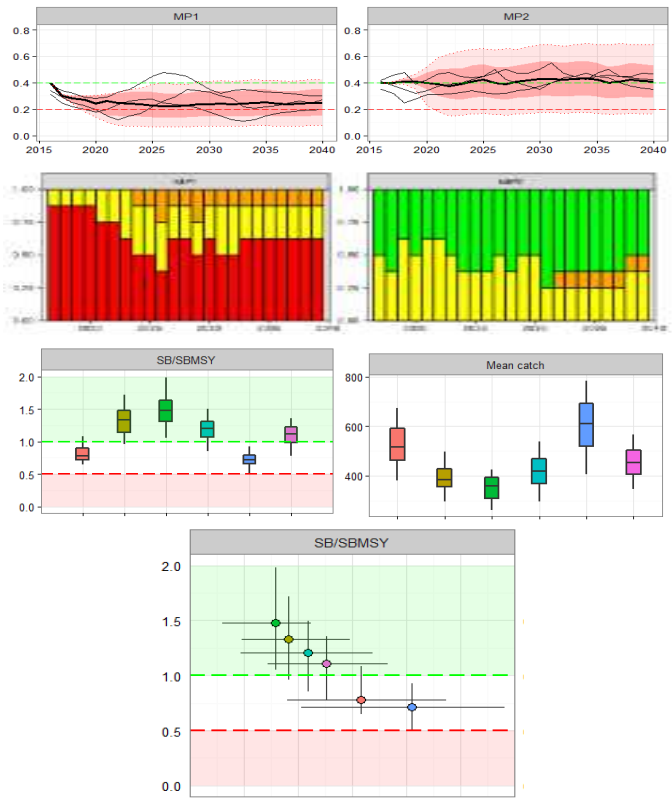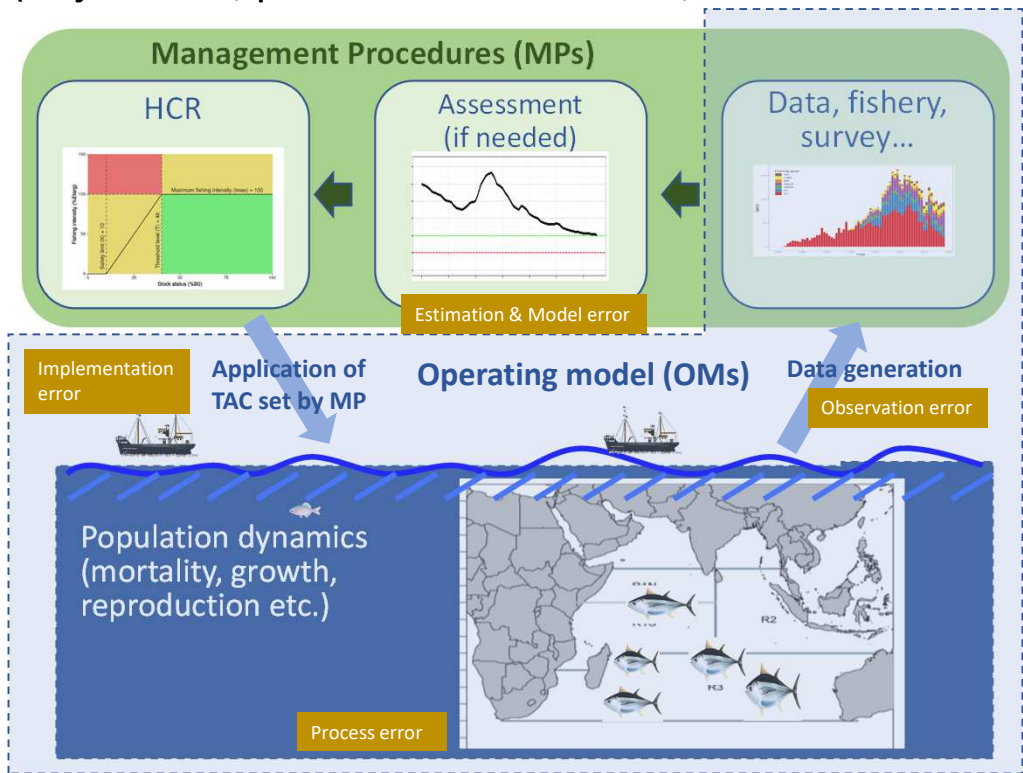
MSE Process

1. Identification of **Management objectives** and **performance measures**

2. Development of **Operating Models (OMs)**

3. Development of **Management Procedures (MPs)**

4. **Simulation testing** of MPs with the OMs

5. **Selection of an MP** based on simulation performance

6. **Implementation of the MP**

Management objectives ⟷ Performance measures

Selection of an MP

Management Procedures (MPs)

HCR — Assessment (if needed) — Data, fishery, survey…

Estimation & Model error

Implementation error

Application of TAC set by MP

Operating model (OMs)

Data generation

Observation error

- Population dynamics (mortality, growth, reproduction)
- Environmental factors
- Food web
- Genetic stock structure

Process error

Simulation testing

MP1

MP3

Stock size

SB/SBMSY

SB/SBMSY

Mean catch
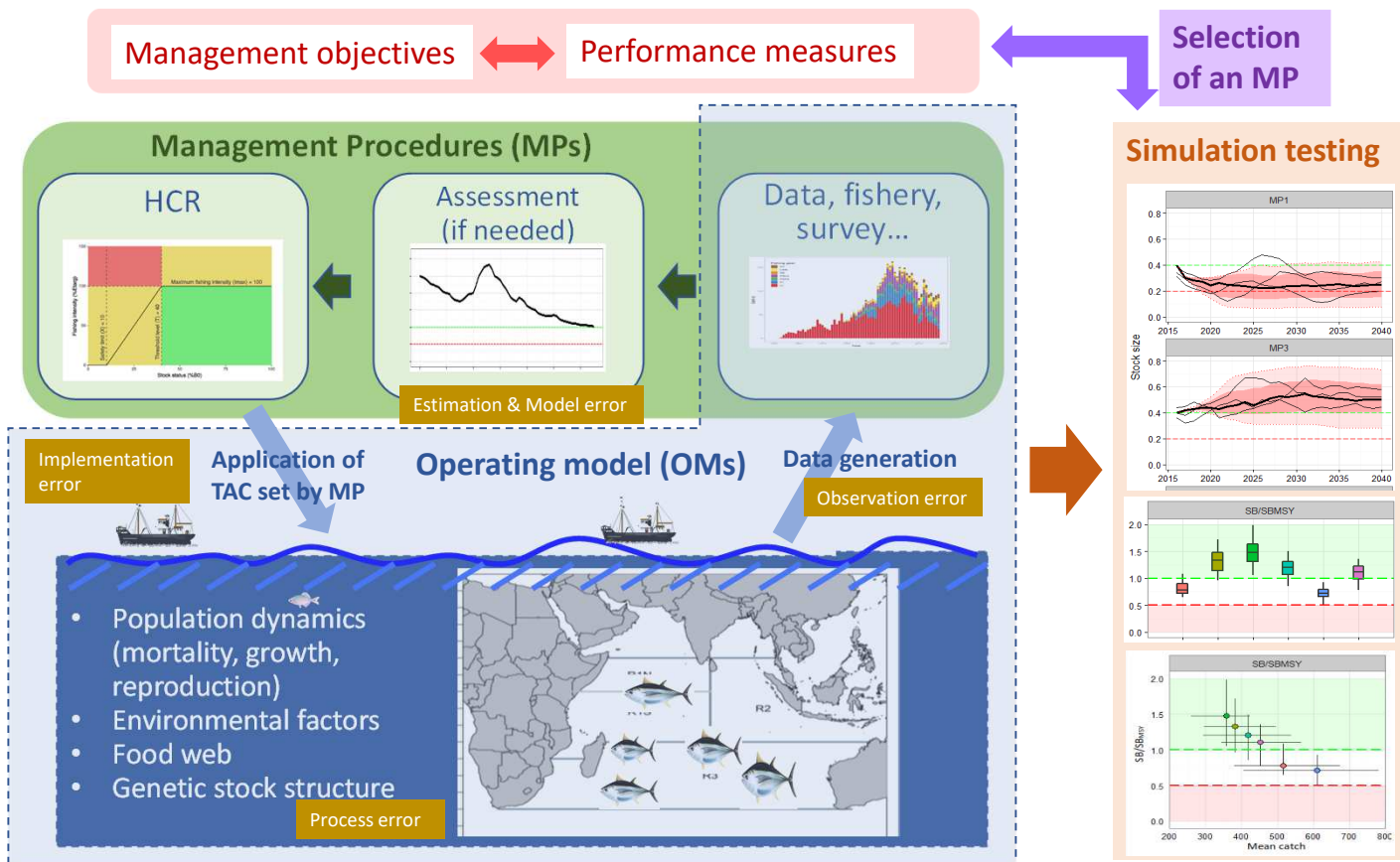
SOME REMARKS AND CAVEATS

Difference between **"Projection based on stock assessment"** and **"Projection in MSE"**?

"Management strategy evaluation is not the same as conducting projections from a stock assessment, although a stock assessment may form the basis for the operating model(s) which are core to a MSE" (Punt et al. 2016)

Constant catch

Biomass

B_0

B_{target}

−20%

0%

+20%

Past   Current   Future
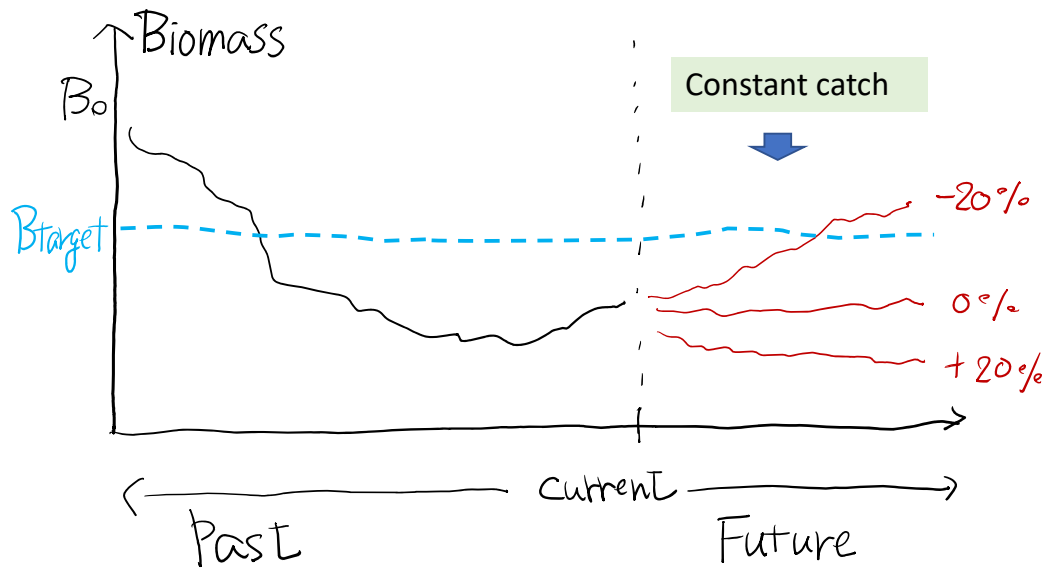
**Simple projection in K2SM:**
Based on a **predetermined** but **constant** catch over time with a certain level of catch reduction/enlargement

Reference point and projection timeframe	Alternative catch projections (relative to the average catch level from YYYY–YYYY) and probability (%) of violating MSY-based target reference points ($B_{targ} = B_{MSY}$; $F_{targ} = F_{MSY}$)								
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Difference between **"Projection based on stock assessment"** and **"Projection in MSE"**?

"Management strategy evaluation is not the same as conducting projections from a stock assessment, although a stock assessment may form the basis for the operating model(s) which are core to an MSE" (Punt et al. 2016)


With use of information available during the management period
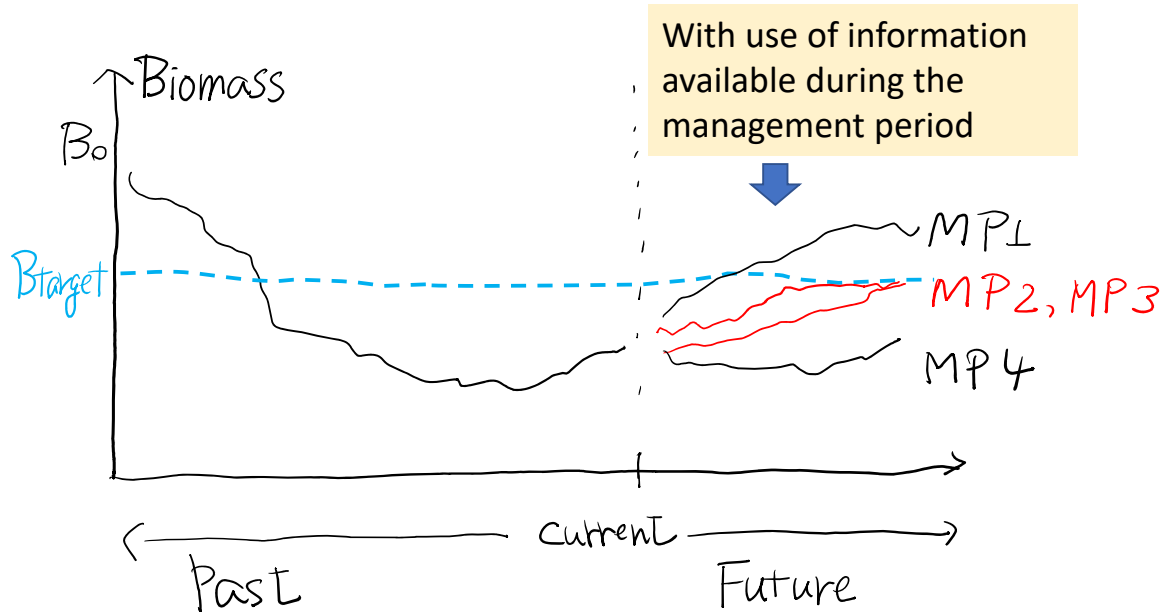
Projection in MSE:
Based on a **predetermined rule** with a **feedback mechanism** to control the catch

Difference between "Management Procedure (MP)" and "Harvest Control Rule (HCR)"?

- The both are predetermined rules

- An **HCR** (like the right figure) can work for setting a TAC only if an estimate of biomass is given

- So how to give an estimate of biomass with use of what information?

- An **MP** is a package of
 - Inputs for HCR (data collection and assessment if needed)
  - HCR

TAC

Biomass level

No catch

Some catch

Full catch
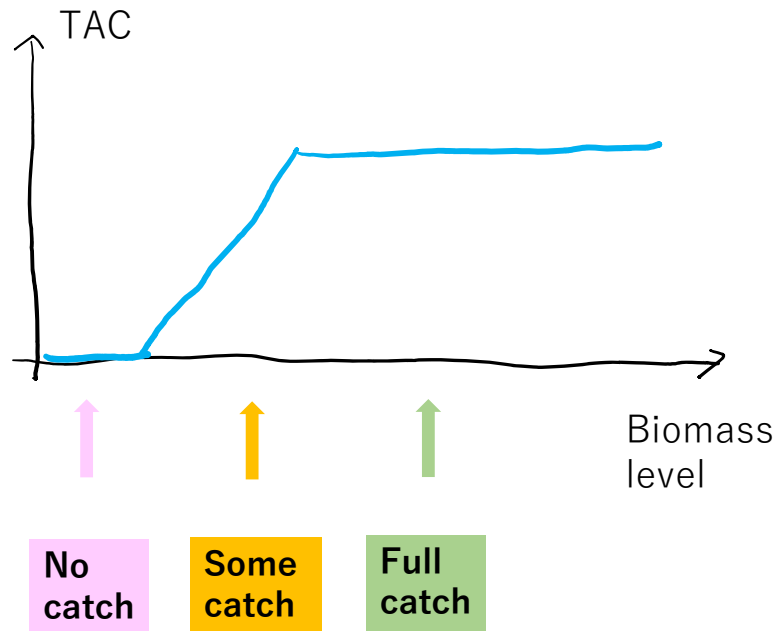
SKJ HCR (Resolution 16/02)

Harvest Control Rule (HCR)

6. The skipjack tuna stock assessment shall be conducted every three (3) years, with the next stock assessment to occur in 2017. Estimates of 7(a–c) shall be taken from a model-based stock assessment that has been reviewed by the Working Party on Tropical Tunas and endorsed by the Scientific Committee via its advice to the Commission.

7. The skipjack tuna HCR shall recommend a total annual catch limit using the following three (3) values estimated from each skipjack stock assessment. For each value, the reported median from the reference case adopted by the Scientific Committee for advising the Commission shall be used.

   a) The estimate of current spawning stock biomass (B_{curr});

   b) The estimate of the unfished spawning stock biomass (B_0);

   c) The estimate of the equilibrium exploitation rate (E_{targ}) associated with sustaining the stock at B_{targ}.
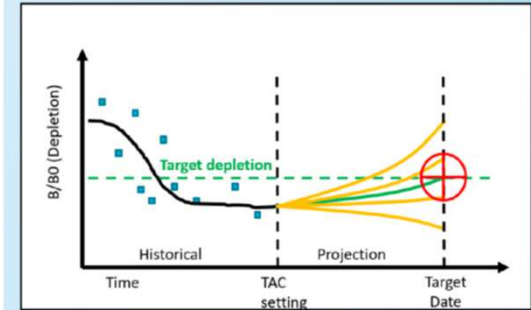
SEVERAL TYPES OF MPs IN IOTC
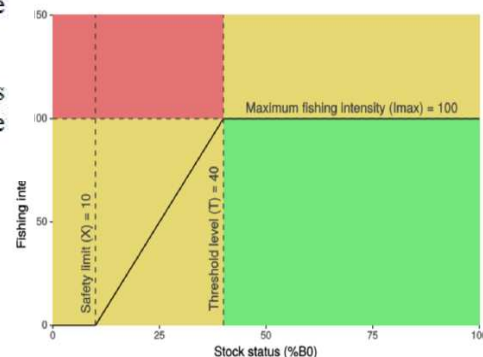
Empirical
(model-free, CPUE-based)
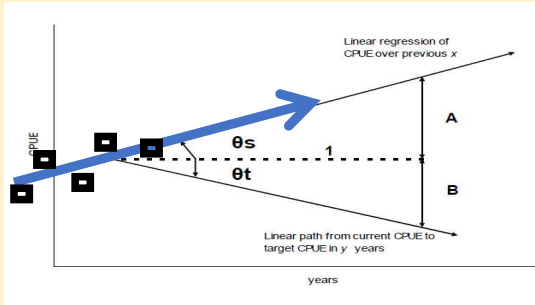
Model-based with
simple stock assessment
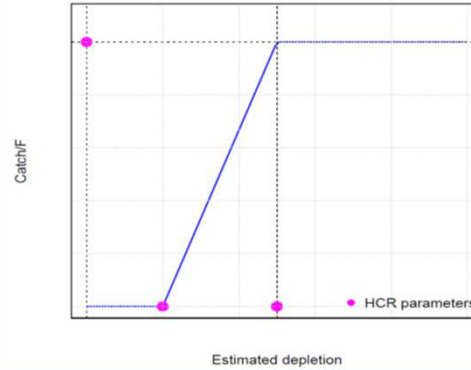
Model-based MP with
internal projection

- **Models for stock assessment**
  - Not only to know stock status and benchmark statistics but also to capture detailed mechanism and history of population dynamics (by age/life stage), fisheries impact (by gear/space/time), environmental impact etc.
  - Complicated models (e.g. spatial, age, gender-structured) are preferred to reflect reality as much as possible

- **Models for stock assessment in Management Procedures (MPs)**
  - Normally **simpler assessment models** than the actual assessment models are used to give input to HCR
  - Models used in MP should not be completely equal to the "assessment models" and "OMs" (like blind test)

- **Operating Models (OMs) in MSE**
  - To play roles of **"virtual population dynamics"** and **"virtual fishery"** in the simulation
  - To produce virtual data (with observation error) to be used in MPs
  - To reflect catch (and its implementation error) from specified MPs by virtual fishery in virtual population
  - OMs are primarily based on the stock assessment, but several and broader ranges of uncertainties in key parameters are considered to test the performance and robustness of MPs comprehensively

Models for assessment within MPs

Simpler assessment models to give **robust input on stock status** to HCR
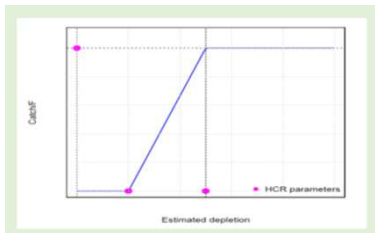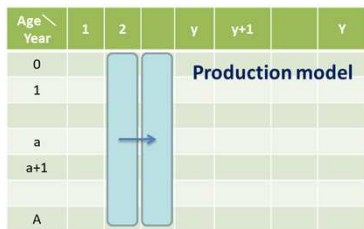
Models for assessment

Stock status, benchmark, detailed mechanism and life history (by age/life stage and by gear/space/time)
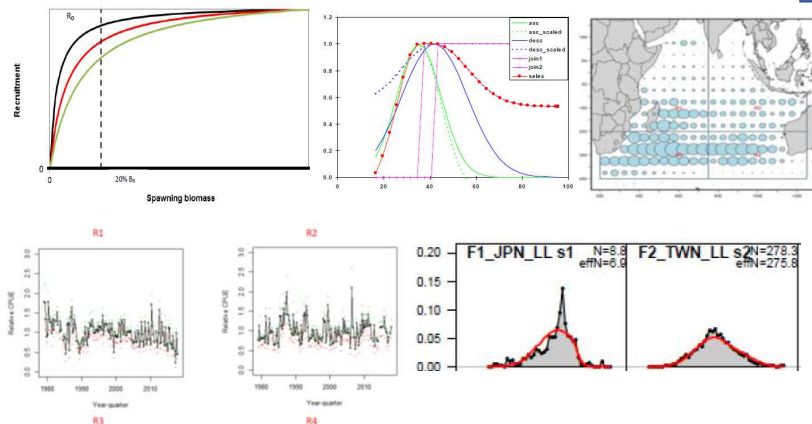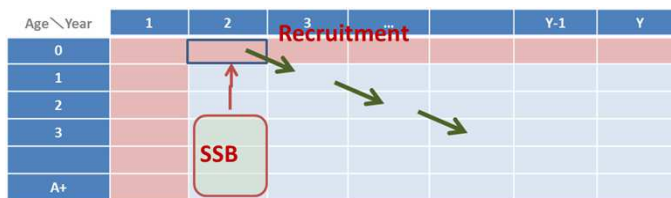
Operating Models (OMs) in MSE

To play roles of "virtual population dynamics" and "virtual fishery" in the simulation

Primarily based on the stock assessment, but several and broader ranges of uncertainties in key parameters are considered

- MSE is to test MPs as a mechanism to set TAC

- So, MSE has to consider a reality of each target stock, but not necessarily overly mimic the best available knowledge

- Rather, MSE considers various uncertainty in OMs and accounts for potential situations

- However, if stock assessment results fall outside the range of uncertainty captured by the OMs, and reconditioning of the OMs might be needed

- MSE is to be reviewed and updated regularly
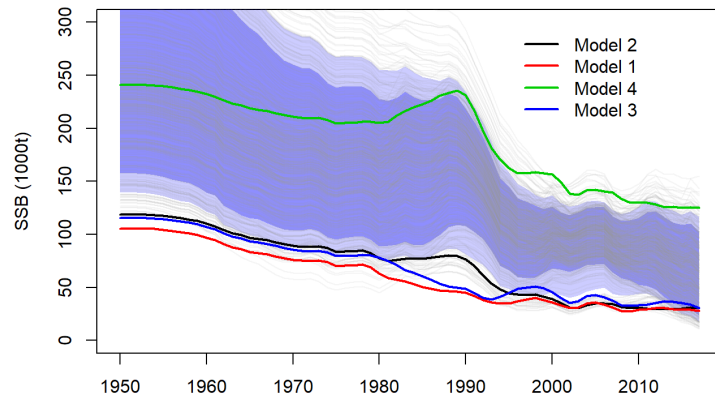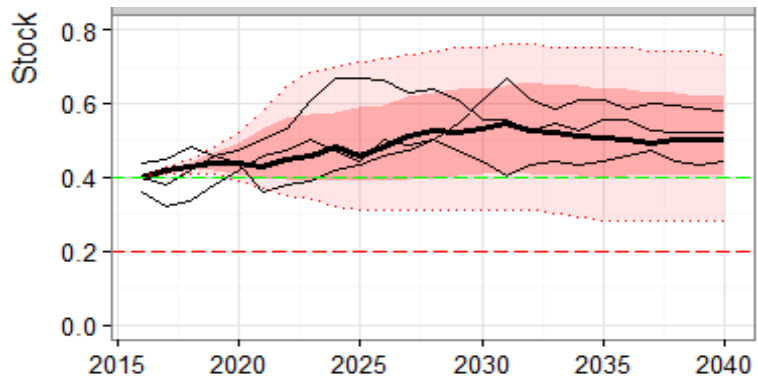
- **Need "regular monitoring" for MP implementation**
- **Need safeguard for "Exceptional Circumstances"**
  - New information: out of range of previous knowledge
    - e.g. stock status, fishing operations, dynamics, biology etc.
  - Input data for MP: missing (no longer available), historically changed etc.
  - Inconsistency between TAC recommended and actual catch
  - Rare events, when the fishery system falls outside of the scope of the simulation testing, e.g.
    - Large IUU catches identified
    - Sustained recruitment failure

Further discussion under Item 7.1 and 7.6

PART II

RECENT HISTORIES OF MSE ACTIVITY IN THE IOTC

& ROLES OF RESPONSIBILITIES, DIALOGUE TOOLS, AND FEEDBACK MECHANISM

MSE works for 5 stocks:

- **Albacore**
- **Bigeye**
- **Yellowfin**
- **Skipjack**
- **Swordfish**
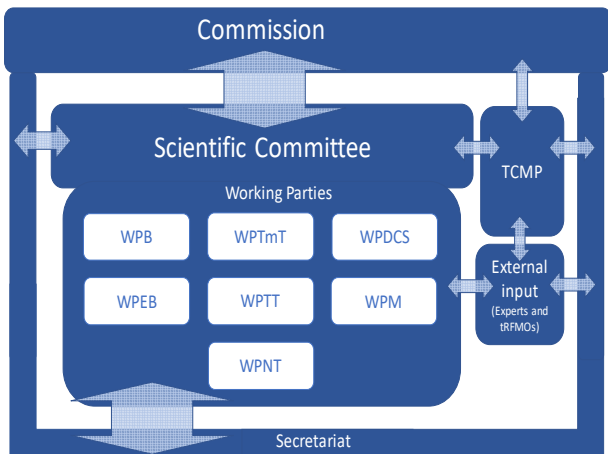
Task	Responsibility	Where
Specify and priorities objectives, qualitatively/quantitatively	Managers/Stakeholders (Scientist) - Dialogue	TCMP-COM
Translate objectives into performance measures statistics	Managers/Stakeholders (Scientist) - Dialogue	TCMP-COM
Develop Operating Models and key uncertainty	Scientist	WPM-SC
Development of candidate Management Procedures	Scientist (Managers)	WPM-SC
MSE Simulation of the candidates of management procedure	Scientist	WPM-SC
Compare MP performance statistics and trade-offs	Managers/Stakeholders	TCMP
Selection and adoption of Management Procedure	Managers	COM

- **In 2016**
  - Resolution 16/09 on establishing a TCMP
  - MP/MSE Workplan developed by WPM/SC

- **In 2017, 2018 and 2019**
  - 1st, 2nd and 3rd Sessions of TCMP (and hands-on workshop)
  - MP/MSE Workplan adopted by Commission

- **In 2020-2021**
  - Continued work on development of MSE (progress and status will be introduced soon)
  - 4th TCMP virtually in 2021

- Tuning only works for a single (high priority) objective
- Tuning involves changing a control parameter within Management Procedures
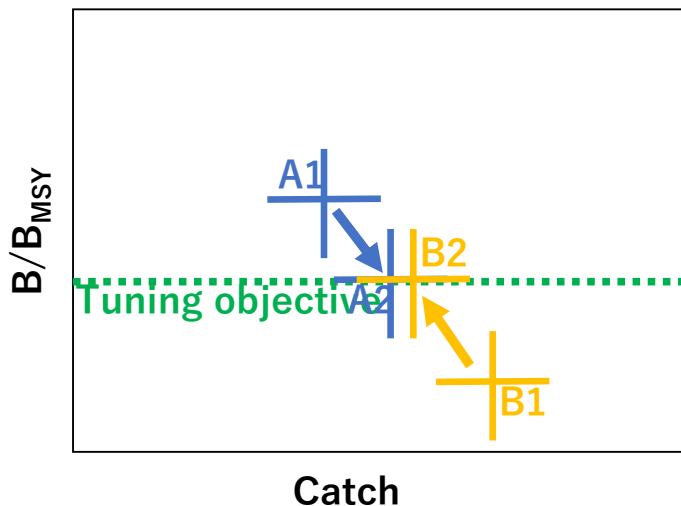
A1 & B1 are not tuned at the same level and, thus, not comparable

A2 & B2 are tuned to achieve the target biomass objective

B2 yields higher catch than A2

Bigeye tuna

- **B1**: Pr(Kobe green zone 2030:2034) = 0.5.   The stock status is in the Kobe green quadrant over the period 2030-2034 exactly 50% of the time (averaged over all simulations).
- **B2**: Pr(Kobe green zone 2030:2034) = 0.6.   The stock status is in the Kobe green quadrant over the period 2030-2034 exactly 60% of the time (averaged over all simulations).
- **B3**: Pr(Kobe green zone 2030:2034) = 0.7.   The stock status is in the Kobe green quadrant over the period 2030-2034 exactly 70% of the time (averaged over all simulations).

Yellowfin

- **Y1**: Pr(SB(2024)>=SB(MSY)) = 0.5 (SB in 2024 exceeds SBMSY in exactly 50% of the simulations).
- **Y2**: Pr(SB(2029)>=SB(MSY)) = 0.5 (SB in 2029 exceeds SBMSY in exactly 50% of the simulations).
- **Y3**: Pr(SB(2034)>=SB(MSY)) = 0.5 (SB in 2034 exceeds SBMSY in exactly 50% of the simulations).

Albacore tuna

- **A1**: Pr(mean(SB(2019:2038)>=SB(MSY)) = 0.5. Average SB over the period 2019-2038 exceeds SB MSY in exactly 50% of the simulations).
- **A2**: Pr(Kobe green zone 2019:2038) = 0.5. The stock status is in the Kobe green quadrant over the period 2019-2038 exactly 50% of the time (averaged over all simulations).
- **A3**: Pr(Kobe green zone 2019:2038) = 0.6. The stock status is in the Kobe green quadrant over the period 2019-2038 exactly 60% of the time (averaged over all simulations).
- **A4**: Pr(Kobe green zone 2019:2038) = 0.7. The stock status is in the Kobe green quadrant over the period 2019-2038 exactly 70% of the time (averaged over all simulations).

- B1[50%] represents a substantially higher risk of exceeding SB reference points than B2[60%] and B3[70%].
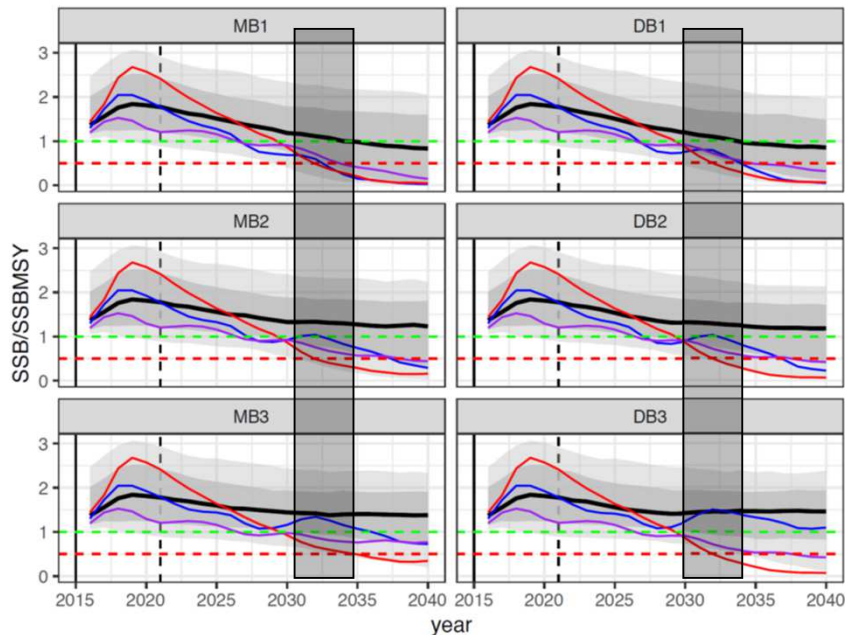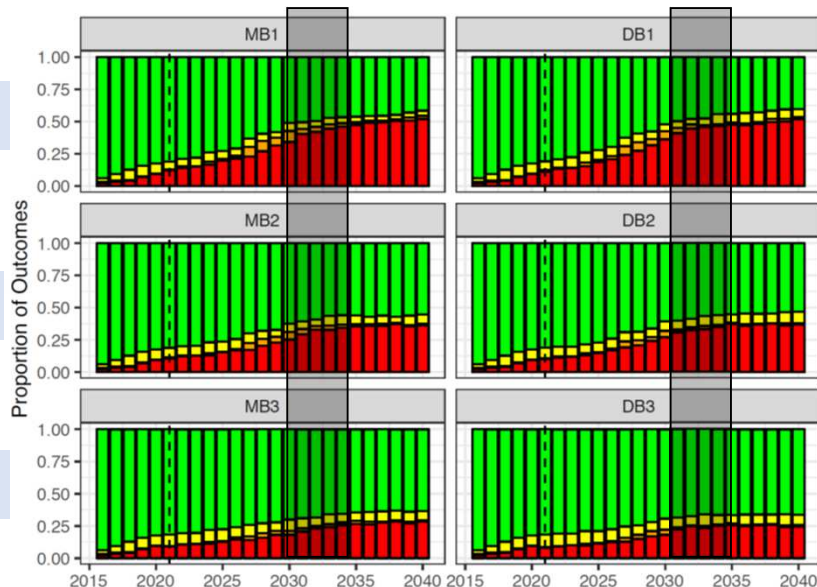
- Achieving the B1 tuning requires a substantial increase in average catches in the short term. This does not appear to be desirable for industry at present, because catches have been declining in recent years, despite the perception of healthy stock status.

50% tuning
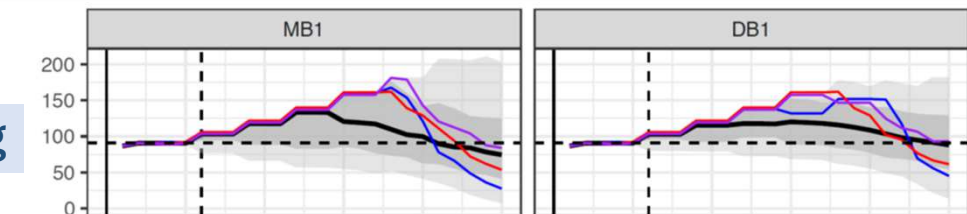
60% tuning
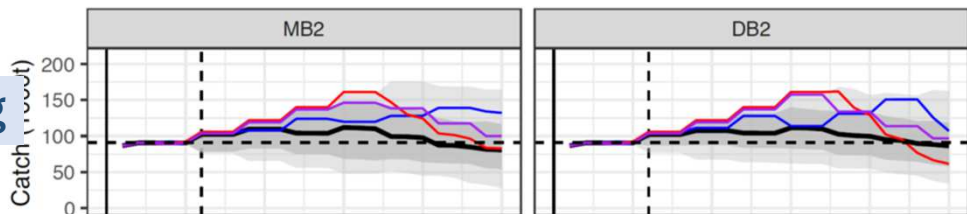
70% tuning
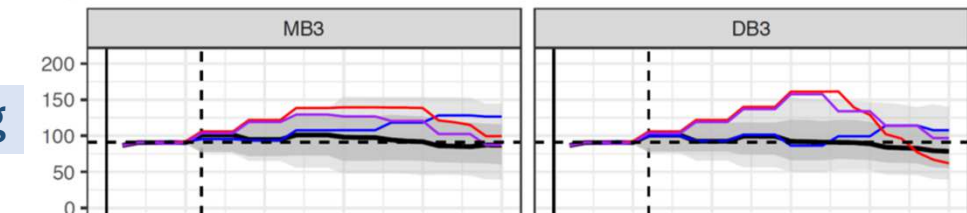
TCMP in 2019

Bigeye tuna

- ~~**B1:** Pr(Kobe green zone 2030:2034) = 0.5. The stock status is in the Kobe green quadrant over the~~
  ~~period 2030-2034 exactly 50% of the time (averaged over all simulations).~~
- **B2:** Pr(Kobe green zone 2030:2034) = 0.6. The stock status is in the Kobe green quadrant over the
  period 2030-2034 exactly 60% of the time (averaged over all simulations).
- **B3:** Pr(Kobe green zone 2030:2034) = 0.7. The stock status is in the Kobe green quadrant over the
  period 2030-2034 exactly 70% of the time (averaged over all simulations).

TCMP in 2021

Skipjack:
Same as the bigeye tuning criteria (but 50, 60, 70%)

Year	Albacore	Skipjack	Yellowfin	Bigeye	Swordfish
	TCMP: Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the Commission, including the performance of candidate MPs against Commission objectives.	**TCMP:** Provide advice to the Commission on outcomes from the application of the HCR. Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the Commission, including the performance of candidate MPs against Commission objectives.	**TCMP:** Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the Commission, including the performance of candidate MPs against Commission objectives.	**TCMP:** Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the Commission, including the performance of candidate MPs against Commission objectives.	**TCMP:** Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the Commission, including the performance of candidate MPs against Commission objectives.
	Commission: Consider work and advice from subsidiary bodies and provide direction to the WPs/SC on the need for further MSE of candidate or alternative MPs.	**Commission:** Consider work and advice from subsidiary bodies and provide direction to the WPs/SC on the need to undertake further MSE of candidate or alternative MPs	**Commission:** Consider work and advice from subsidiary bodies and provide direction to the WPs/SC on the need to undertake further MSE of candidate or alternative MPs.	**Commission:** Consider work and advice from subsidiary bodies and provide direction to the WPs/SC on the need to undertake further MSE of candidate or alternative MPs.	**Commission:** Consider work and advice from subsidiary bodies and provide direction to the WPs/SC on the need to undertake further MSE of candidate or alternative MPs.
	WPs/SC: Consider recommendations from the Commission and undertake MSE to provide advice on the performance of candidate MPs.	**WPs/SC:** Consider recommendations from the Commission and undertake MSE to provide advice on the performance of candidate MPs.	**WPs/SC:** Consider recommendations from the Commission and undertake MSE to provide advice on the performance of candidate MPs.	**WPs/SC:** Consider recommendations from the Commission and undertake MSE to provide advice on the performance of candidate MPs.	**WPs/SC:** Consider recommendations from the Commission and undertake MSE to provide advice on the performance of candidate MPs.

Year	Albacore	Skipjack	Yellowfin	Bigeye	Swordfish
2022	**TCMP:** Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the Commission, including the performance of candidate MPs against Commission objectives.	**TCMP:** Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the Commission, including the performance of candidate MPs against Commission objectives.	**TCMP:** Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the Commission, including the performance of candidate MPs against Commission objectives.	**TCMP:** Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the Commission, including the performance of candidate MPs against Commission objectives.	**TCMP:** Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the Commission, including the performance of candidate MPs against Commission objectives.
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	WPs/SC: Consider recommendations from the Commission and undertake MSE to provide advice on the performance of candidate MPs.	**WPs/SC:** Consider recommendations from the Commission and undertake MSE to provide advice on the performance of candidate MPs.	**WPs/SC:** Consider recommendations from the Commission and undertake MSE to provide advice on the performance of candidate MPs.	**WPs/SC:** Process and application of the adopted MP.	**WPs/SC:** Consider recommendations from the Commission and undertake MSE to provide advice on the performance of candidate MPs.

Year	Albacore	Skipjack	Yellowfin	Bigeye	Swordfish
2023	**TCMP:** Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the	**TCMP:** Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the	**TCMP:** Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the	**TCMP:**	**TCMP:** Provide advice to the Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the
	Commission, including the performance of candidate MPs against Commission objectives.	Commission, including the performance of candidate MPs against Commission objectives.	Commission, including the performance of candidate MPs against Commission objectives.		Commission, including the performance of candidate MPs against Commission objectives.
	Commission: Consider work and advice from subsidiary bodies and provide direction to the WPs/SC on the need to undertake further MSE of candidate or alternative MPs.	**Commission:** Consider work and advice from subsidiary bodies. Decision and adoption of an MP.	**Commission:** Consider work and advice from subsidiary bodies and provide direction to the WPs/SC on the need to undertake further MSE of candidate or alternative MPs.	**Commission:**	**Commission:** Consider work and advice from subsidiary bodies and provide direction to the WPs/SC on the need to undertake further MSE of candidate or alternative MPs.
	WPs/SC: Consider recommendations from the Commission and undertake MSE to provide advice on the performance of candidate MPs.	**WPs/SC:** Consider recommendations from the Commission and undertake MSE to provide advice on the performance of candidate MPs.	**WPs/SC:** Consider recommendations from the Commission and undertake MSE to provide advice on the performance of candidate MPs.		**WPs/SC:** Consider recommendations from the Commission and undertake MSE to provide advice on the performance of candidate MPs,

Year	Albacore	Skipjack	Yellowfin	Bigeye	Swordfish
2024	**TCMP:** Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the Commission, including the performance of candidate MPs against Commission objectives.	**TCMP:** Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the Commission, including the performance of candidate MPs against Commission objectives.	**TCMP:** Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the Commission, including the performance of candidate MPs against Commission objectives.		**TCMP:** Provide advice to Commission on elements of candidate MPs, and any proposed Resolutions for an MP, that require a decision by the Commission, including the performance of candidate MPs against Commission objectives.
	Commission: Consider work and advice from subsidiary bodies. Decision and adoption of an MP.	**Commission:** Consider work and advice from subsidiary bodies. Decision and adoption of an MP.	**Commission:** Consider work and advice from subsidiary bodies. Decision and adoption of an MP.		**Commission:** Consider work and advice from subsidiary bodies. Decision and adoption of an MP.

- MSE development have been proceeding for five species parallelly
- Once a bigeye MP can be adopted, next target can be finalization of an MP for skipjack

Short video (~5min):

- PEW & Doug Butterworth : http://blog.through-the-gaps.co.uk/2017/06/scientist-doug-butterworth-on-benefits.html?m=1
- PEW: https://www.pewtrusts.org/en/research-and-analysis/articles/2020/05/04/new-fisheries-management-method-benefits-industry-and-ocean-health
- PEW: https://m.youtube.com/watch?v=V9QEG4R4-w0
- ISSF : https://m.youtube.com/watch?v=BAS4MeI2G2A

Medium length video (20-30min)

- Jim Ianelli: https://vimeo.com/130978719
- Campbell Davies: https://vimeo.com/96833649

Full presentation (60min)

- Andre Punt: https://m.youtube.com/watch?v=6aktDvDK9XY