

FISHERY POPULATION ASSESSMENT AND MANAGEMENT

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(TOKYO UNIVERSITY OF MARINE SCIENCE AND TECHNOLOGY)

JAN 19, 2021 @ONLINE CLASS



Last week

1. Brief introduction of fishery population assessment and management
2. Overview of stock assessment

This week

3. Overview of management strategy evaluation (MSE)

Please submit your report no later than Jan 26th

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- Content: summary of my two classes (2 page, 1 for each, in Japanese or English)



3. OVERVIEW OF MANAGEMENT STRATEGY EVALUATION (MSE)



Goals of fishery management

- Sustainability
(Medium & long-term interest with a conservation perspective)
 - Profit
(short- & medium-term interest, fishermen's perspective)
- => Generate sustainable economic and social benefit with a balance

Requirements of fishery management

- Clear agreed objectives for the fishery
 - **Assessment of stock status**
 - Sustainable level of harvest
- => "Management procedure" to control fishing in response to changes in population status

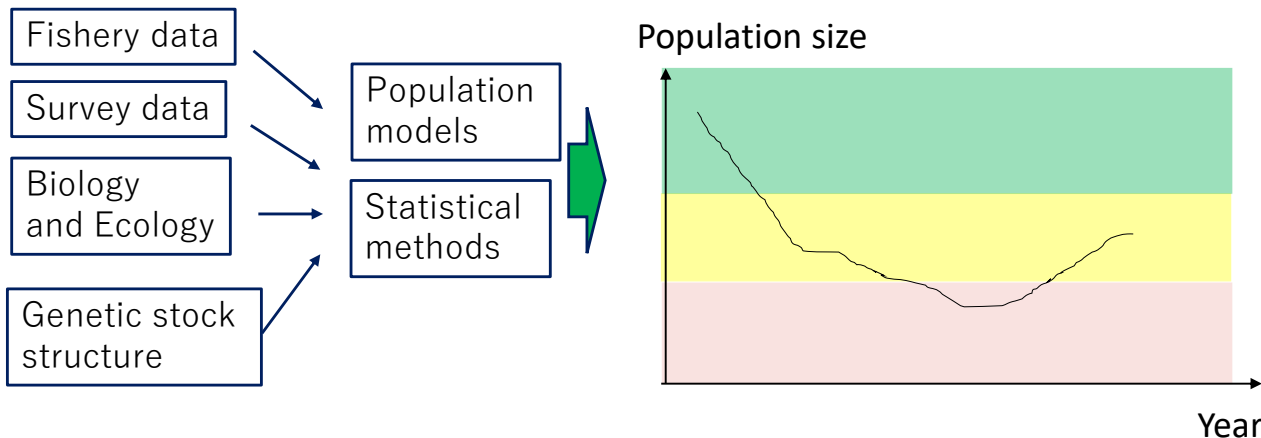
Easier to say, but...



Challenging issues

Assessments

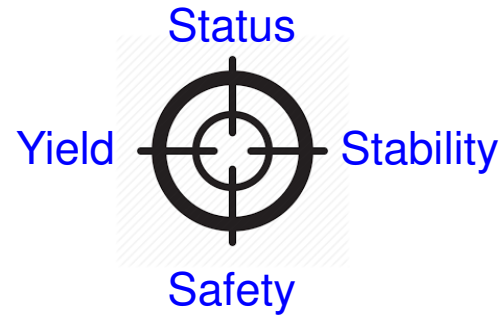
- Even obtaining valid fishery data (including catch, efforts etc.)
- Conducting fishery-independent surveys for monitoring (to cover space-time and several life stages)
- Stock structures and biology



Challenging issues

Development of Management Procedures

- Setting management objectives
because of trade-offs (conservation and fishery perspectives)
- Setting management procedures



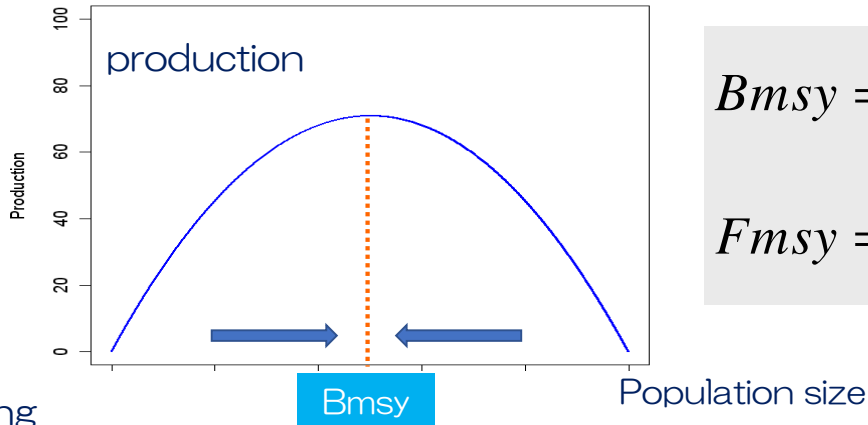
Challenging issues

Actions

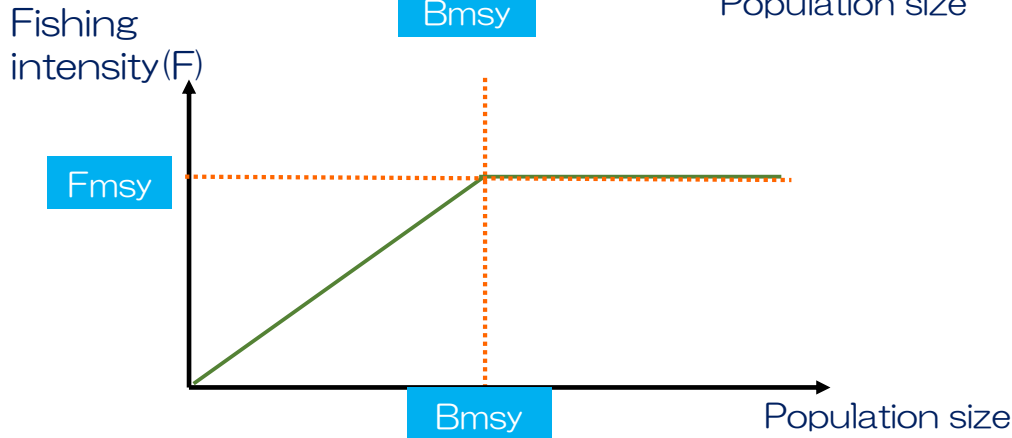
- Implementation of a regulation with allocation criteria
- Develop a future monitoring scheme to check any implementation errors or violations



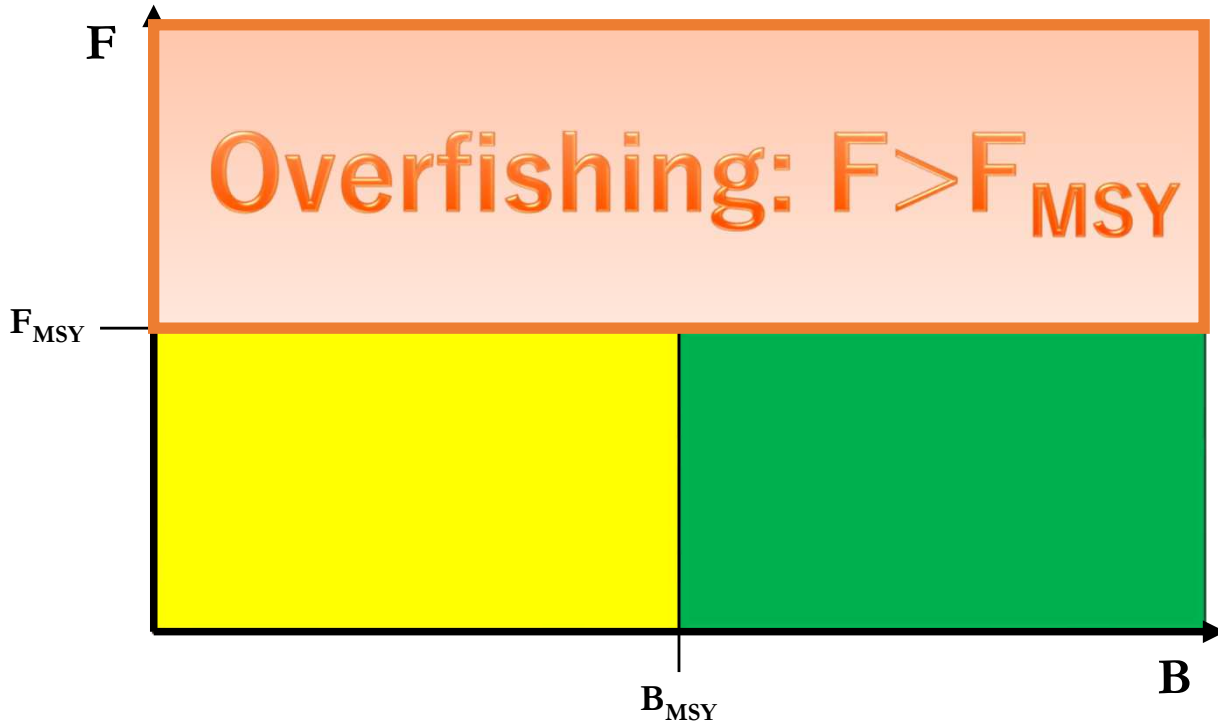
Quickly about Bmsy and Fmsy



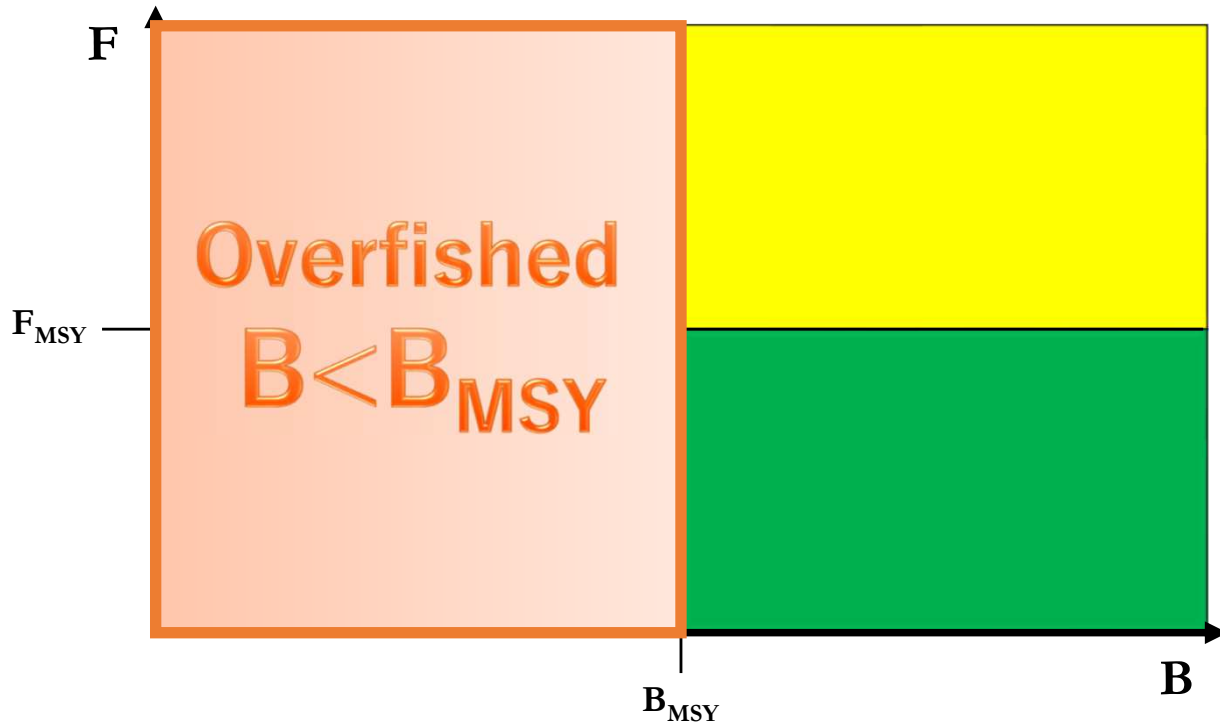
$$Bmsy = \frac{K}{2}$$
$$Fmsy = \frac{r}{2}$$



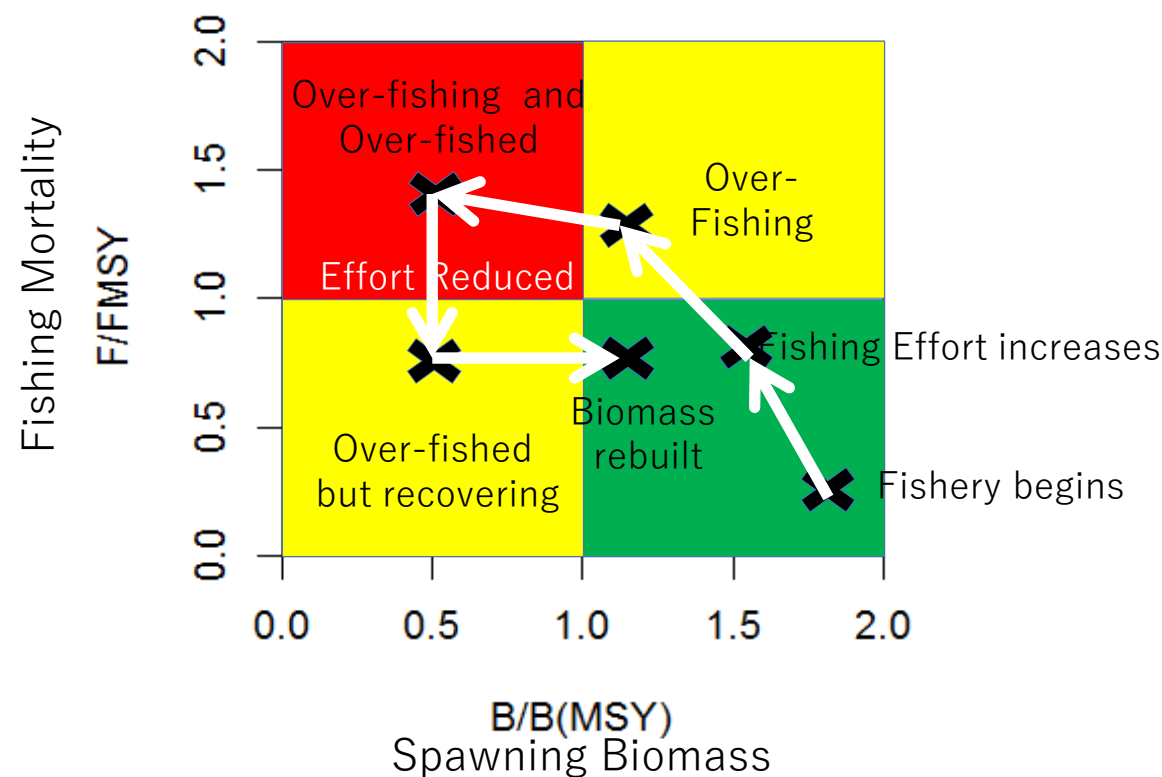
“Kobe plot”



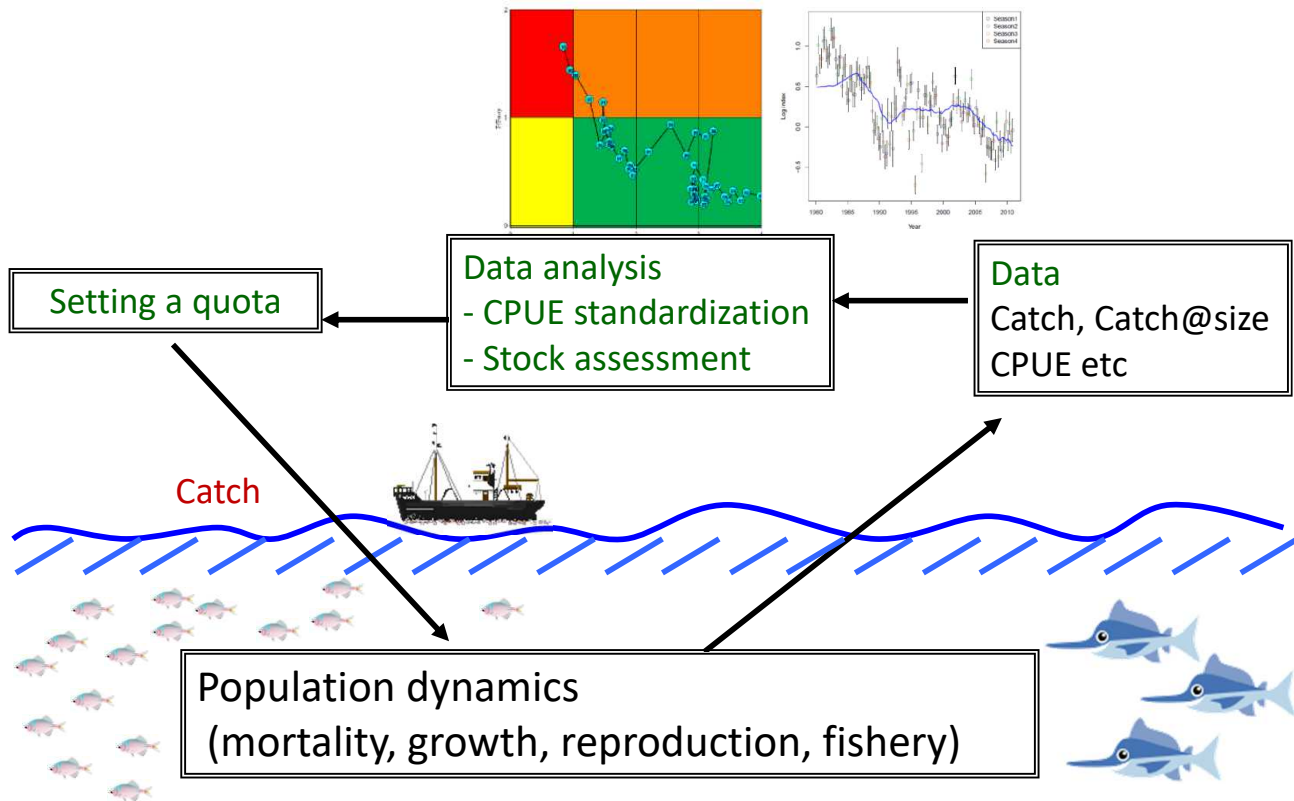
“Kobe plot”



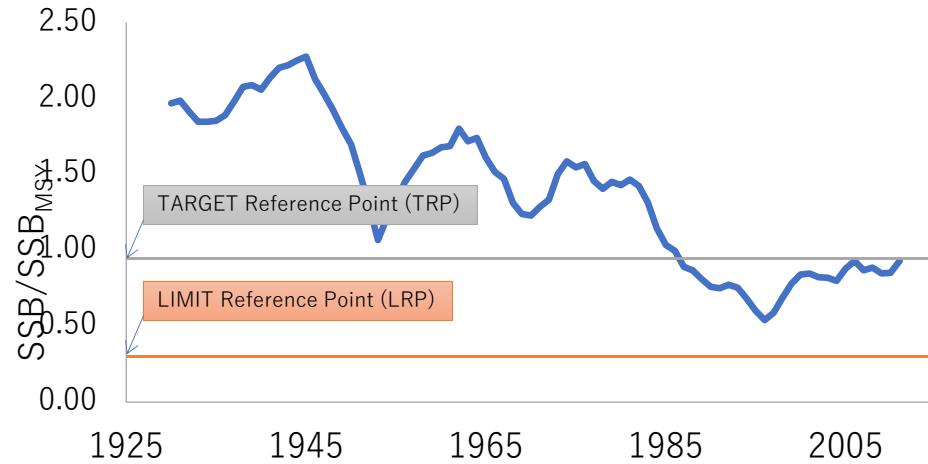
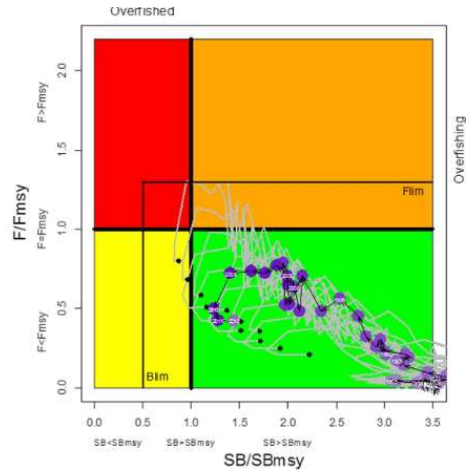
Providing scientific advice



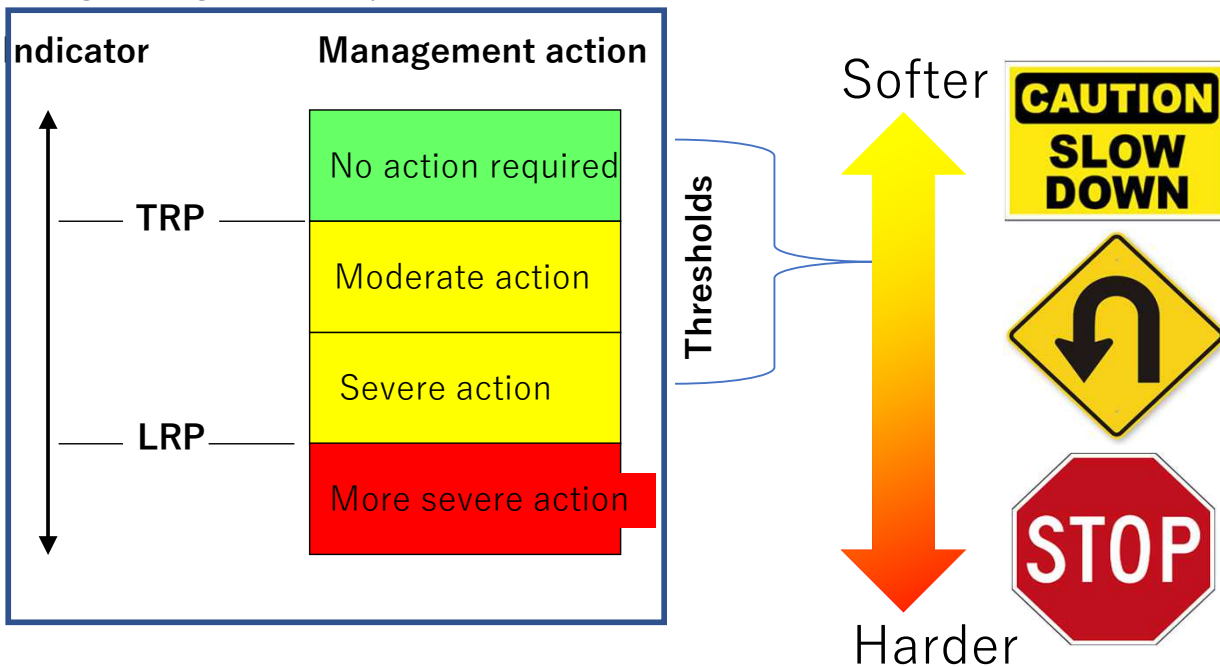
MSE in nutshell



1.- Stock assessment – where we are now



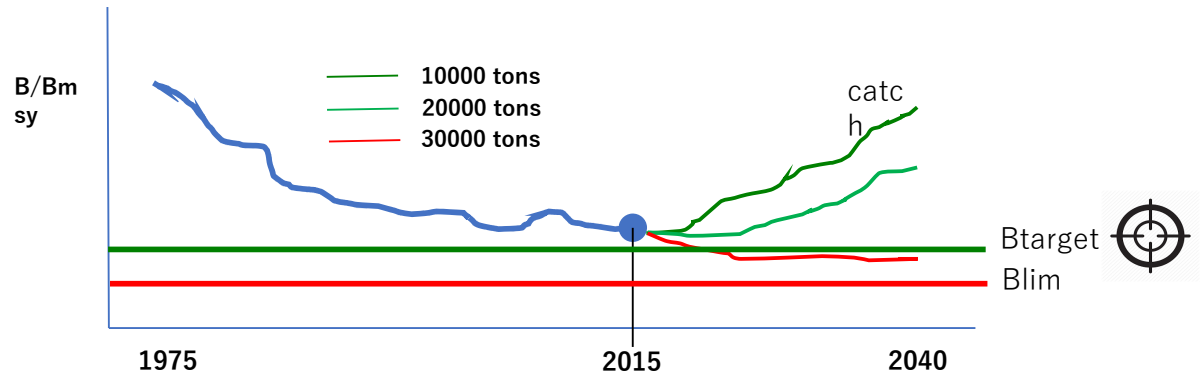
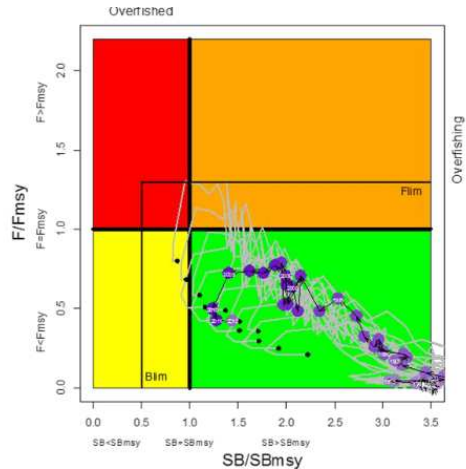
- **Target Reference Points (TRPs)**: values for stock size and/or fishing mortality rate that a manager aims to **achieve and maintain**.
- **Limit Reference Points (LRPs)**, which describe an undesirable state of the indicator that should be **avoided** with high probability.
- **Thresholds** defining management responses.



Providing scientific advice: Traditional approach

1.- Stock assessment – where we are now

2.- Stock Projections – How to get to the target



Kobe II Strategy Matrix

TAC	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
60,000	54%	63%	71%	75%	79%	82%	84%	85%	86%	87%
70,000	54%	61%	67%	71%	74%	76%	77%	79%	80%	81%
80,000	54%	58%	62%	66%	68%	70%	71%	72%	73%	74%
90,000	54%	57%	58%	60%	61%	62%	62%	63%	63%	64%
100,000	53%	54%	54%	54%	54%	54%	54%	54%	55%	55%
110,000	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%



Why MSE?

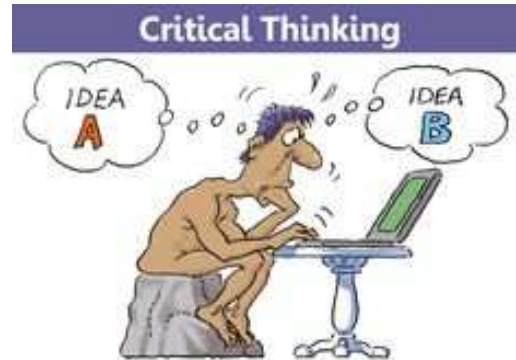
- Imagine that you are a responsible person to set a fishery quota for next XX years
- You might want to check if a quota set by "you" works or not



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Why MSE?

- But, how do you set a quota?
- How do you evaluate it?

➔ you need predetermined goals/objectives



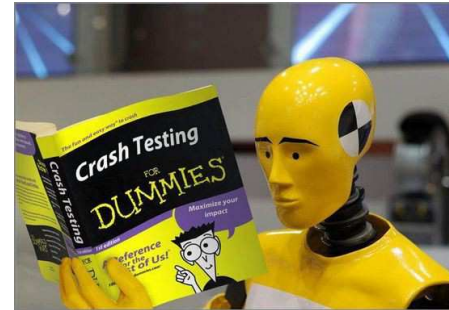
Why MSE?

- How do you set?
- How do you evaluate?



You need predetermined goals/objectives

You need computation
for simulation

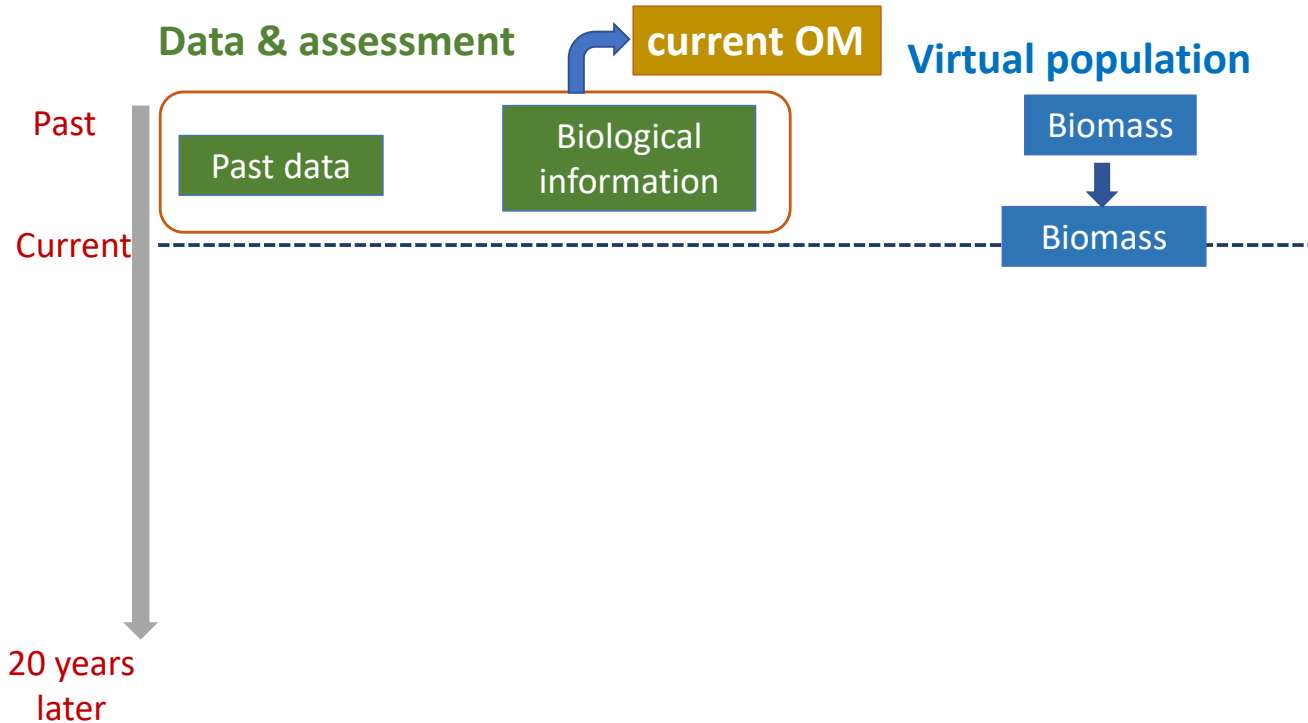


If the quota set by you does not perform adequately under simulation, can we expect it to work in the real world?"

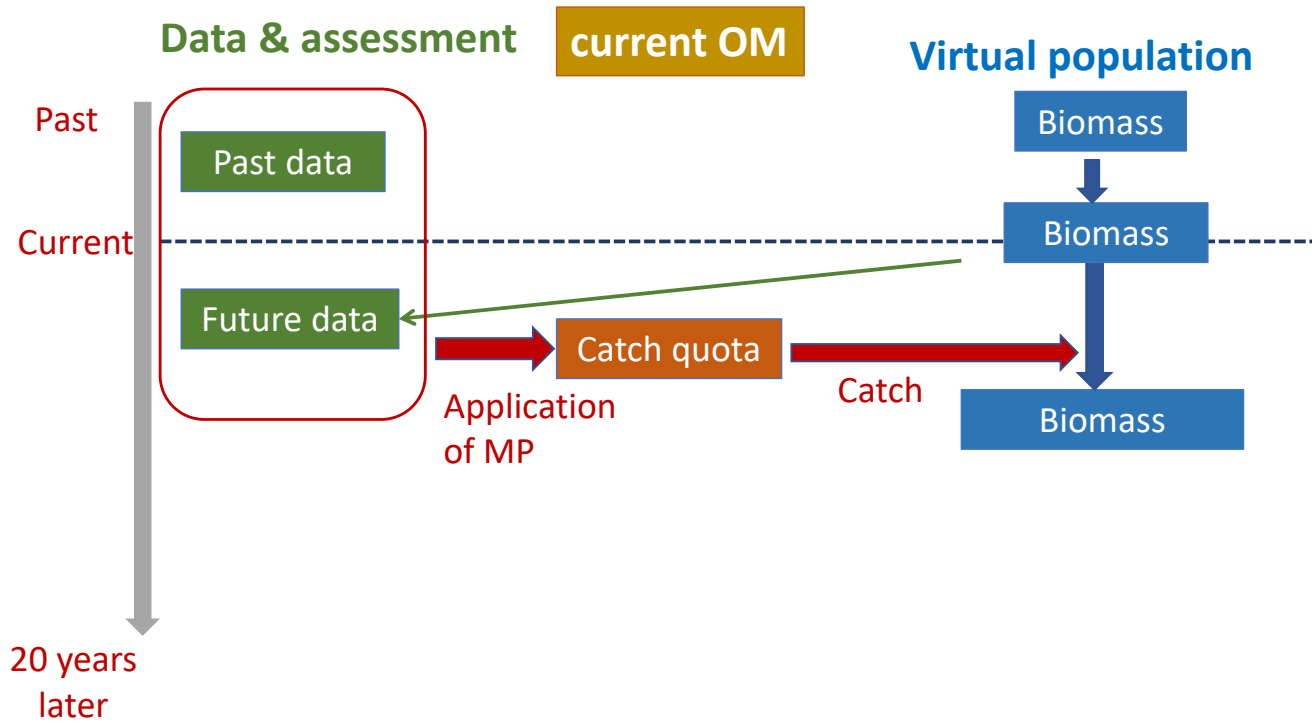
=> No!



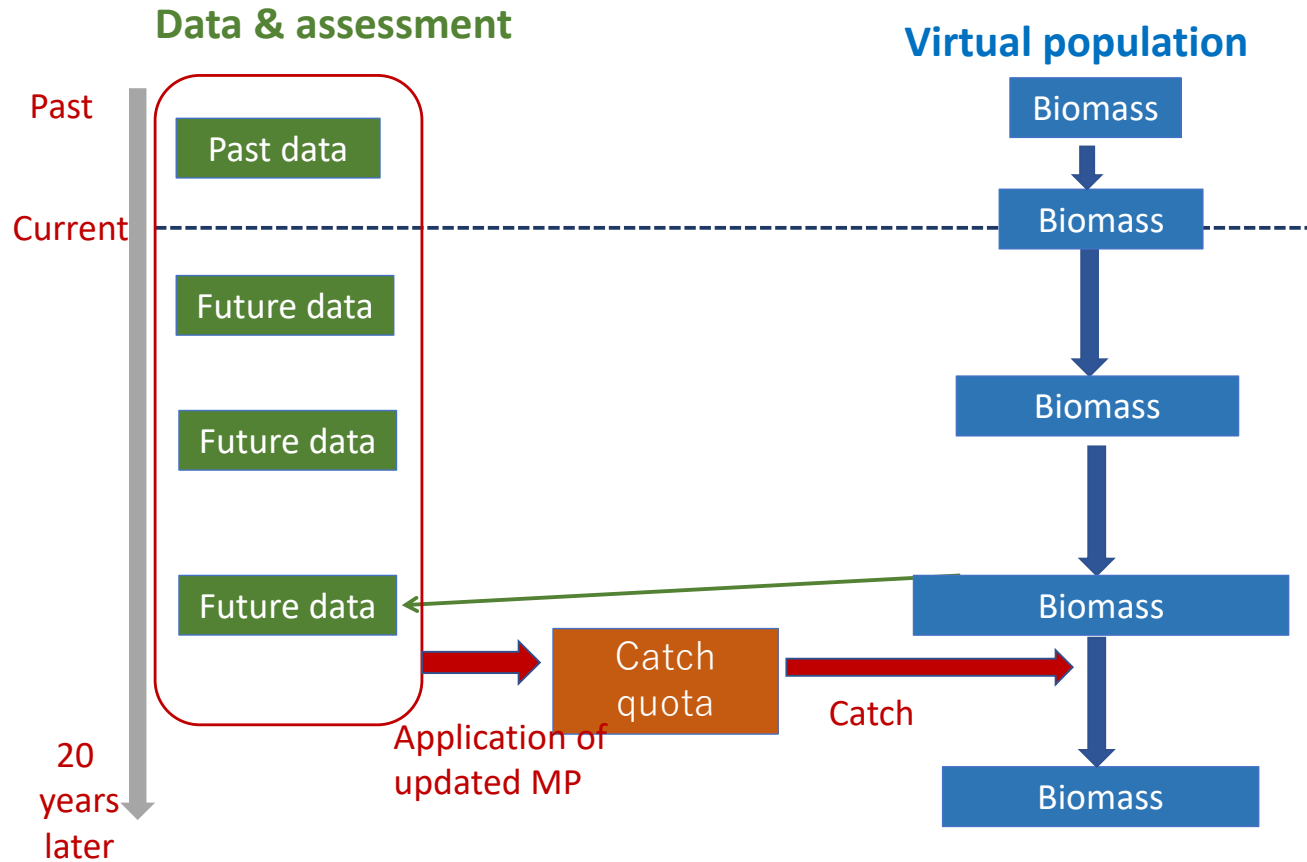
Update of MPs



Update of MPs



Update of MPs

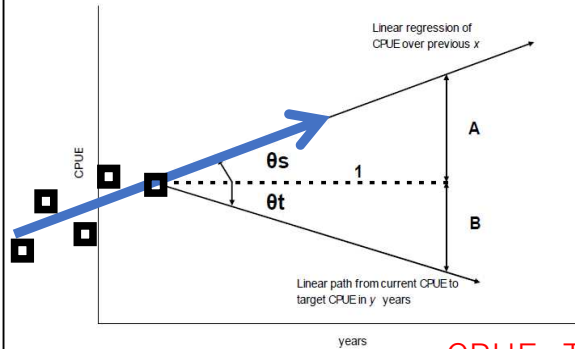


Currently two types of MPs

- 1) Empirical (model-free, CPUE-based)
- 2) Model-based (with a simple stock assessment)

1) Empirical MP:

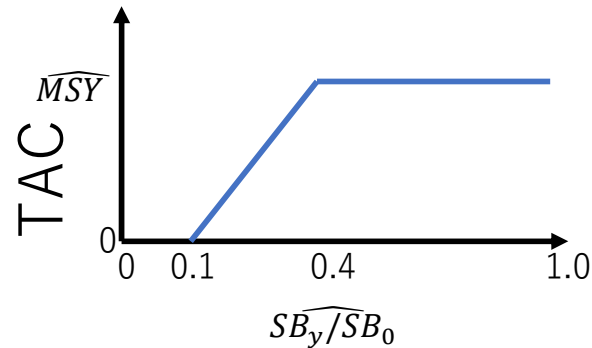
Aims to keep the stock near a target CPUE



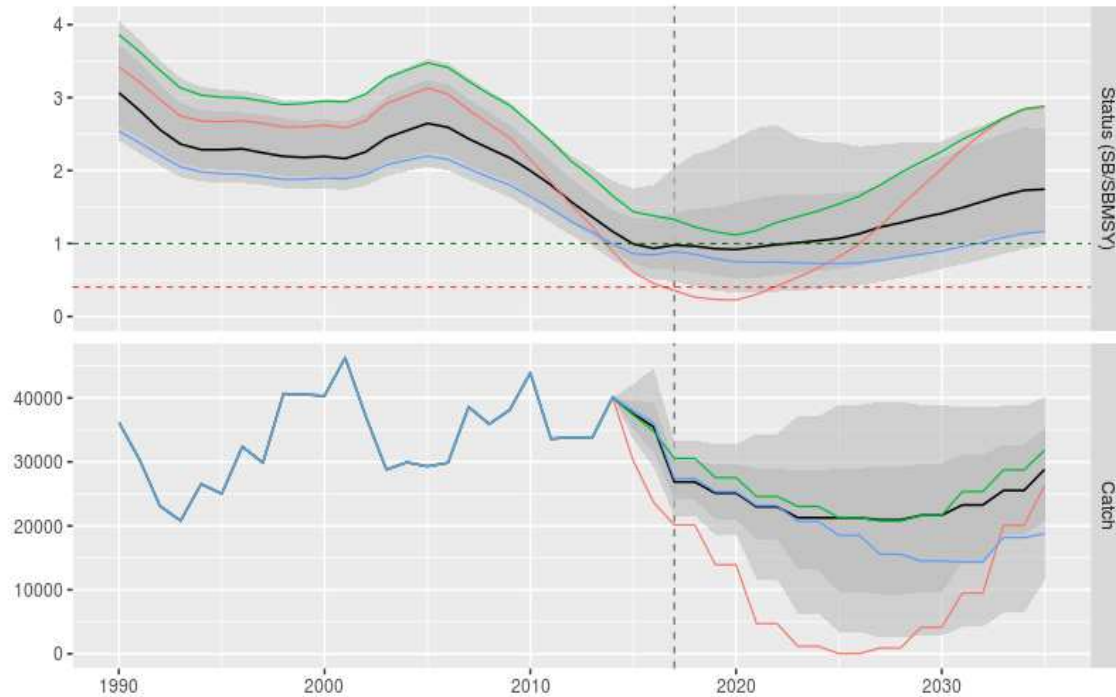
CPUE < Target
TAC decrease

2) Model-based MP:

- Fits a Pella-Tomlinson surplus production model,
- Set the TAC using a 40:10-type HCR



Update of MPs



- A simulation framework for assessing the performance of management procedures for wildlife
- The questions are: **if goals/objectives are achieved or not**
- Through this process, **various sources of uncertainty** are taken into account
- Also, **adaptive procedures** can be incorporated and tested
- So, MSEs should be practical as much as possible
- A pioneer work: **IWC/SC's RMP**
- Since then, the idea has been used and developed for lots of species (not only fishery resources but also terrestrial animals)



Opinion

Management strategy evaluation: a powerful tool for conservation?

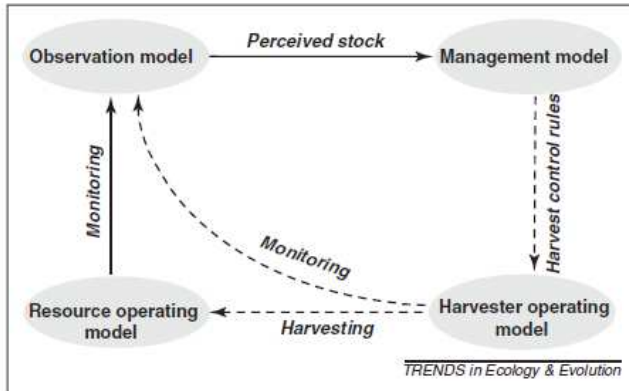
Nils Bunnefeld¹, Eriko Hoshino^{1,2} and Eleanor J. Milner-Gulland¹

¹ Department of Life Sciences, Imperial College London, Silwood Park, Buckhurst Road, Ascot, SL5 7PY, UK

² School of Economics and Finance, University of Tasmania, Private Bag 85, Hobart, TAS 7001, Australia



FRSOS in Ecology & Evolution



Box 1. Example of the successful use of MSE in fisheries

The Southern and Eastern Scalefish and Shark Fishery (SESSF) in Australia is a complex multi-species, multi-gear fishery with 34 stock units managed under a quota system as well as restrictions on gear and input controls implemented based on expert judgment. Despite the introduction of a quota system in 1992, a number of quota-managed species remained overfished. In 2005, a comprehensive harvest strategies framework was introduced and implemented into the SESSF. This framework is similar to a management procedure whereby monitoring and assessment is included as well as explicit harvest control rules [41]. However, at that time, the performance of



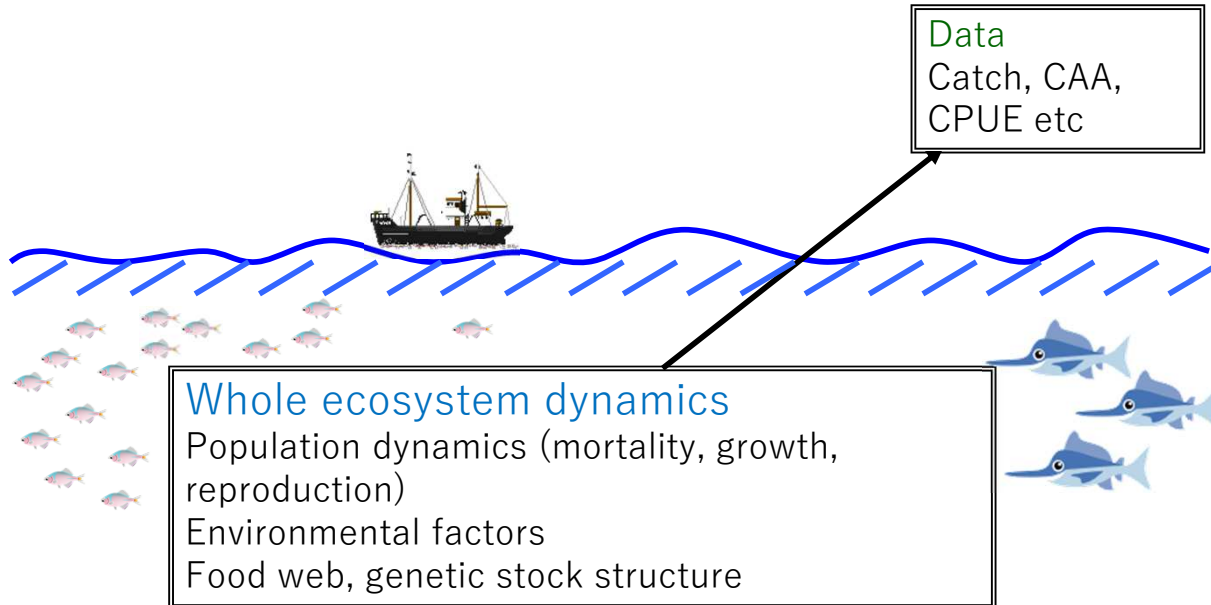
- Possible to handle various types of uncertainty (e.g. Francis & Shotton 1997)
 - Uncertainty in data and input parameters
 - Process uncertainty (e.g. process errors, environmental)
 - Estimation uncertainty (estimation error, SE, CV)
 - Model uncertainty
 - Implementation uncertainty
- Possible to consider adaptive managements
- Objective and comprehensive evaluation of management procedures and harvest control rules in terms of efficacy, advantage/disadvantage and risks
- Compatible with Ecosystem-based Fishery Management (EBFM)
- Bridge between scientific and social interests



1. **Specification and prioritization** of management objectives
2. Translation of the management objectives to **performance measures and risk indicators**
3. Construction of **Operating Models (OMs)**
4. Proposition of management procedures (MPs) or harvest **control rules (HCRs)**
5. **Implementation** of simulation trials
6. **Comparison of performance** for various procedures
7. **Advice** of MPs or HCRs which meet management objectives

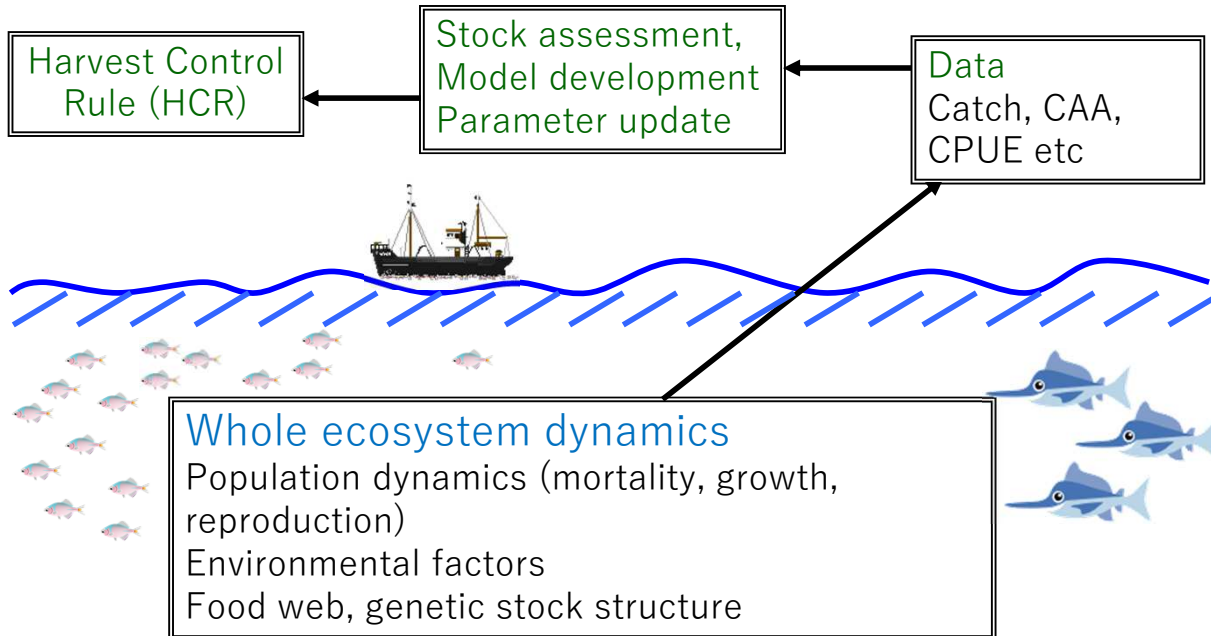


Fishery management

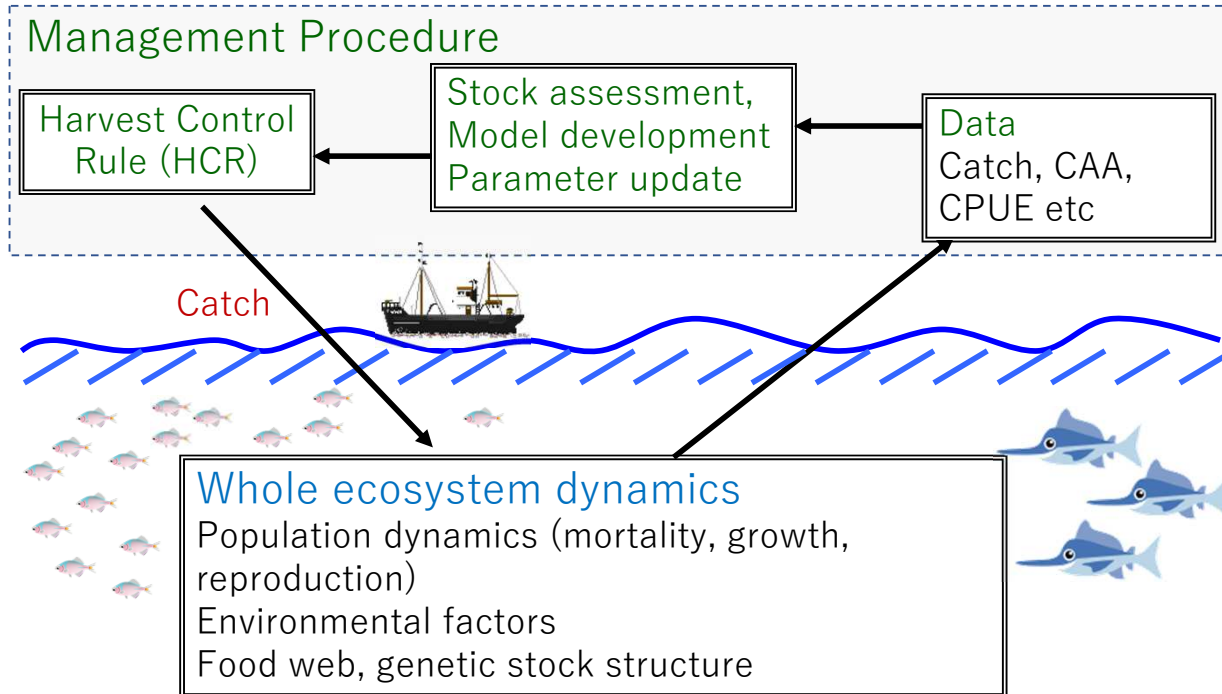


Fishery management

Total Allowable Catch (TAC) Allowable Biological Catch (ABC)



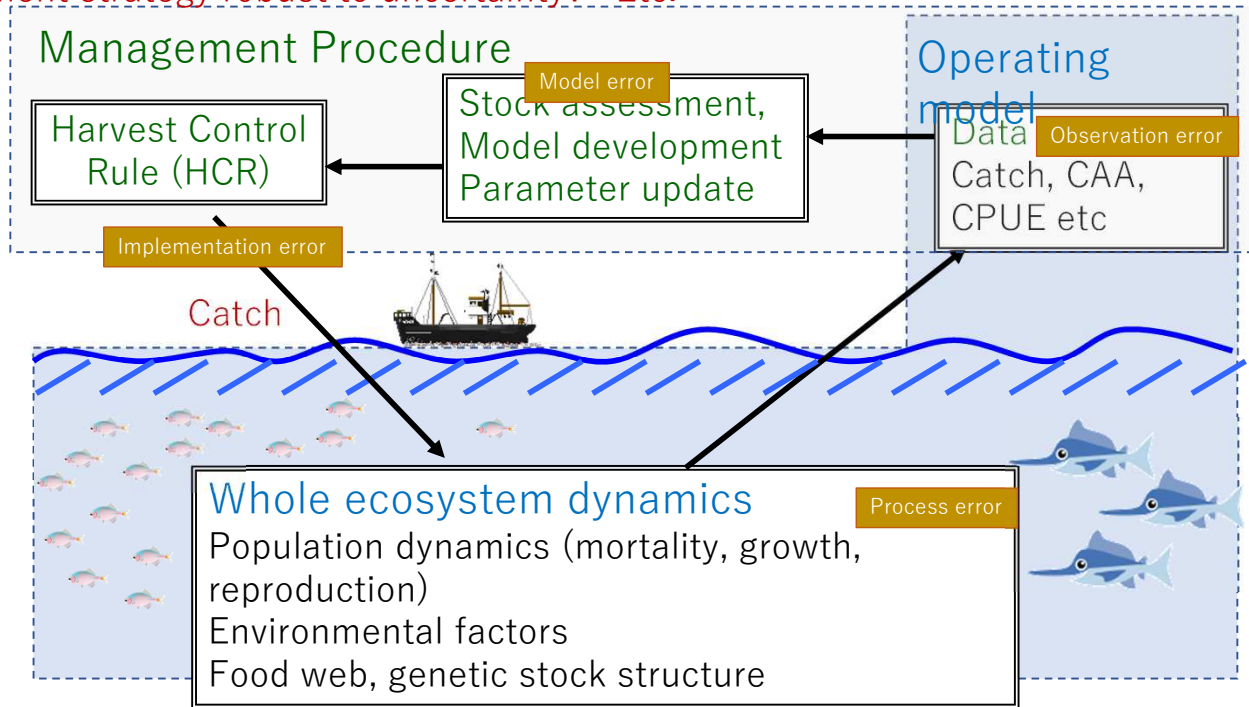
Fishery management



Fishery management

Assess

- Is population sustained by this fishery management strategy?
- How much catch is available in the future? Is it stable?
- Is management strategy robust to uncertainty? Etc.

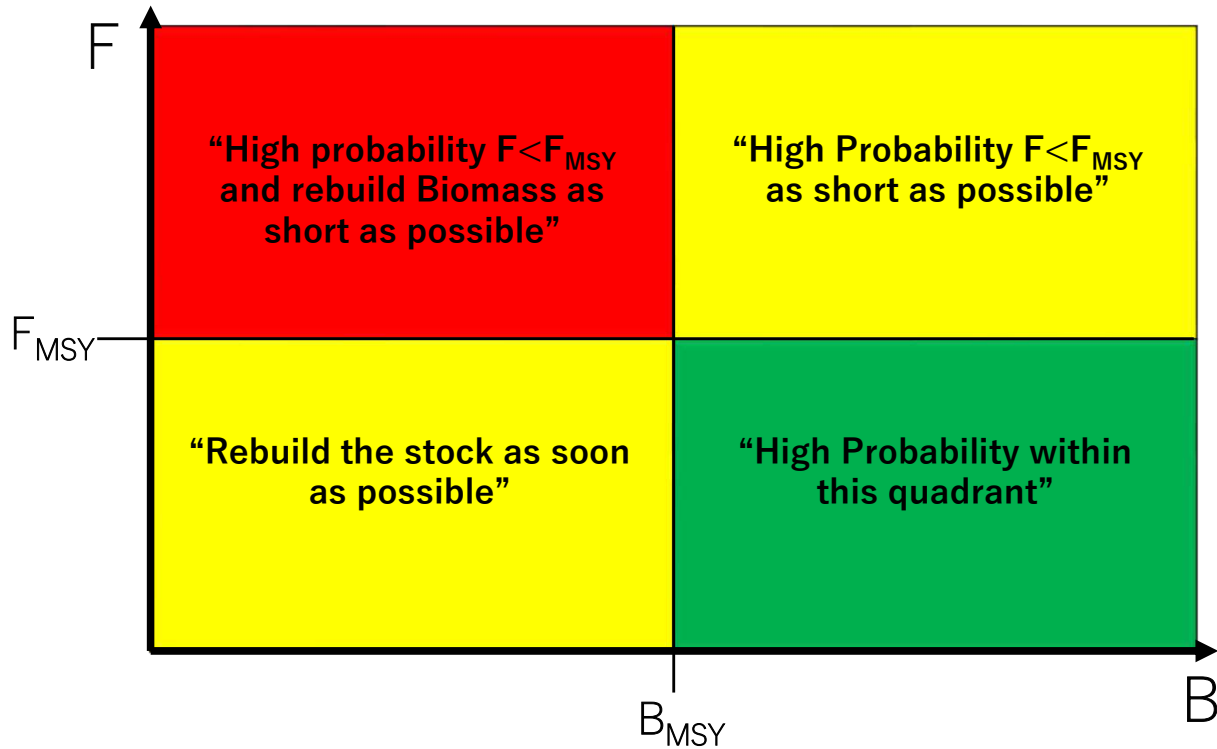


PROCESS/STEPS IN "EVALUATION OF MPs"

1. Specification and prioritization of management objectives
2. Translation of the management objectives to performance measures and risk indicators
3. Construction of Operating Models (OMs)
4. Development of management procedures (MPs) with harvest control rules (HCRs)
5. Simulation trials
6. Comparison of performance for various procedures
7. Advice of MPs which meet management objectives and select an MP

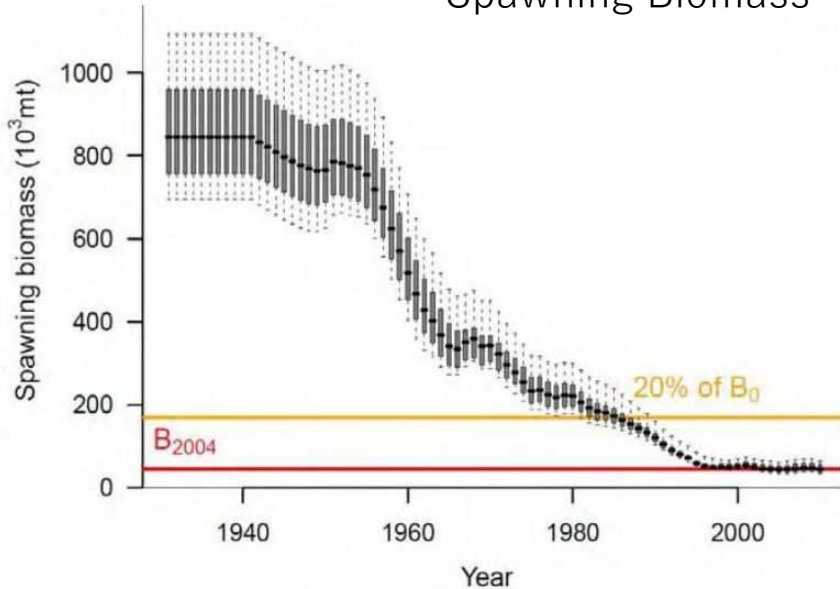


JUST IN CASE: REMINDER

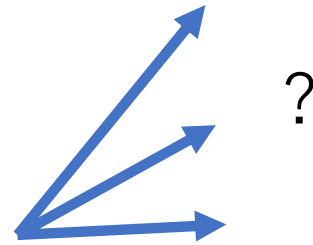


Where and when do we want the fishery to be?

Spawning Biomass



Rebuilding desired,
but when.
How fast?
Or how much catch reduction?



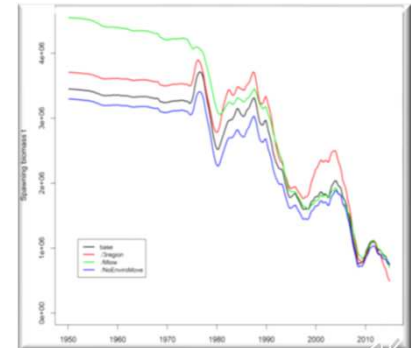
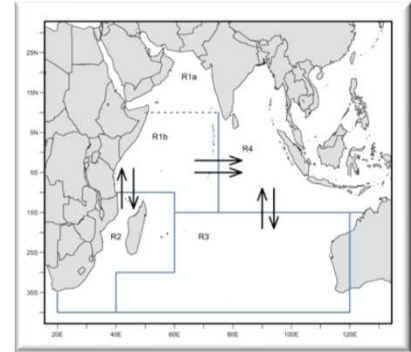
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Usually based on existing stock-assessment with

- Best-available information
- Plausible range of biological ecological parameters
- As virtual reality
- Uncertainty with respect to
 - data
 - parameters
 - models
 - estimation
 - stochastic process in population
 - implementation



PROCESS/STEPS IN "EVALUATION OF MPs"

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MPs including HCRs

- Predetermined rules to set catch limit
- Data collection and assessment

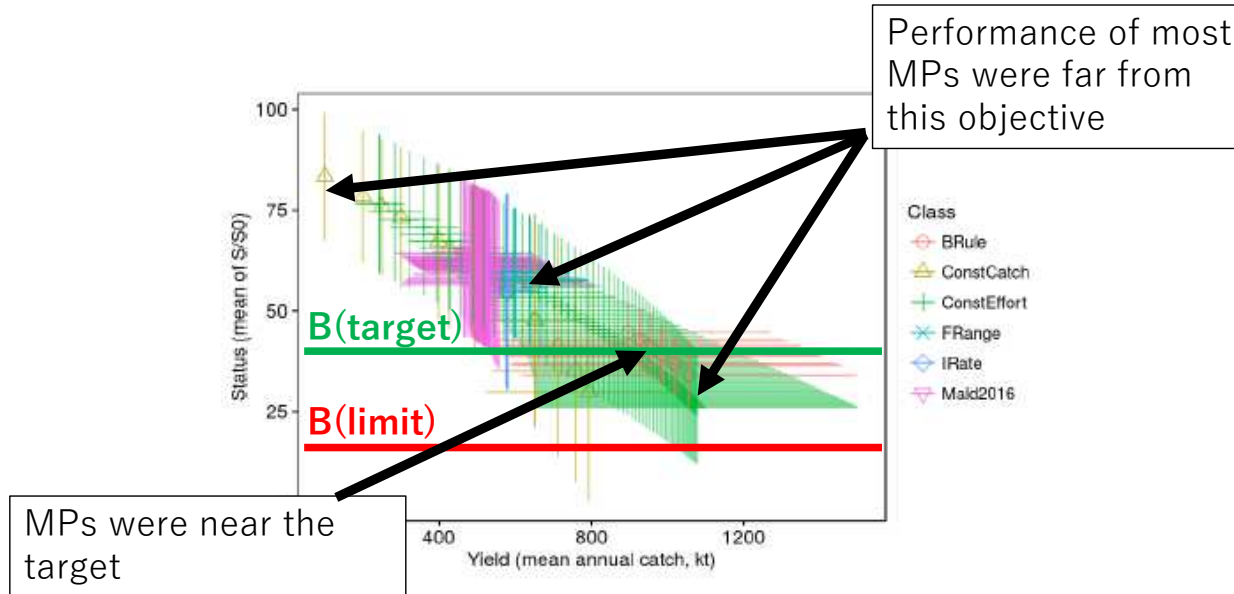
Note: Any MPs do not know the reality of OMs !!

- Kinds of blind tests
- If MPs know OMs, just like "judge" and "prosecutor" is a same person

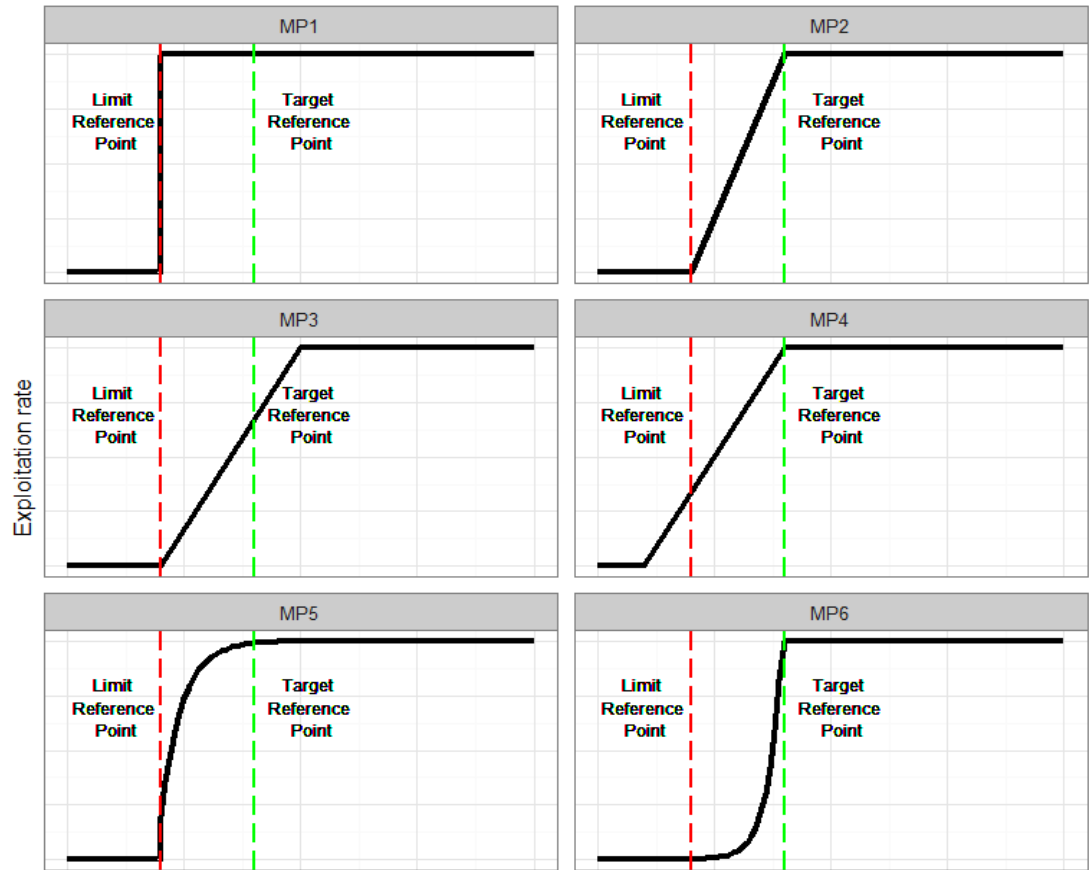


There are some management objectives expressed in the Commission documents

- e.g. Maintain the biomass at the $B(\text{target})$ reference point on average



ILLUSTRATE AND DEFINE CANDIDATE MPs OR HCRS

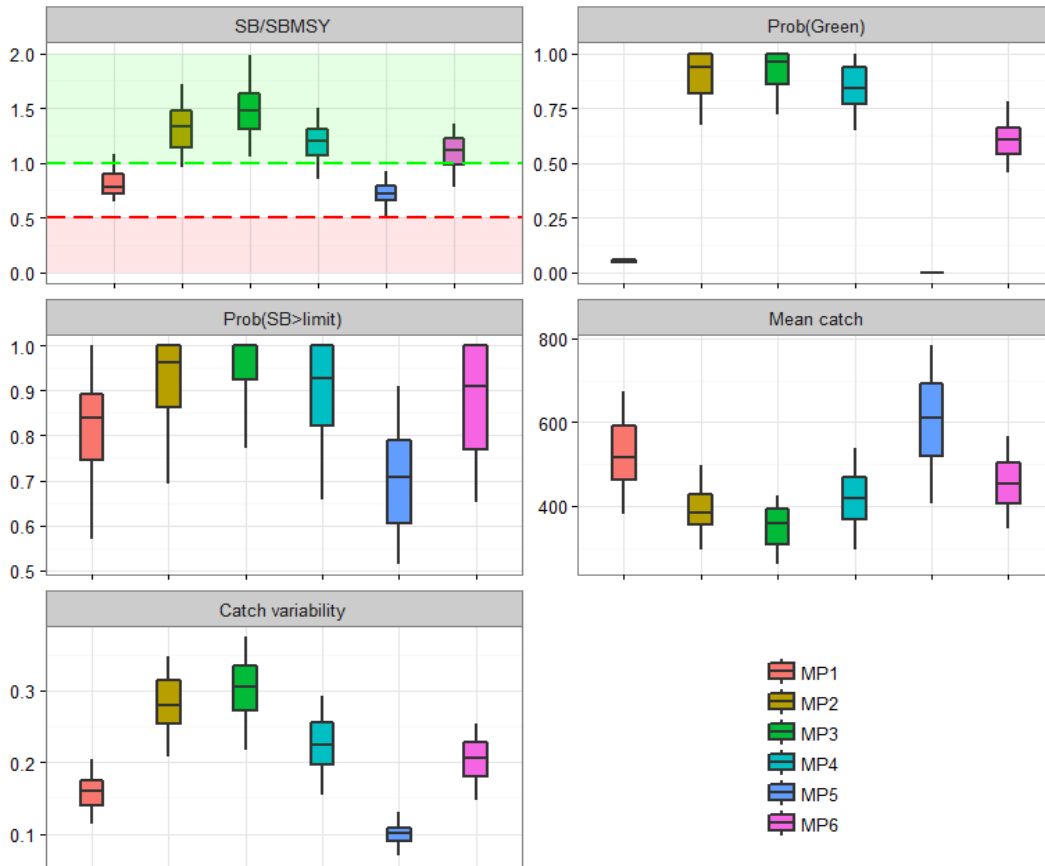


PROCESS/STEPS IN "EVALUATION OF MPs"

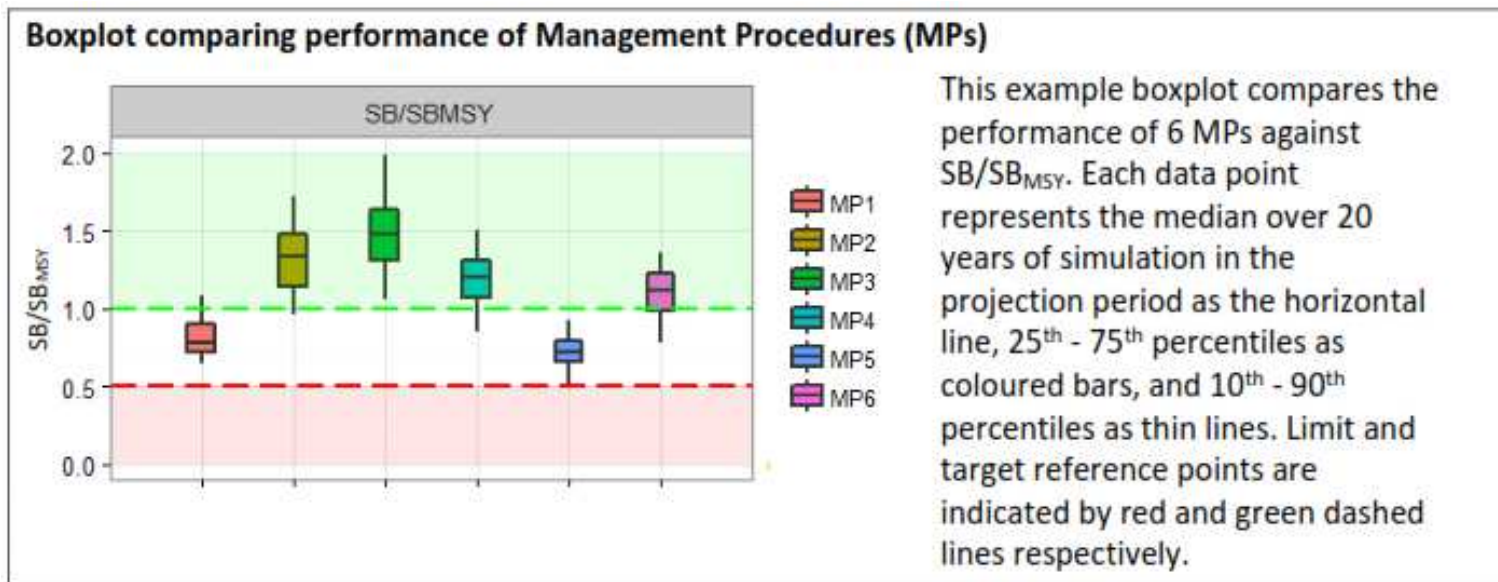
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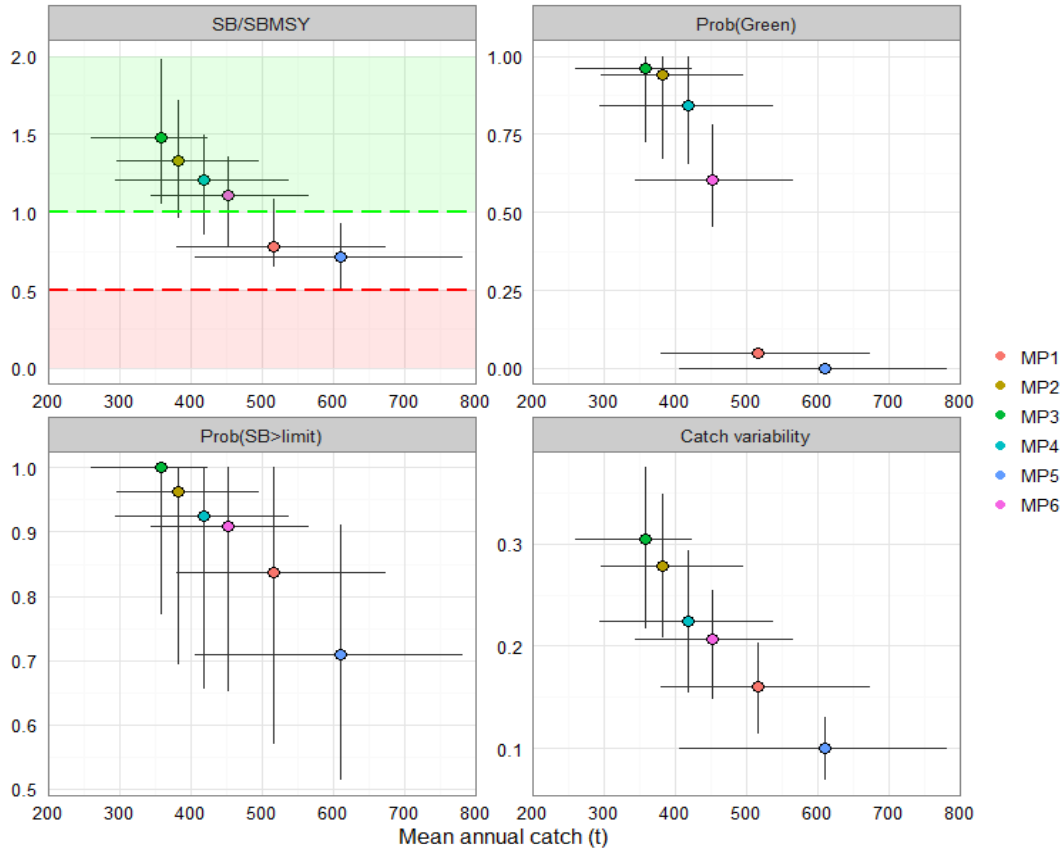
Performance of MPs – (a) Box plots



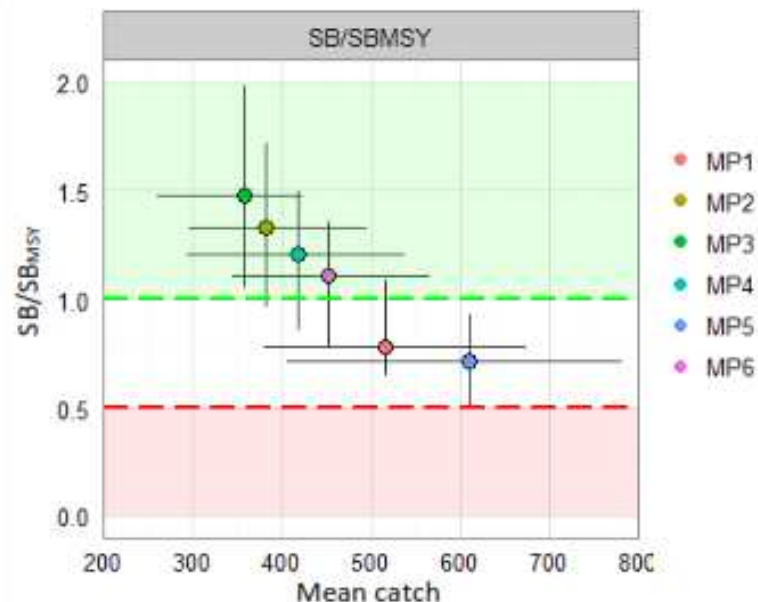
Performance of MPs – Box plots



Performance of MPs – (b) Trade-off plots



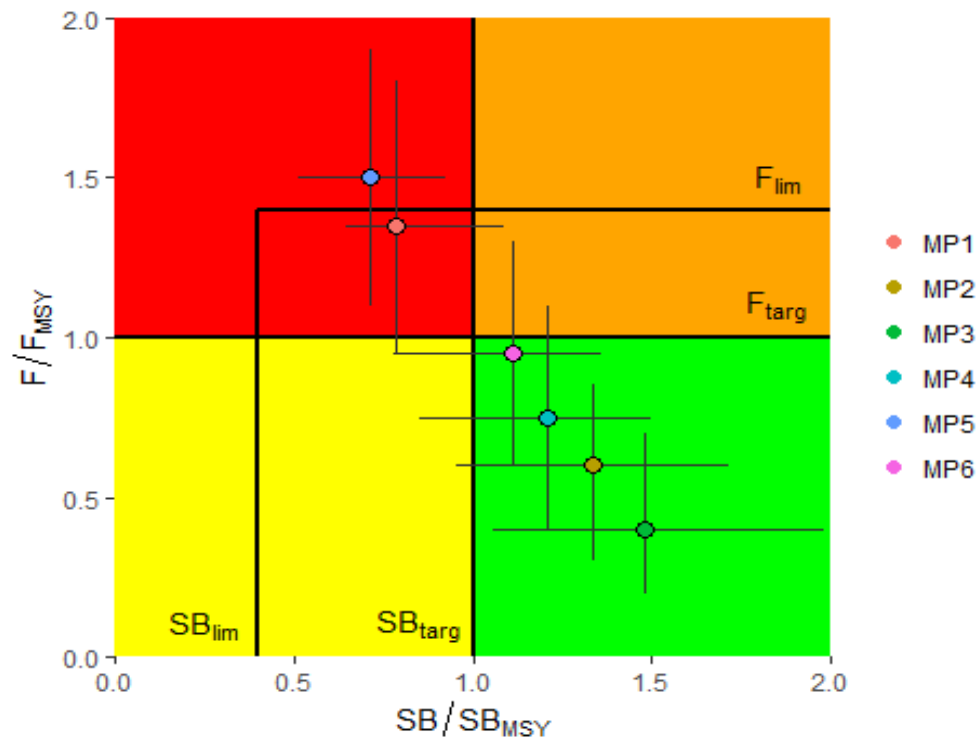
Trade-off plot comparing performance of Management Procedures (MPs)



This example trade-off plot indicates the trade-offs in performance of 6 management procedures (MPs) between catch and SB/SB_{MSY} . Each data point represents the median over 20 years of simulation in the projection period and the errors bars represent 10th and 90th percentiles. Limit and target reference points are indicated by red and green dashed lines respectively.



Performance of MPs - (d) Kobe plot



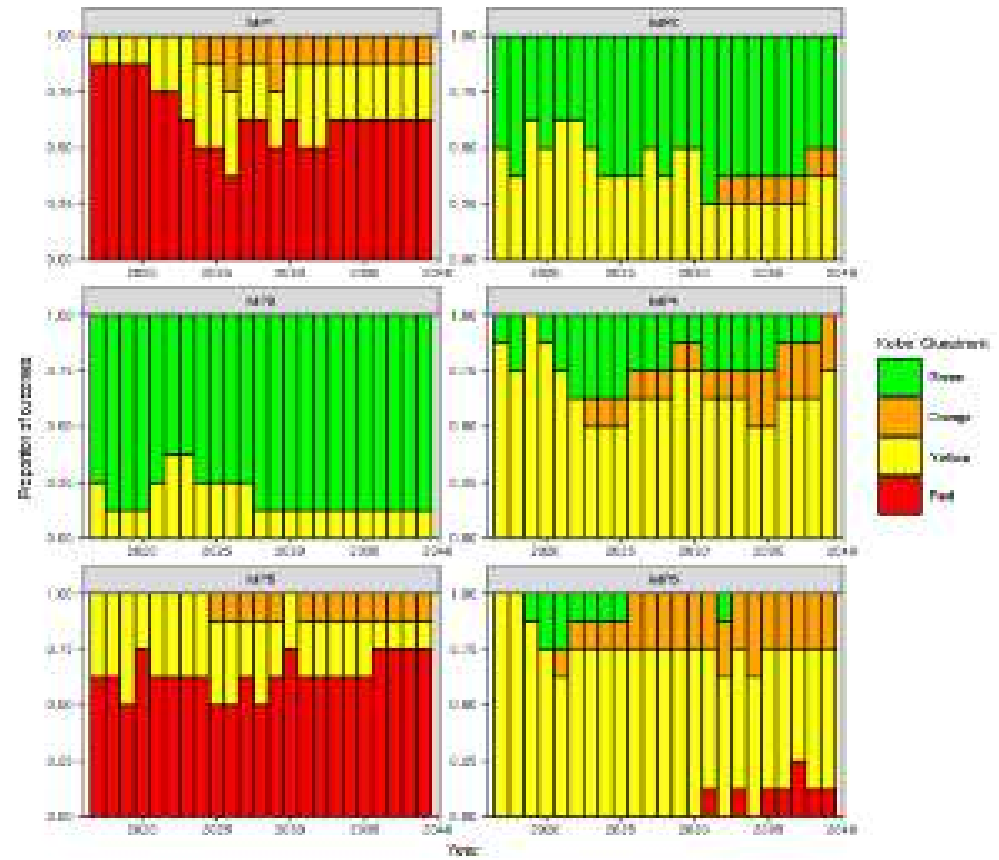
Performance of MPs – (c) summary table

Management Procedure	Performance Measure				
	SB/SB _{MSY}	Prob(Green)	Prob(SB>limit)	Mean Catch	Catch variability
MP1	0.78	0.05	0.84	516	0.16
MP2	1.33	0.94	0.96	383	0.28
MP3	1.48	0.96	1	358	0.3
MP4	1.21	0.84	0.93	419	0.22
MP5	0.72	0	0.71	611	0.1
MP6	1.11	0.61	0.91	452	0.21

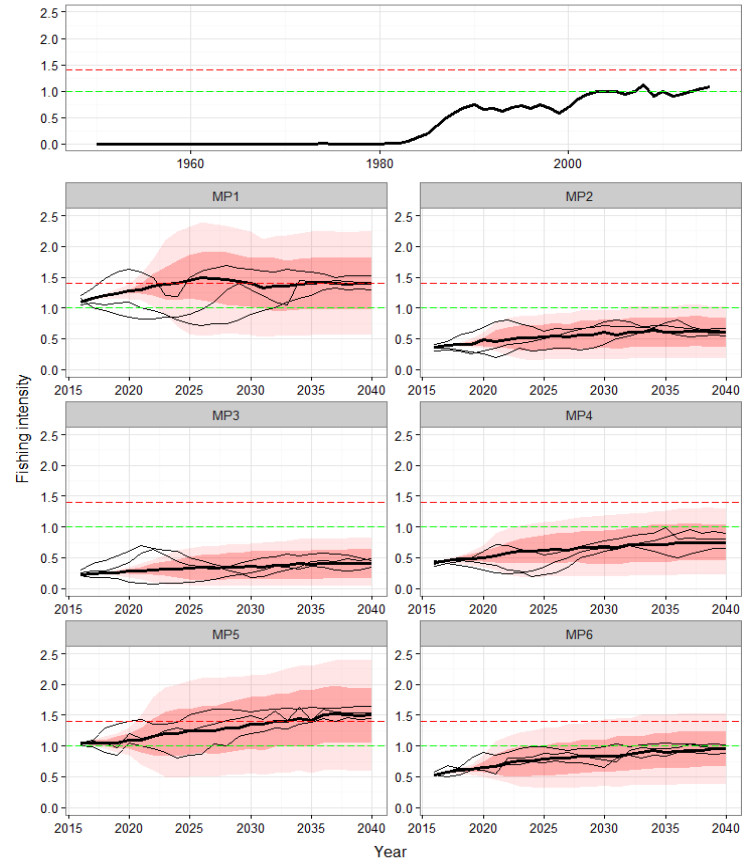
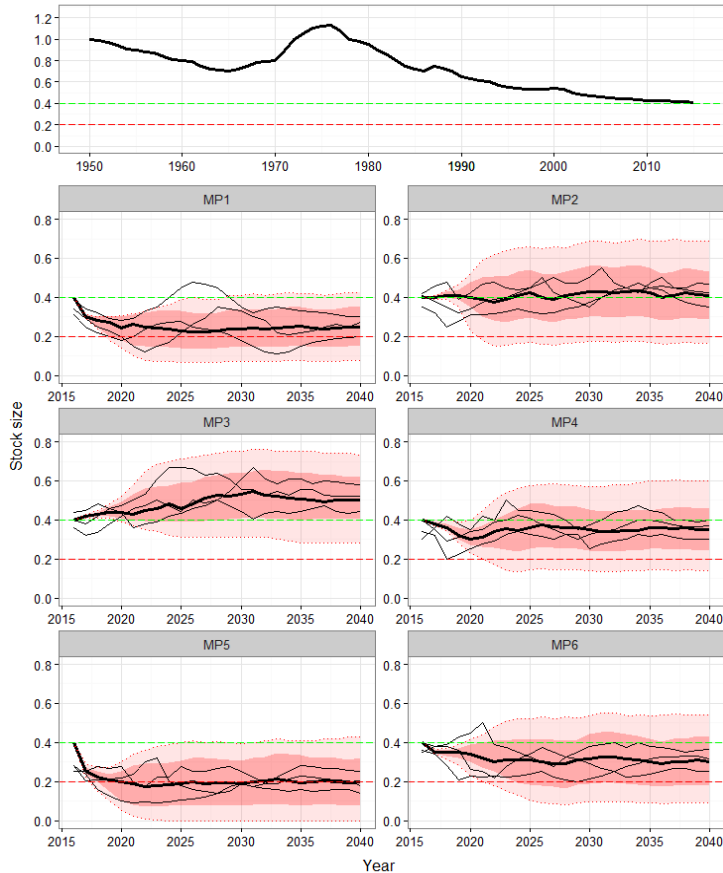
Summary table of performance of Management Procedures (MPs). Performance of 6 MPs against 5 performance measures averaged over 20 years of simulation in the projection period. Shading indicates the relative performance for each MP (dark = better, light = worse).



Performance of MPs – (e) Time series plots for Kobe quadrant

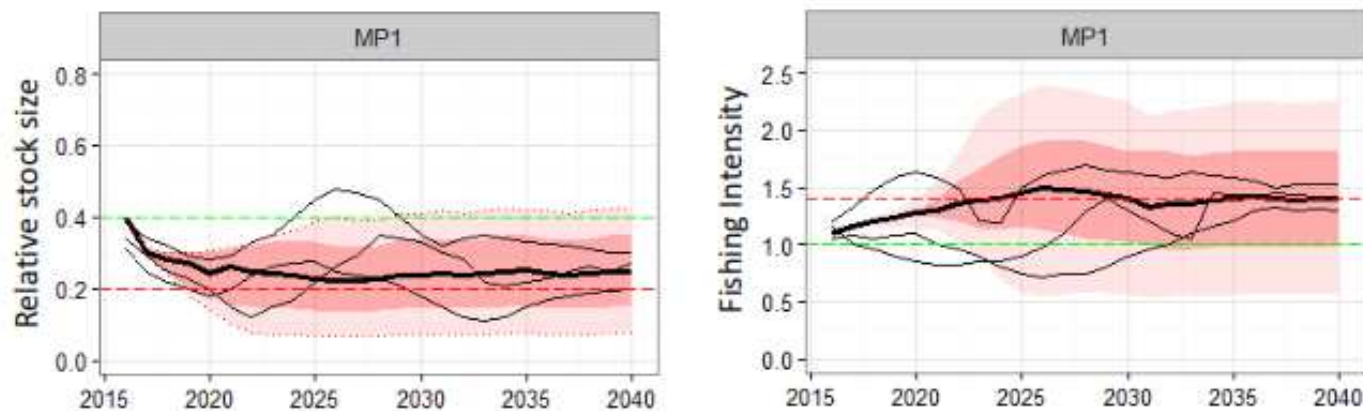


Performance of MPs - (e) Time series plots



Performance of MPs - (e) Time series plots

Time series projections for the performance of Management Procedures (MPs)

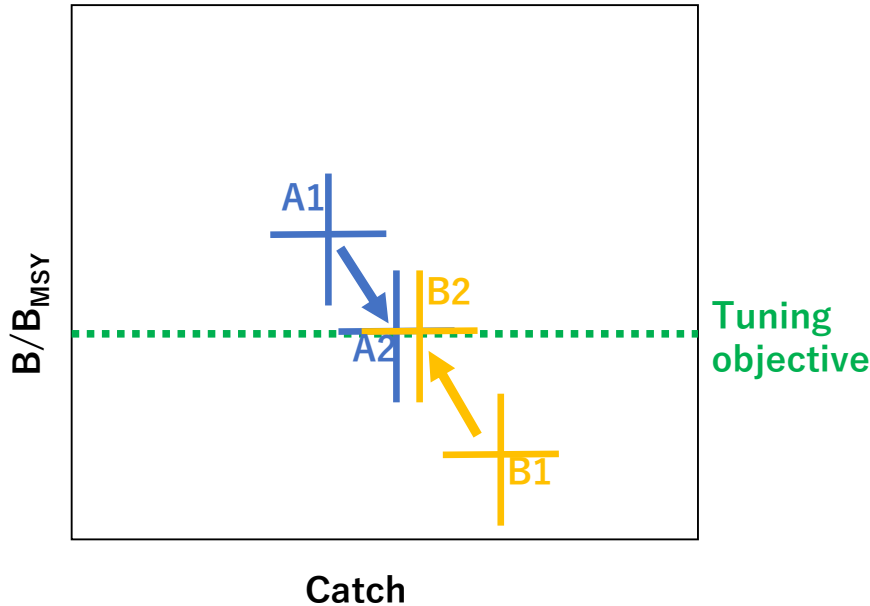


These example time series plots indicate the performance of 1 MP against the stock size (left) and fishing intensity (right) performance measures projected over the years 2016-2040. The median is represented by the bold black lines, a dark ribbon shades the 25th - 75th percentile region and a light ribbon shades the 10th - 90th percentile region. Three additional thin black lines show individual realizations. Horizontal lines indicate target (green) and limit (red) reference points.



Tuning the Management Procedures allows an objective to be achieved exactly

- Tuning only works for a single (high priority) objective
- Tuning involves changing a control parameter within the harvest control rule



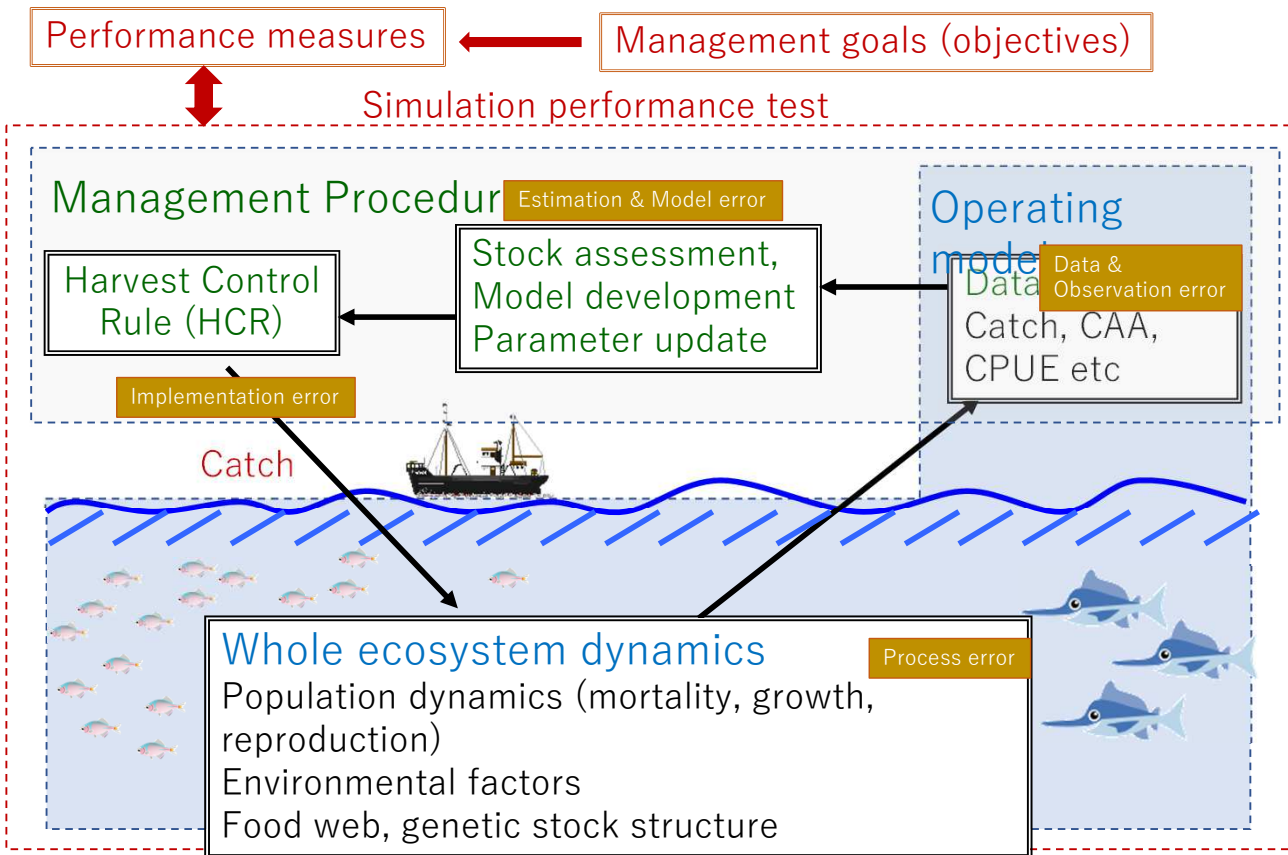
A1 & B1 are not tuned at the same level and, thus, not comparable

A2 & B2 are tuned to achieve the target biomass objective

B2 yields higher catch than A2



Management Strategy Evaluation (MSE)



Shiny application

https://kitakado.shinyapps.io/MSE_shiny_io/

Example of Management Strategy Evaluation

What is your management objective?

Enter your objectives

Prob(B > Bmsy) = 0.5

Management Period: 10

Number of simulation replicas: 500

Configuration of Operating Models

Initial Depletion (D0): 0.4

Intrinsic Rate of Increase (r): 0.1

Carrying Capacity (K): 10000

Shape Parameter (z): 1

Precision of Abundance Estimate (CV): 0.1

Extent of Process Error (tau): 0.05

Setting your Management Procedure

Limit Reference Point: 0.1

Target Reference Point: 0.4

Maximum Allowable Change in Catch (%): 30

Do assessment? (this does not work yet): Yes, parameters are updated

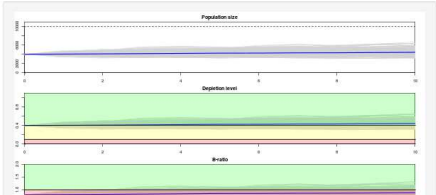
[Run](#)

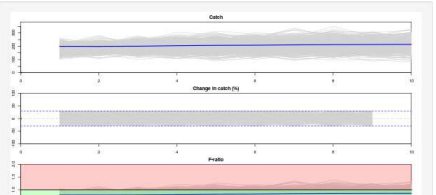
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Simulation results

Performance Measures

Year	B.med	Catch.med	Ratio.med	Fratio.med	Prob.B.greater.than.Bmsy	Prob.F.smaller.than.Fmsy
1	4043.98	199.33	0.81	0.80	0.00	0.99
2	4090.01	198.91	0.82	0.80	0.00	0.99
3	4143.33	200.21	0.83	0.80	0.02	0.97
4	4195.58	204.02	0.84	0.82	0.03	0.94
5	4252.16	206.49	0.85	0.83	0.06	0.90
6	4261.53	207.64	0.85	0.83	0.08	0.89
7	4309.90	210.32	0.86	0.84	0.10	0.88
8	4329.86	212.09	0.87	0.85	0.12	0.85
9	4373.68	213.17	0.87	0.85	0.15	0.83
10	4426.16	214.08	0.89	0.86	0.16	0.83









Please submit your report no later than Jan 26th

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