North Pacific
Fisheries Commission

NPFC

NPFC-2022-SWG MSE PS02-IP01

NPFC 1ST MEETING OF THE JOINT SC-TCC-COM SWG ON MSE FOR PACIFIC SAURY

FEB 21-22, 2022 @VIRTUAL

ITEM 1.

INTRODUCTORY ITEMS

Item 1. Introductory Items

1.1 Opening of the meeting

1.2 Adoption of agenda

1.3 Meeting logistics

Provisional Agenda

Agenda Item 1. Introductory items
- 1.1 Opening of the meeting
- 1.2 Adoption of agenda
- 1.3 Meeting logistics

Agenda Item 2. Role of the joint SWG MSE PS and review of the Terms of Reference
- 2.1 Commission's request and CMM 2021-08
- 2.2 Confirmation of NPFC priority on management
- 2.3 Review of the Terms of Reference

Agenda Item 3. General overview of an MSE process
- 3.1 Basic and general concept of MSE
- 3.2 Reference points, stock status and risks
- 3.3 Potential issues regarding MSE for Pacific saury (and small pelagic fish in general)

Agenda Item 4. Initial discussion toward development of an interim harvest control rule (HCR) for the short-term goal
- 4.1 Management objectives and some constraint conditions for the regulation of fishery
- 4.2 Technical matters on operating models, HCRs, performance measures and simulation

Agenda Item 5. Initial discussion toward development of management procedures (MPs) for the mid-term goal
- 5.1 Management objectives and some constraint conditions for the regulation of fishery
- 5.2 Technical matters on operating models, MPs, performance measures and simulation

Agenda Item 6. Functioning within NPFC
- 6.1 Roles and scientific contributions from the SC and SSC-PS
- 6.2 Roles and contributions from the TCC
- 6.3 Others

Agenda Item 7. Other matters
- 7.1 Selection of an external expert
- 7.2 Capacity building (glossary and demonstration)
- 7.3 Others

Agenda Item 8. Timeline and future process
- 8.1 Timeline
- 8.2 Future meetings

Agenda Item 9. Recommendations to the Commission

Agenda Item 10. Adoption of report

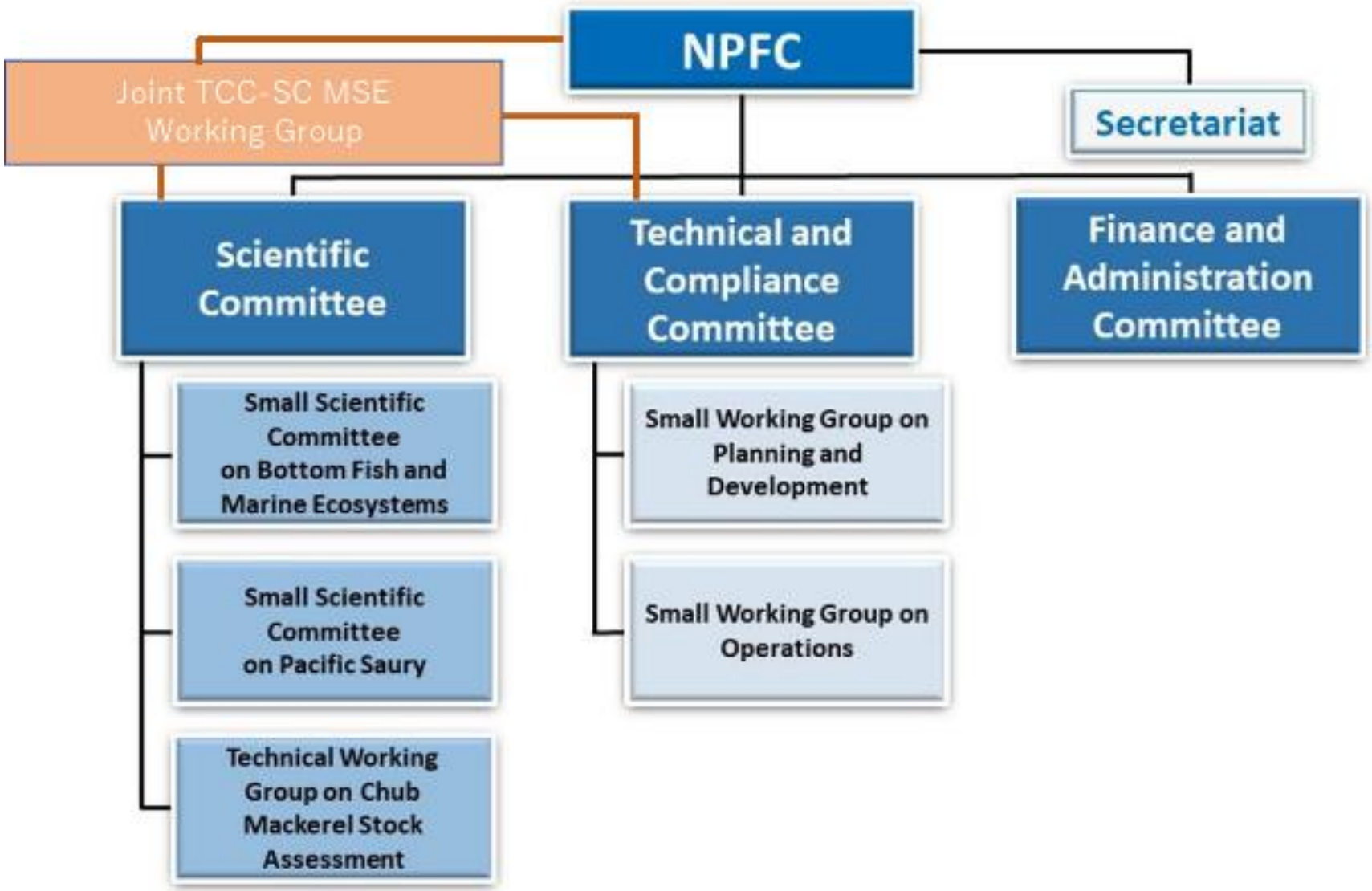
ITEM 2. ROLE OF THE JOINT SWG MSE PS AND REVIEW OF THE TOR

2.1 COMMISSION'S REQUEST AND CMM 2021-08

2.2 CONFIRMATION OF NPFC PRIORITY ON MANAGEMENT

2.3 REVIEW OF THE TERMS OF REFERENCE

Item 2. Role of the joint SWG MSE PS and review of the ToR



According to the ToR

SECTION 4 – FUNCTIONS

6. The functions of the SWG-MSE-PS are to:

a) develop and submit recommendations to the Commission on a draft interim harvest control rule, draft management objectives, key sources of uncertainty, and, if feasible, candidate management procedures;

b) facilitate communications among commissioners, scientists, managers, stakeholders and observers and provide relevant information to the Committees and their subsidiary bodies;

c) propose to the Commission on the operation of the SWG-MSE-PS including the timeline and additional work to be conducted; and

d) provide relevant information to other subsidiary bodies including SC, TCC, and FAC.

Terms of References

NPFC

North Pacific Fisheries Commission

TERMS OF REFERENCE FOR A JOINT SC-TCC-COM SMALL WORKING GROUP ON MANAGEMENT STRATEGY EVALUATION FOR PACIFIC SAURY

The North Pacific Fisheries Commission (NPFC),

Recalling that Article 3(b) of the Convention states that in giving effect to the objective of this Convention, the following actions shall be taken individually or collectively as appropriate: (b) adopting measures, based on the best scientific information available, to ensure that fisheries resources are maintained at or restored to levels capable of producing maximum sustainable yield, taking into account fishing patterns, the interdependence of stocks and any generally recommended international minimum standards, whether subregional, regional or global;

Objectives stipulated in ToR of SWG MSE PS

Short-Term Objectives: within one to two years:

a) develop **draft interim management objectives** and a **draft interim harvest control rule (HCR)** that meets such objectives to report to the Commission (preferably before the 8th Commission annual meeting); and

b) **evaluate the robustness of the draft interim harvest control rule** with consideration of possible uncertainties including effects of climate changes.

Mid-Term Objectives: within three to five years:

a) develop **draft mid- to long-term management objectives** by setting the **target and limit reference points** for the population status as well as by defining "overfishing" and "overfished" for the sustainable use of the Pacific saury stock;

b) assess the feasibility of establishing a **management procedure through an MSE**

ITEM 3. GENERAL OVERVIEW OF AN MSE PROCESS

3.1 BASIC AND GENERAL CONCEPT OF MSE

3.2 REFERENCE POINTS, STOCK STATUS AND RISKS

3.3 POTENTIAL ISSUES REGARDING MSE FOR PACIFIC SAURY (AND SMALL PELAGIC FISH IN GENERAL)

Some Key Questions

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**

1. What is the MSE in a nutshell?
2. What is the difference between **"Projection based on stock assessment"** and **"Projection in MSE"**?
3. What is the difference between **"MP"** and **"HCR"**?
4. What is the difference between **"OM"** and **"Assessment model"**?

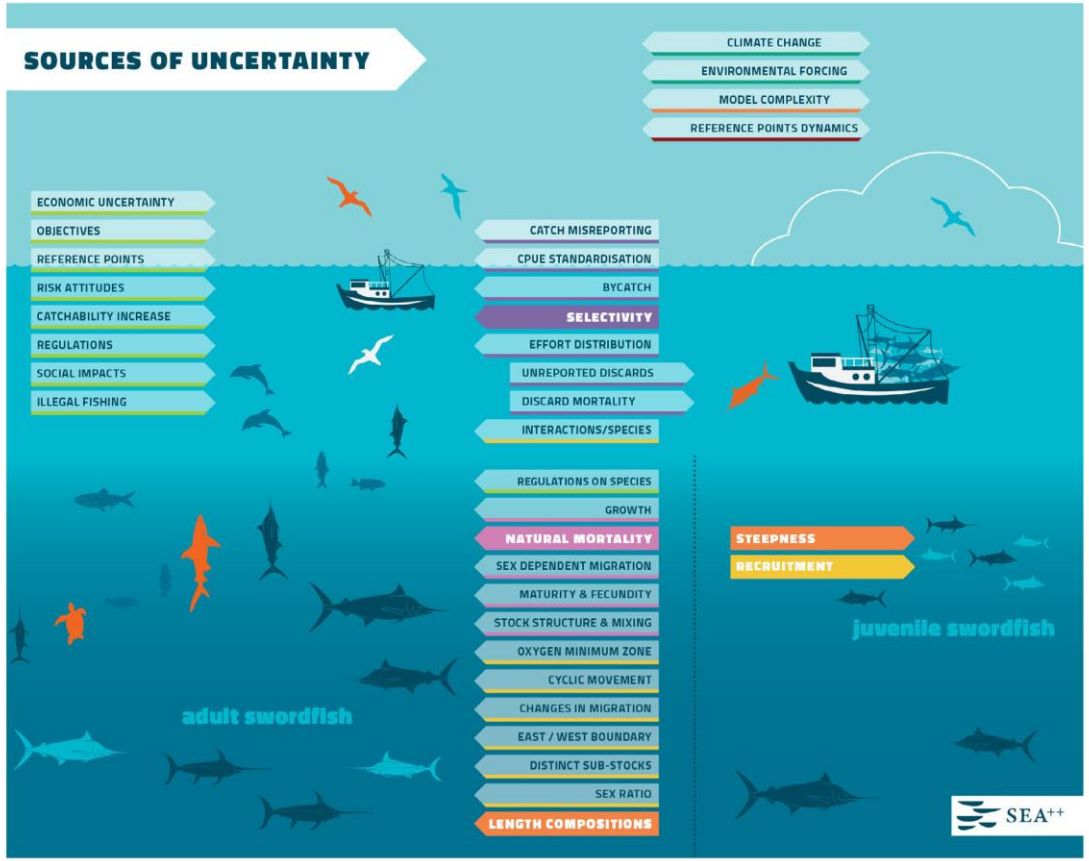
Question 1.
What is the MSE in a nutshell?

"In essence, harvest strategies amount to agree the rules of the game before it is played"

--- Doug Butterworth

In brief…

- MSE is a simulation approach to evaluate pre-determined management procedures that are well specified and implementable in reality before they are used
- A pioneer work was conducted in the IWC-SC for its development of the RMP
- MSE can take into account several sources of uncertainty



In brief…

- MP-based approaches can reduce lengthy negotiations and free up time for longer-term research, enable better evaluation of risk, provide a sound basis to impose limits on TAC variability, are consistent with the Precautionary Principle, and provide a framework for interactions with stakeholders. (para 14, NPFC -2019-WS BRP-HCR-MSE01)

But

- The MP should be fully-specified, otherwise complex the evaluation process will be needed.
- There has been a greater frequency of recourse to exceptional circumstances and MP revisions than was originally foreseen.
- Furthermore, the MSE processes are lengthy, resulting in less time saved than originally envisioned. It may also be difficult to explain MPs to stakeholders and convince stakeholders of their value initially.

Different people use different figures

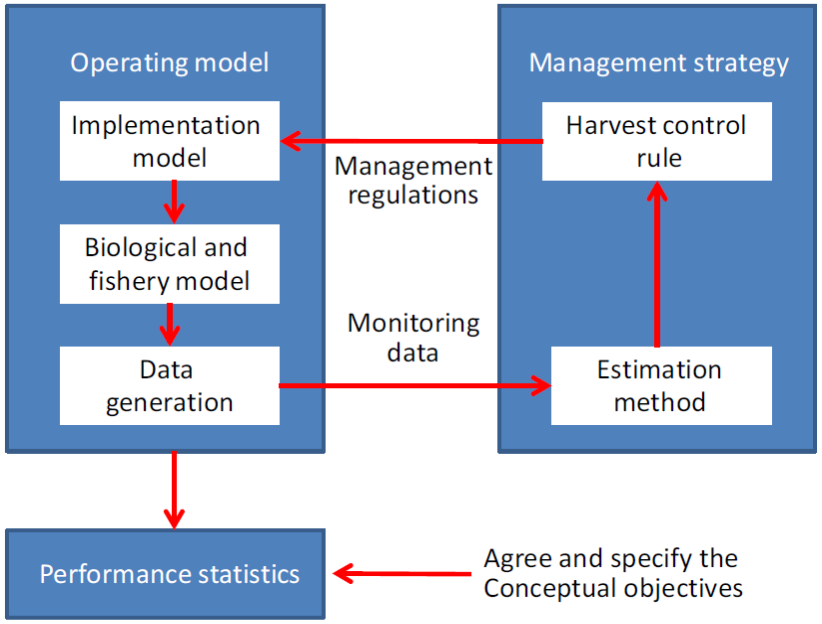
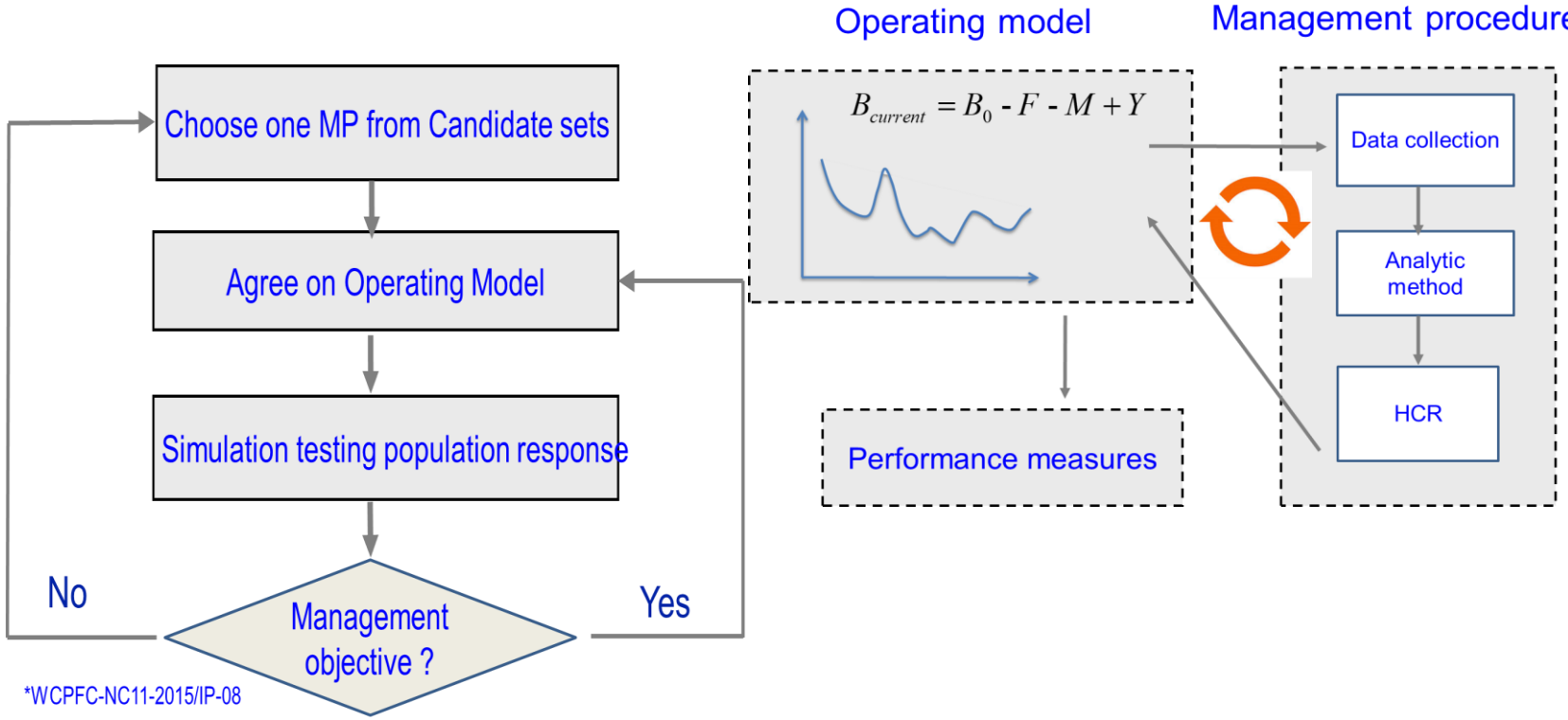


Figure 1 Conceptual overview of the management strategy evaluation modelling process.



MSE in nutshell

MSE Process

1. Identification of **Management objectives** and **performance measures**
2. Development of **Operating Models (OMs)**
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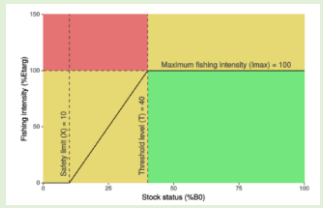
5. **Selection of an MP** based on simulation performance
6. **Implementation of the MP**

Management objectives ⟷ Performance measures

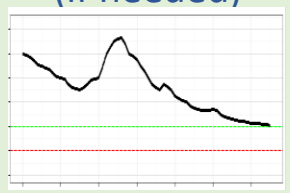
Selection of an MP

Management Procedures (MPs)

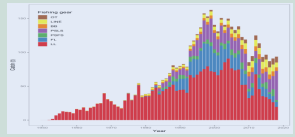
HCR



Assessment (if needed)



Data, fishery, survey…



Estimation & Model error

Implementation error

Application of TAC set by MP

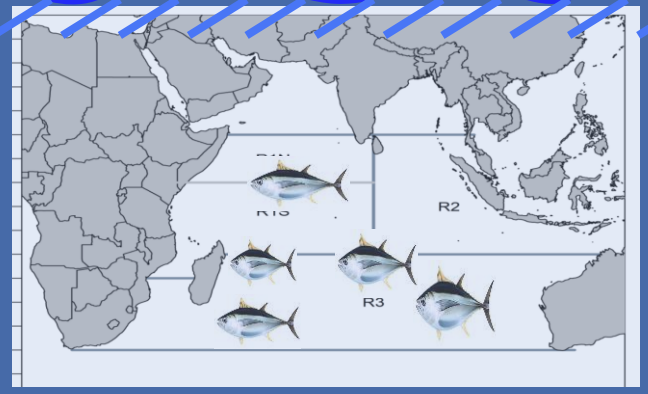
Operating model (OMs)

Data generation

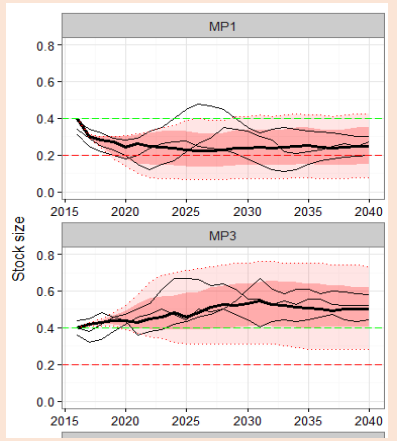
Observation error

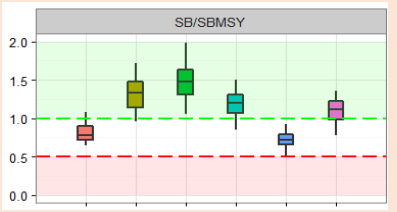
- Population dynamics (mortality, growth, reproduction)
- Environmental factors
- Food web
- Genetic stock structure

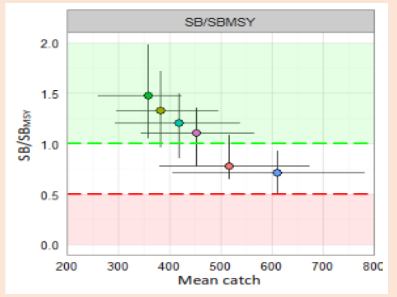
Process error



Simulation testing







1. WHAT IS THE MSE IN A NUTSHELL, WHAT ARE WE DEVELOPING FOR WHAT PURPOSES?

The MSE is a computer simulation framework

- to understand the expected behavior of “Management Procedures (MPs)” if implementing them in an actual fishery
- to develop MPs to robustly meet the Management Objectives
- to select a MP for implementation in actual fisheries

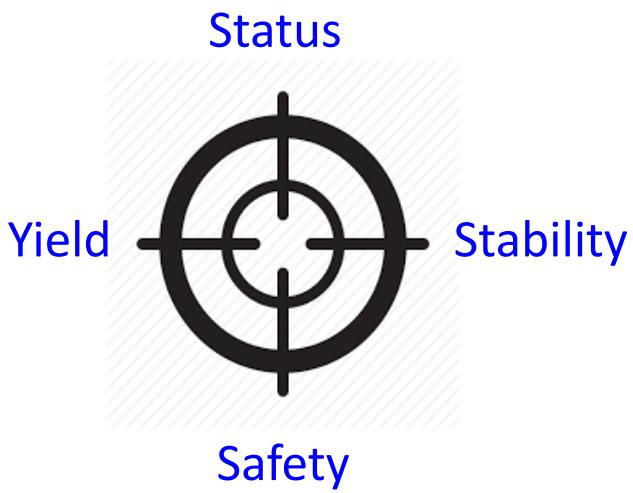
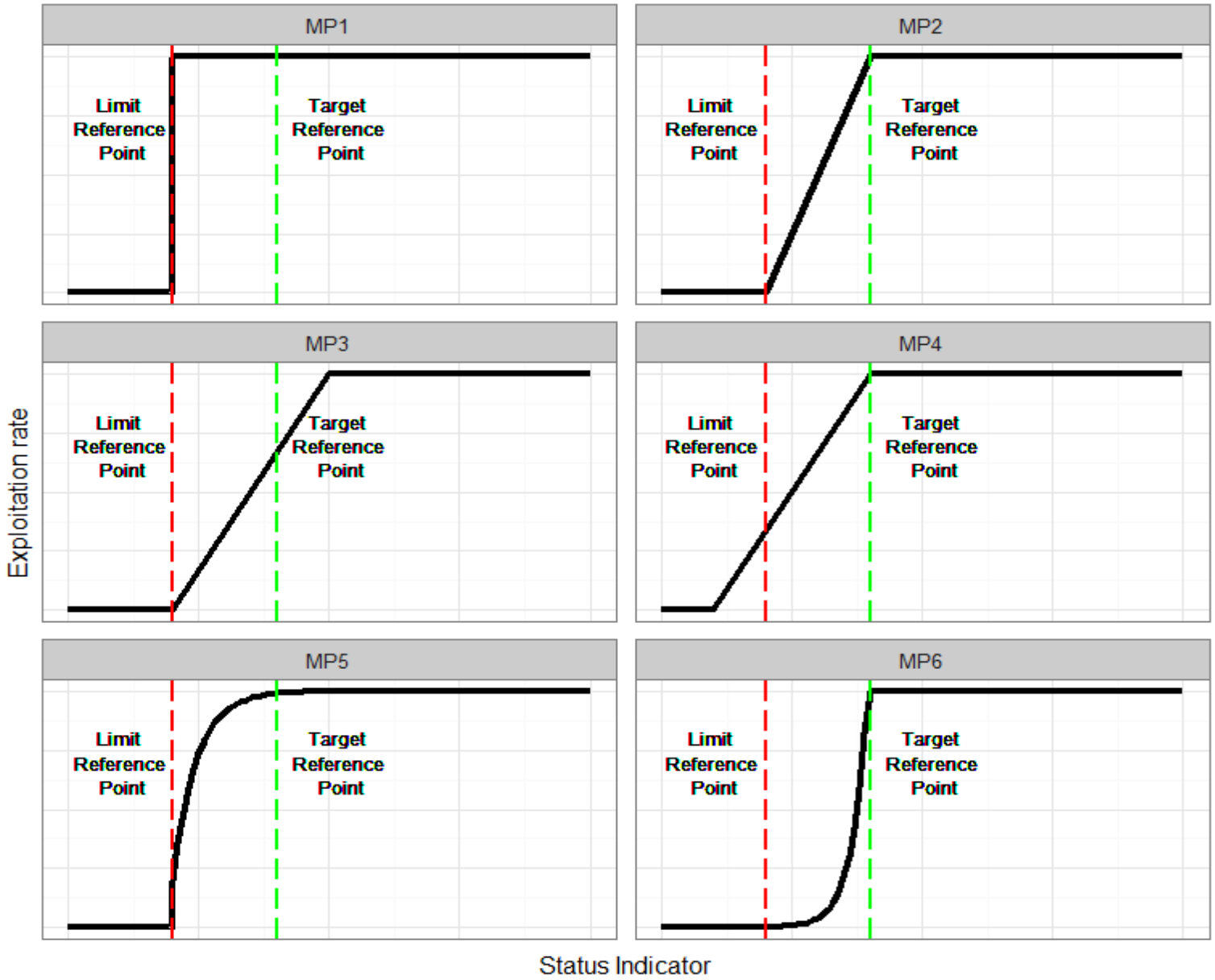
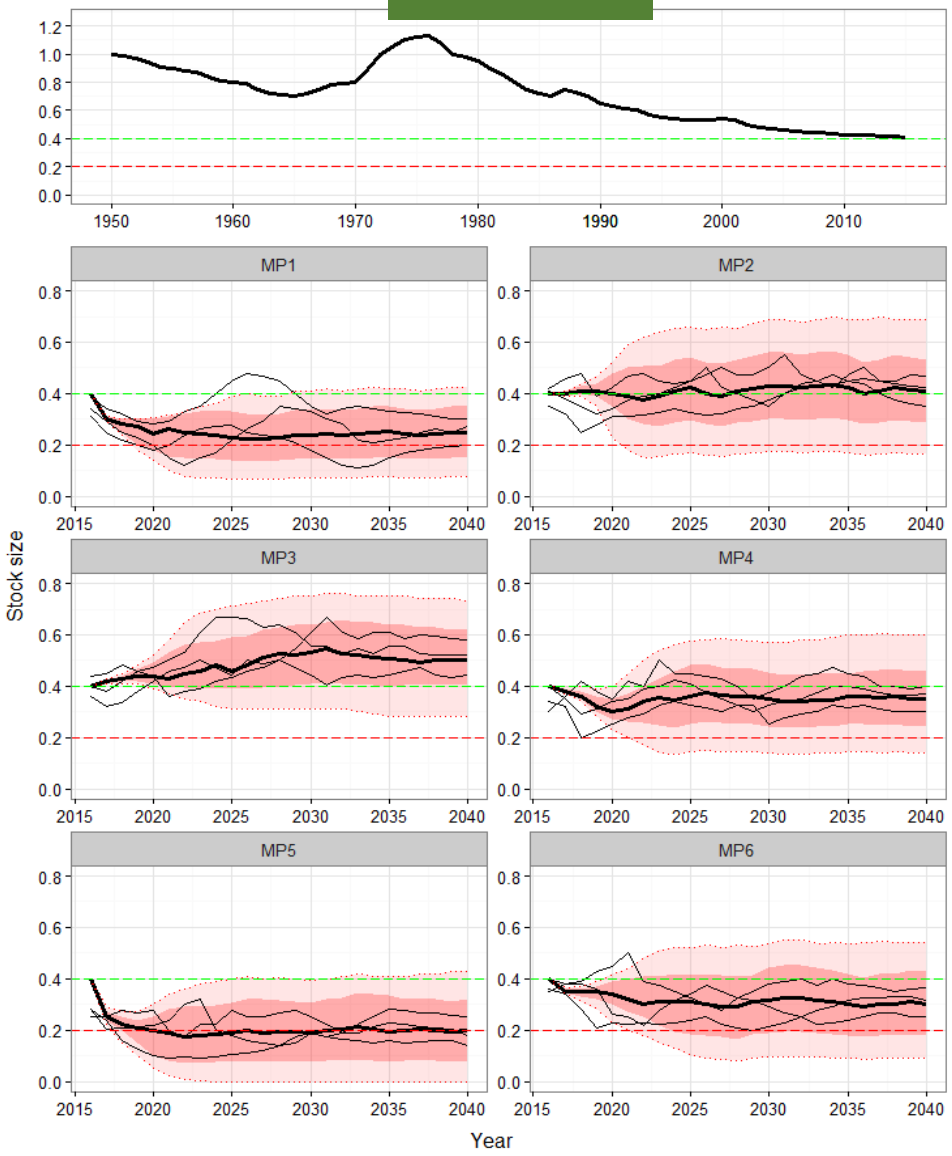


ILLUSTRATION OF CANDIDATE MANAGEMENT PROCEDURES

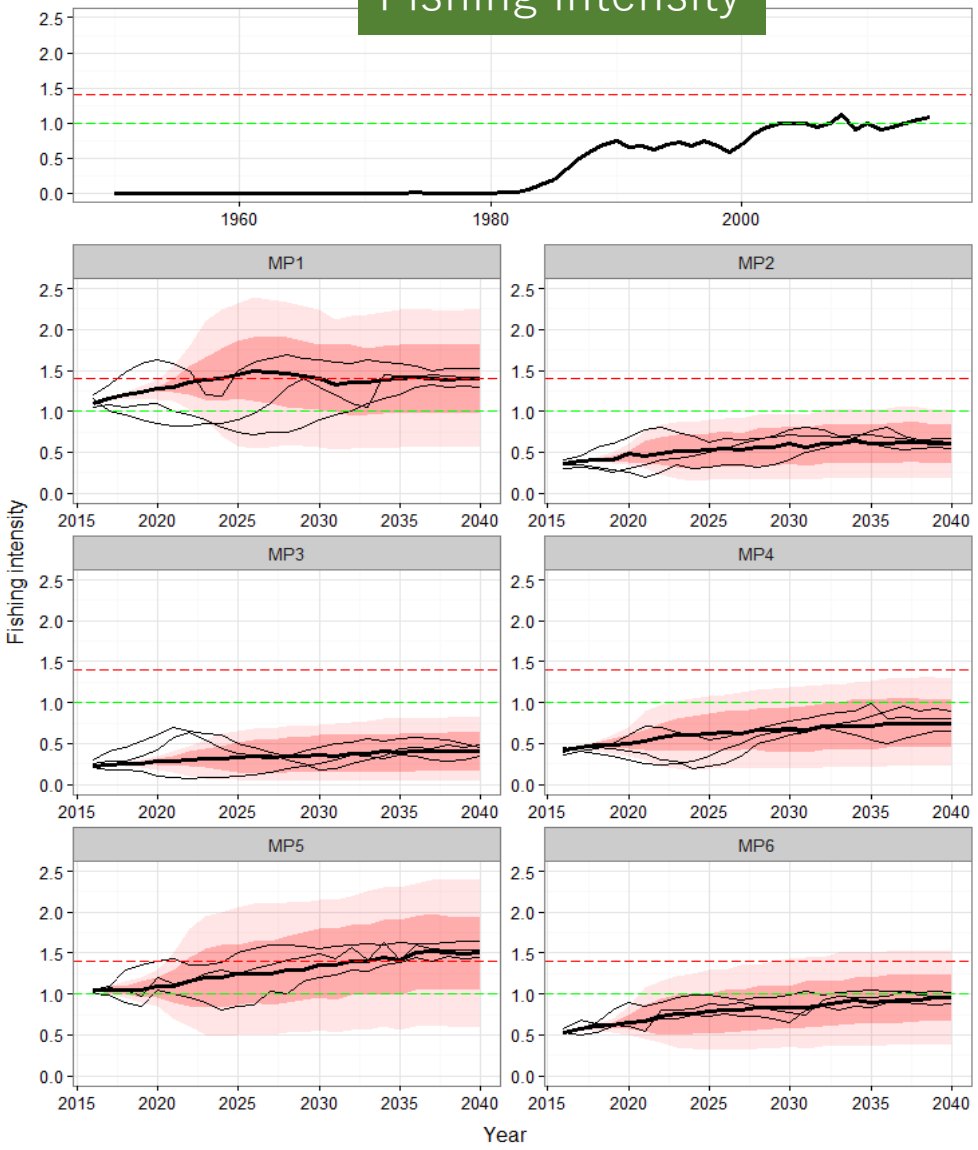


PERFORMANCE OF MPS – TIME SERIES PLOTS

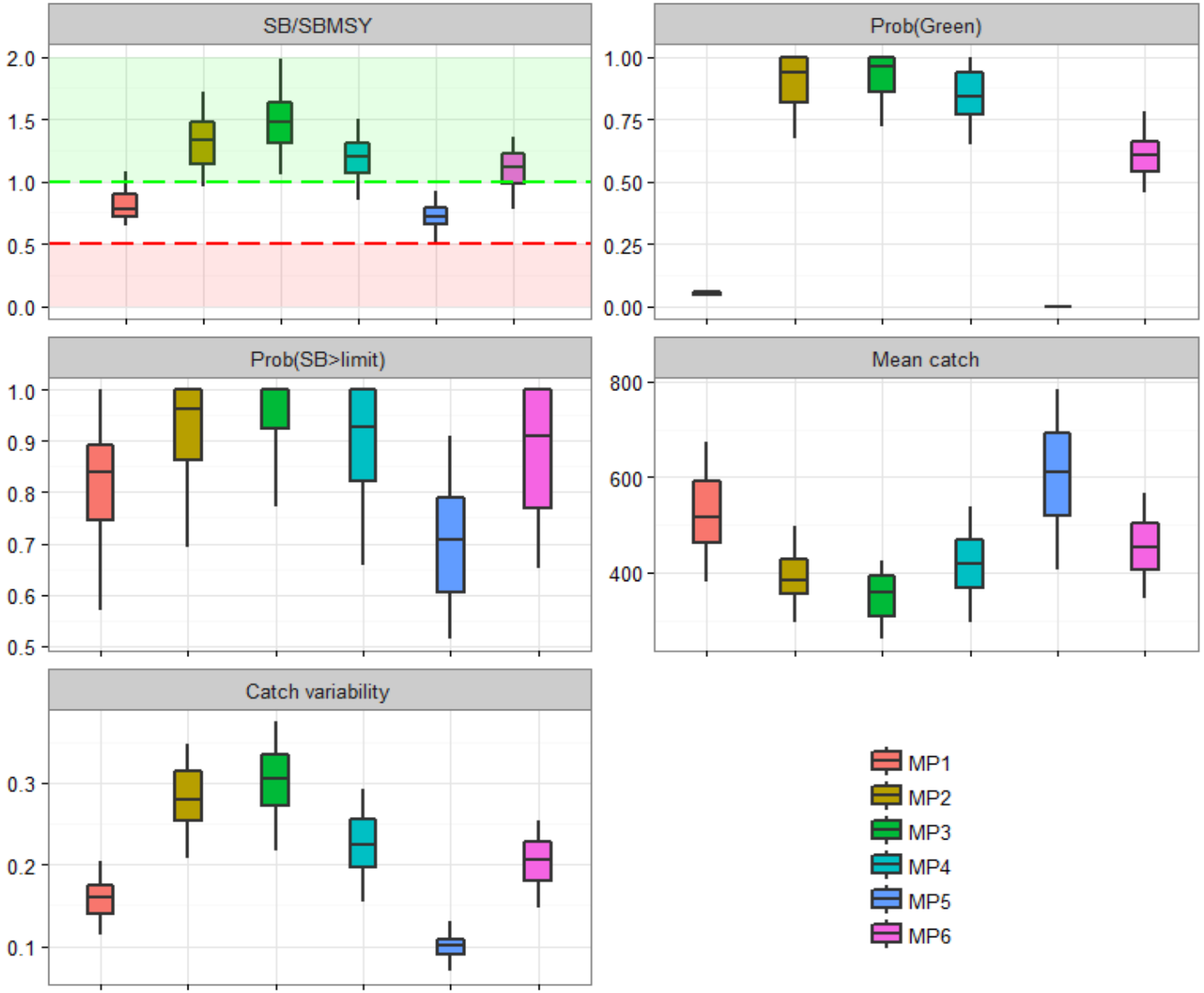
Stock size



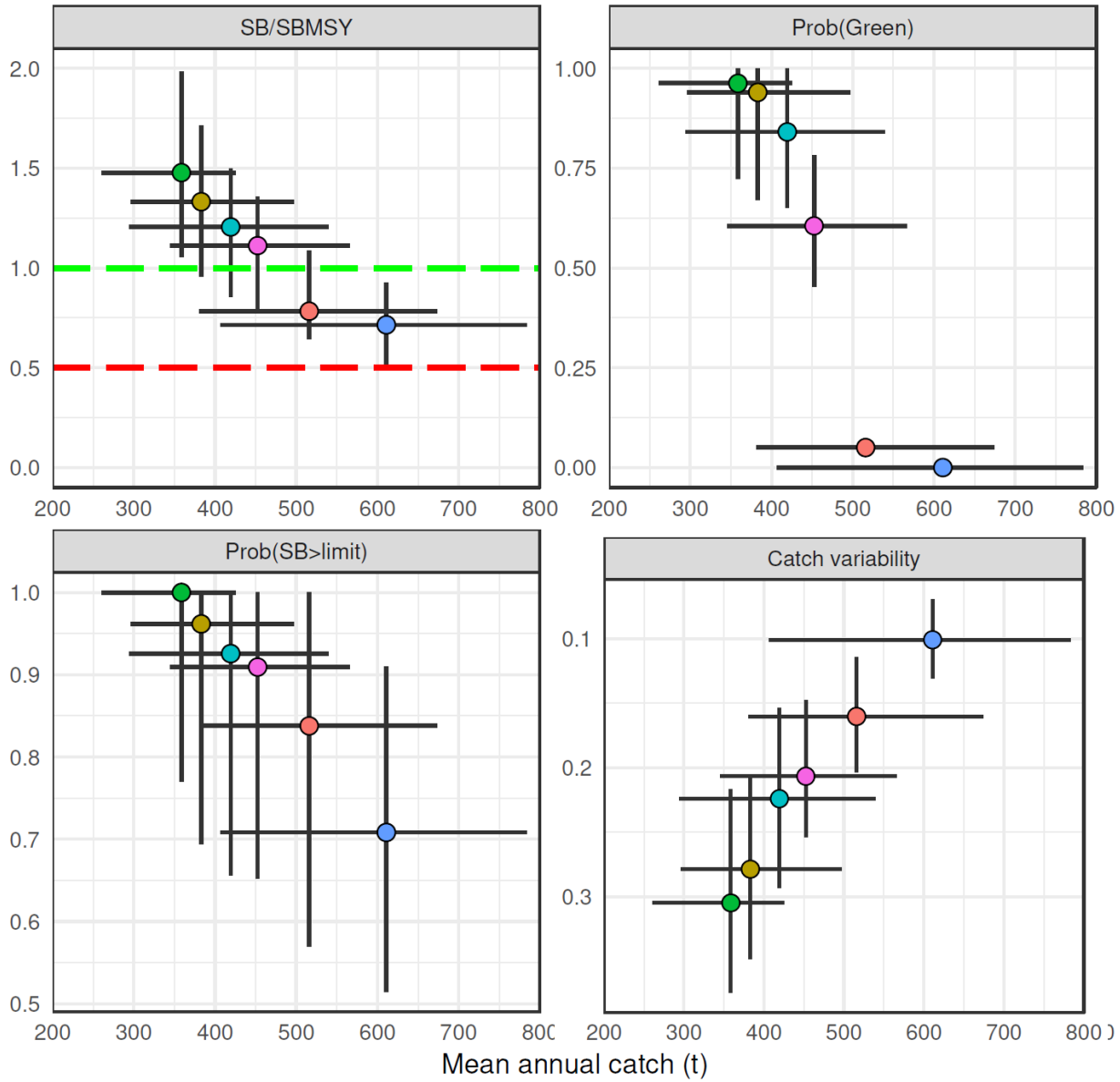
Fishing intensity

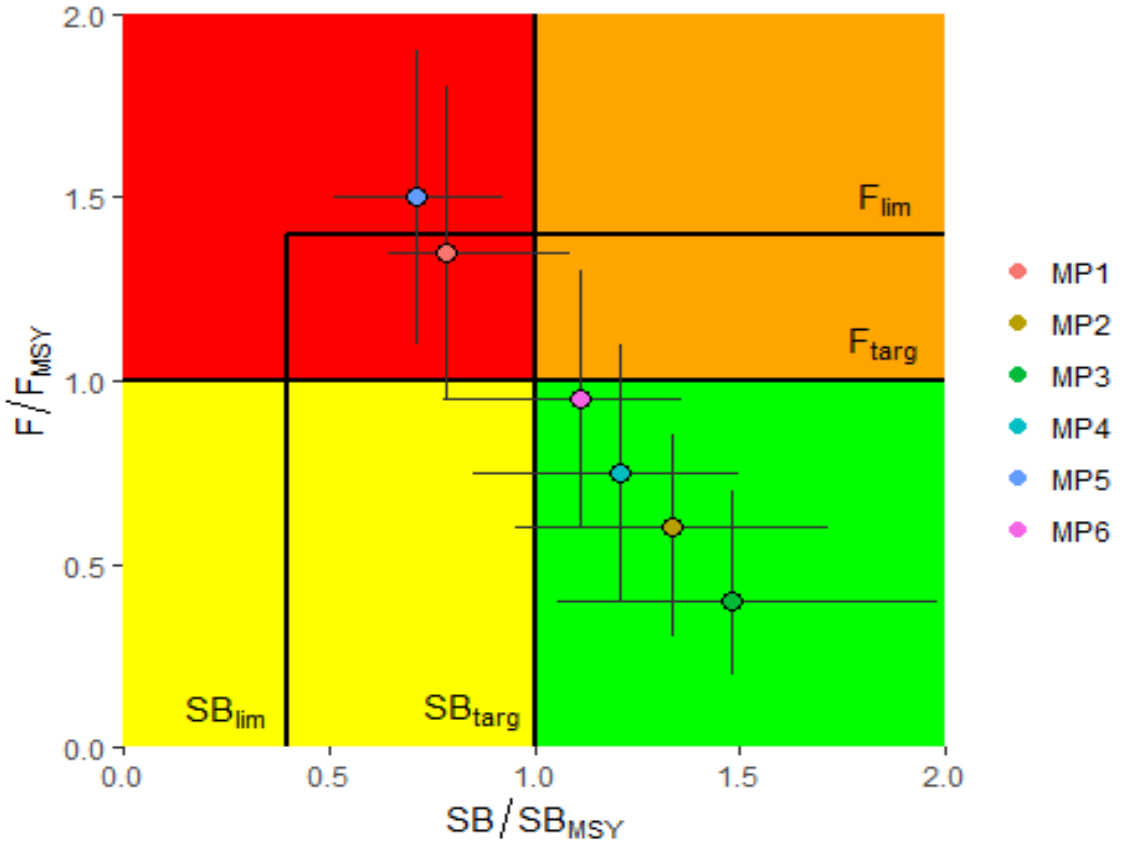


PERFORMANCE OF MPS –BOX PLOTS

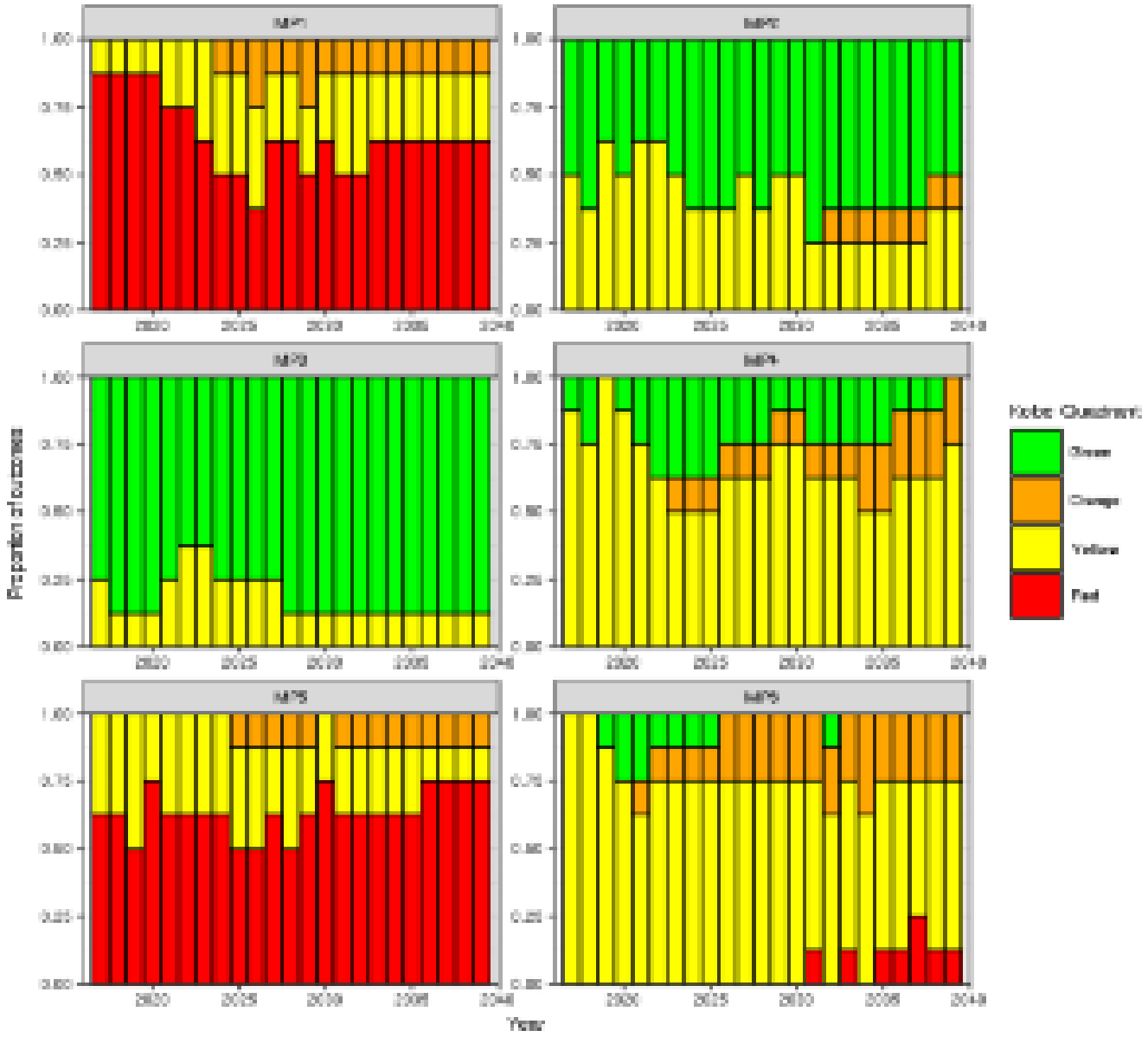


PERFORMANCE OF MPS – TRADE-OFF PLOTS





PERFORMANCE OF MPS –TIME SERIES PLOTS FOR KOBE QUADRANT



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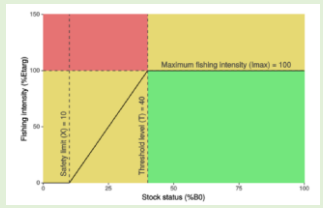

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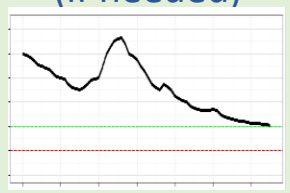

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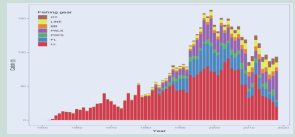

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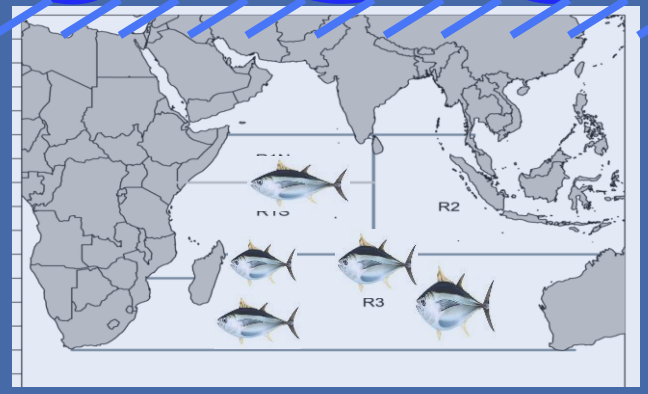
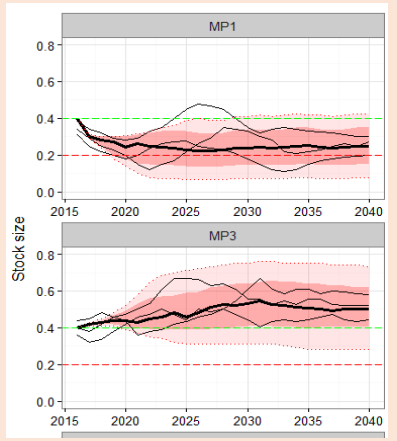
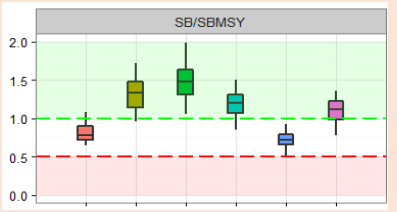
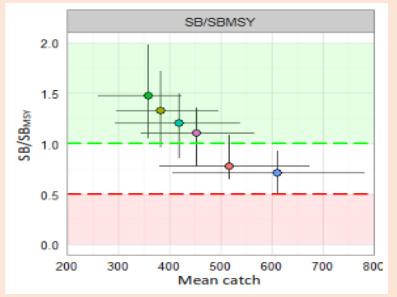


Simulation testing







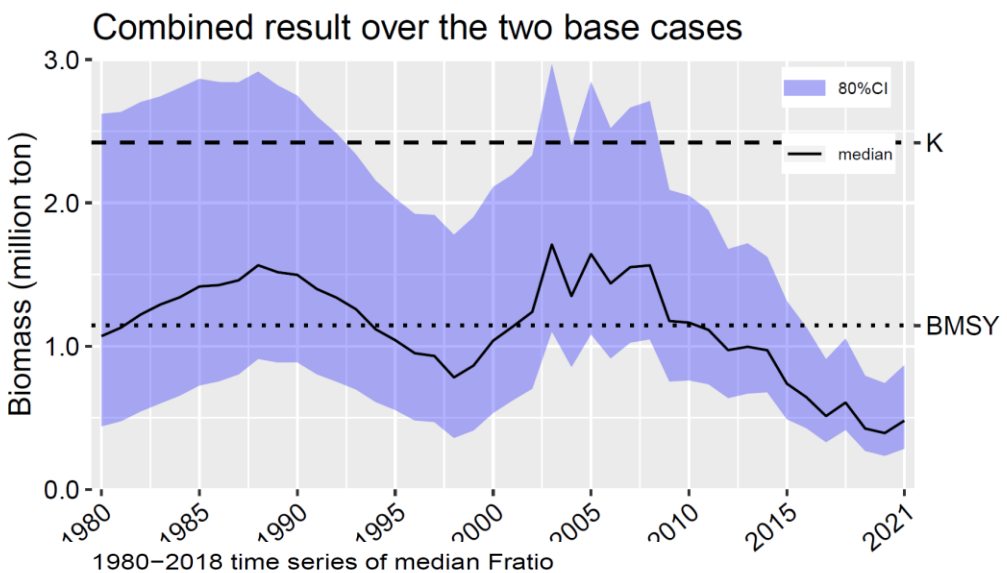
Question 2.

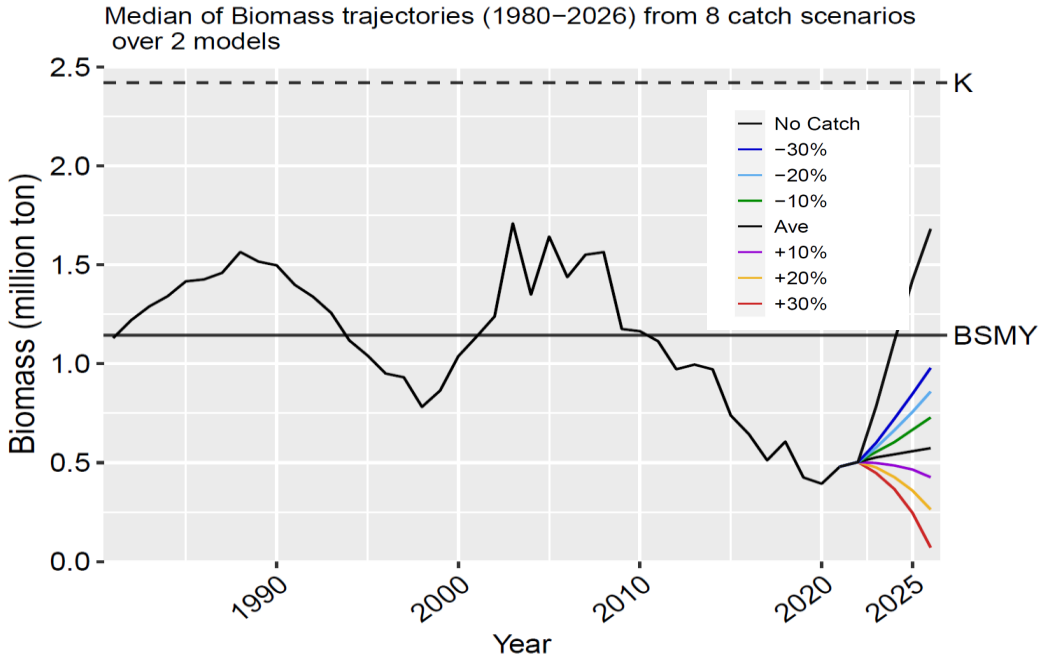
What is the difference between "projection based on assessment" and "projection in MSE"?

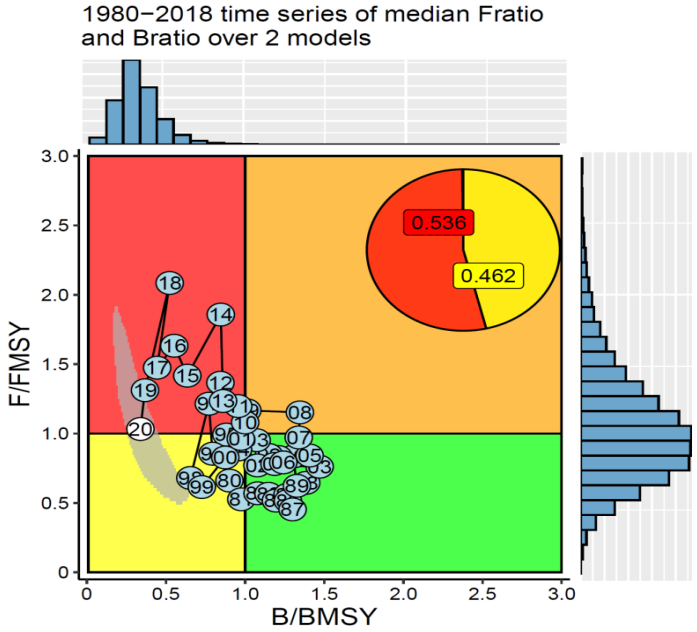
"Prediction is very difficult, especially if it's about the future"

--- Niels Bohr, Physicist

WHAT IS THE DIFFERENCE BETWEEN "PROJECTION BASED ON ASSESSMENT" AND "PROJECTION IN MSE"?





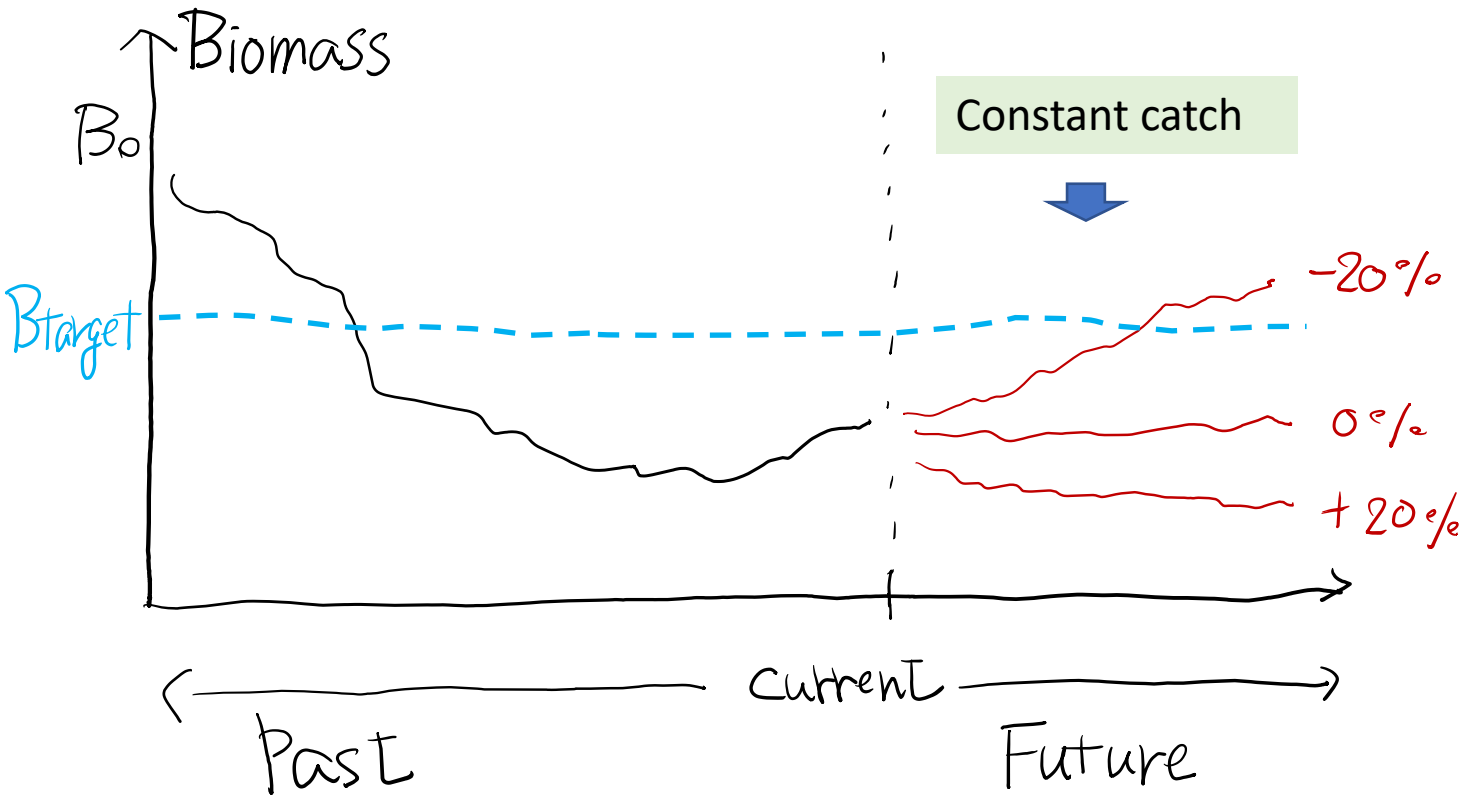


	Red	Orange	Yellow	Green	B<BMSY	F>FMSY
+30%	0.784	0.001	0.053	0.162	0.837	0.785
+20%	0.725	0.000	0.080	0.194	0.806	0.726
+10%	0.662	0.000	0.108	0.229	0.771	0.663
±0%	0.587	0.000	0.139	0.274	0.726	0.588
-10%	0.495	0.000	0.181	0.323	0.677	0.495
-20%	0.406	0.000	0.227	0.366	0.634	0.406
-30%	0.315	0.000	0.266	0.419	0.581	0.315
No Catch	0.000	0.000	0.254	0.746	0.254	0.000

WHAT IS THE DIFFERENCE BETWEEN "PROJECTION BASED ON ASSESSMENT" AND "PROJECTION IN MSE"?

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)



Simple projection for a risk table:
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 ($B_{targ} = B_{MSY}$; $F_{targ} = F_{MSY}$)								
	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

Some Key Questions (2)

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

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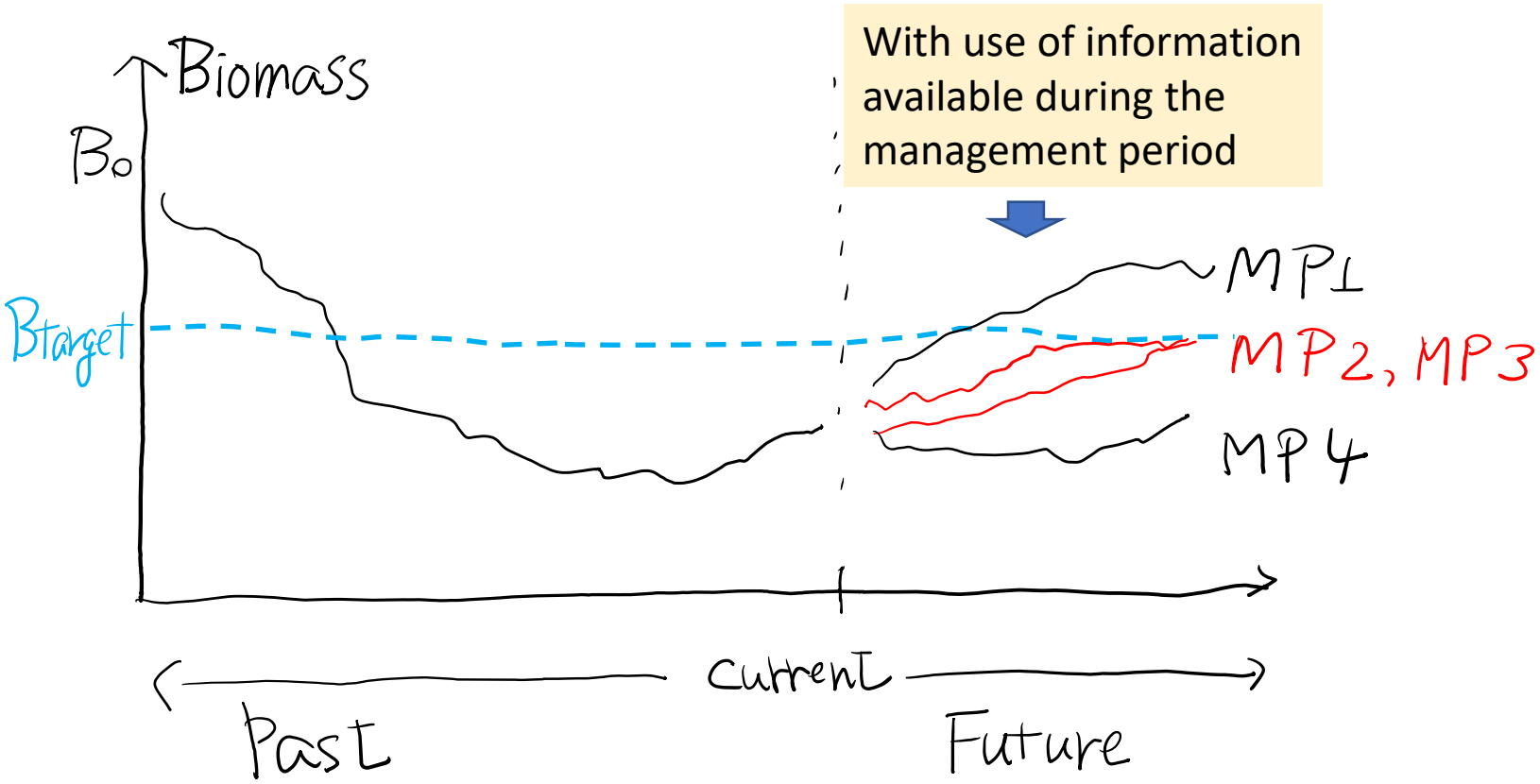


Projection in MSE:

Based on a **predetermined rule** with a **feedback mechanism** to control the catch

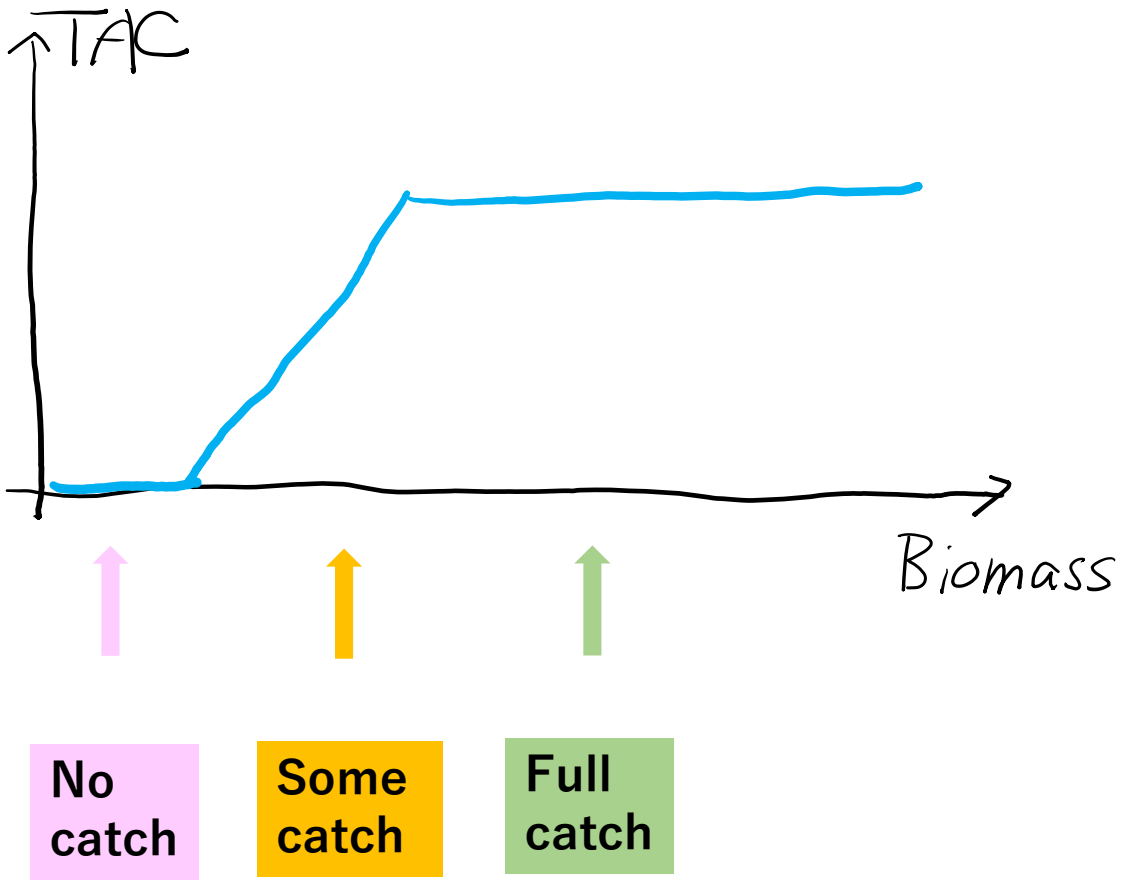
Question 3.
What is the Difference between "Management Procedure (MP)" and "Harvest Control Rule (HCR)"?

"There is always a better way" --- Thomas Edison

3. MP AND HCR

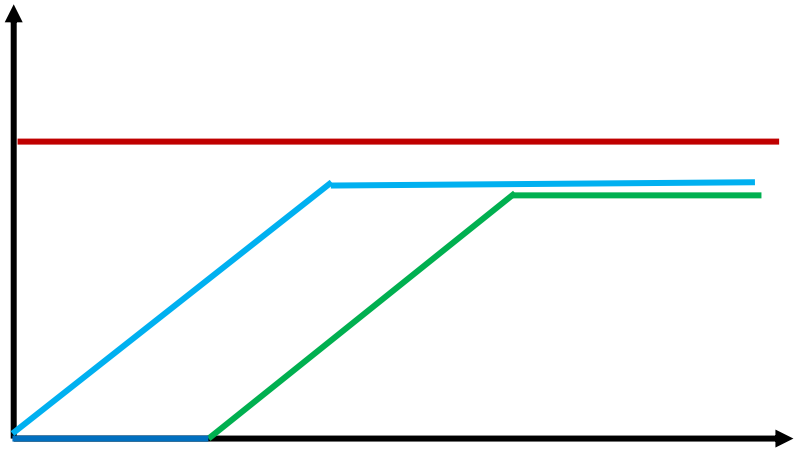
Difference between **"Management Procedure (MP)"** and **"Harvest Control Rule (HCR)"**?

- The both are predetermined rules
- An **HCR** (if 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



3. MP AND HCR

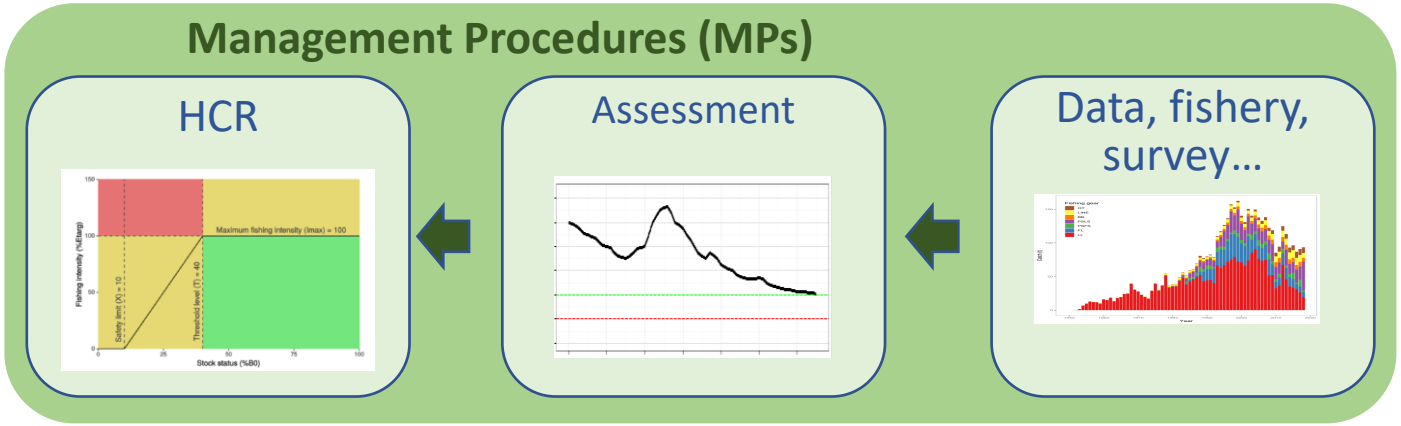
- An **MP** (model-based) is a package of
  - ➢ Data collection and preparation
    - Catch only
    - Catch + well-standardized CPUE
    - Catch + well-standardized CPUE + fishery-independent survey, ….
  - ➢ Assessment (if needed)
    - Simple assessment model (robust but not sensitive to changes?)
    - Very complicated assessment model (comprehensive but heavily dependent on the assumption?) , ….
  - ➢ Harvest Control Rule (HCR)
    - Aggressive (reckless)
    - Conservative
    - Intermediate , …..



Model-based and empirical MPs

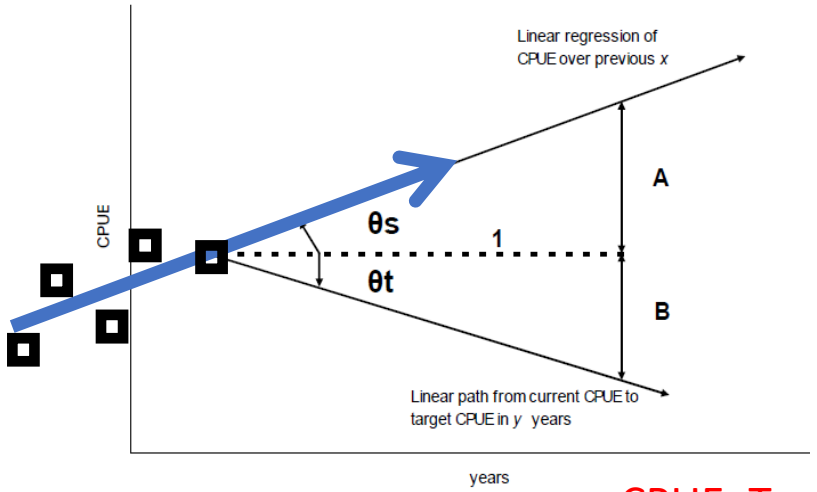
Model-based MP:

- Stock assessment
- HCR



Empirical MP:

Aims to keep the stock near a target CPUE



CPUE<Target
TAC decrease

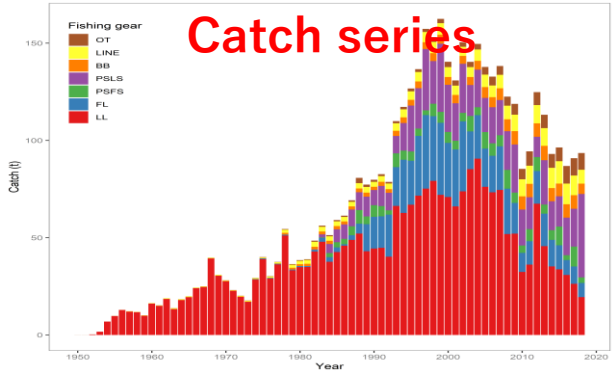
Question 4.
What is the Difference between "OM" and "Assessment model"?

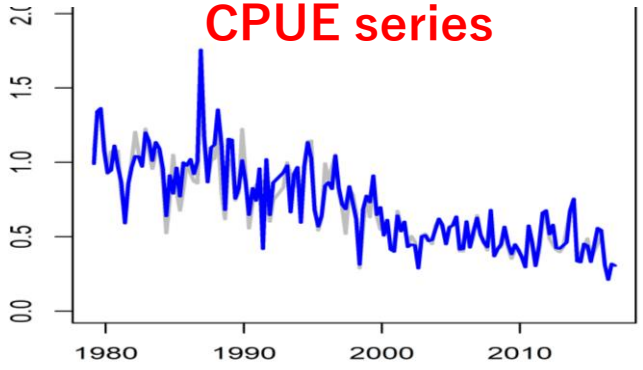
"All models are wrong, but some are useful" --- George Box, Statistician

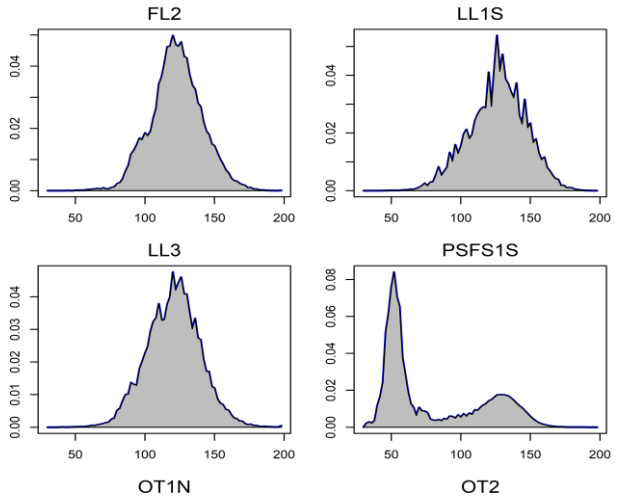
4. OM AND ASSESSMENT MODEL

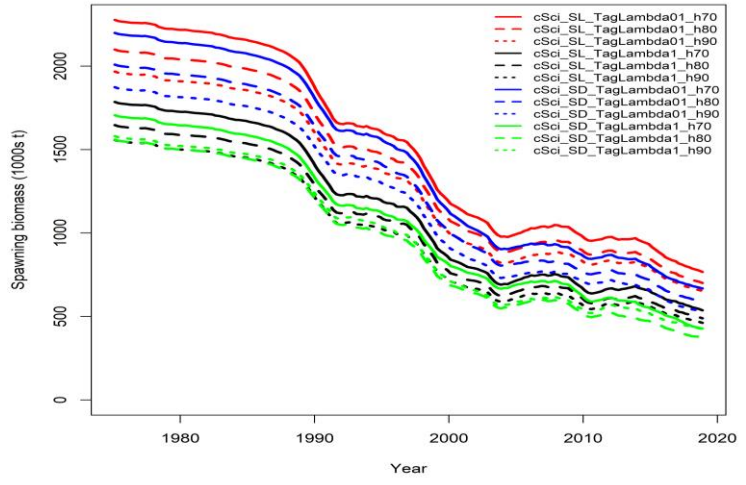
What is the "**Operating Model (OM)**" and how different from the "**Assessment Model**"?

- **Assessment model**
  - Population dynamics (+ unknown stochasticity)
  - Fisheries impacts through catch and size selectivities
  - Conditioned (and estimated) in the stock assessment









4. OM AND ASSESSMENT MODEL

What is the "**Operating Model (OM)**" and how different from the "**Assessment Model**"?

- **Assessment model**
  - Population dynamics (+ unknown stochasticity)
  - Fisheries impacts through catch and size selectivities
  - Conditioned (and estimated) in the stock assessment

- OMs
  - Play roles of "**virtual population dynamics**" and "**virtual fishery**" and in the simulation
  - OMs are primarily based on the stock assessment
  - OMs should not be completely equal to the Assessment models
  - Consider several uncertainties in key parameters
  - Account for other uncertainties to evaluate the **robustness**

4. OM AND ASSESSMENT MODEL

What is the "**Operating Model (OM)**" and how different from the "**Assessment Model**"?

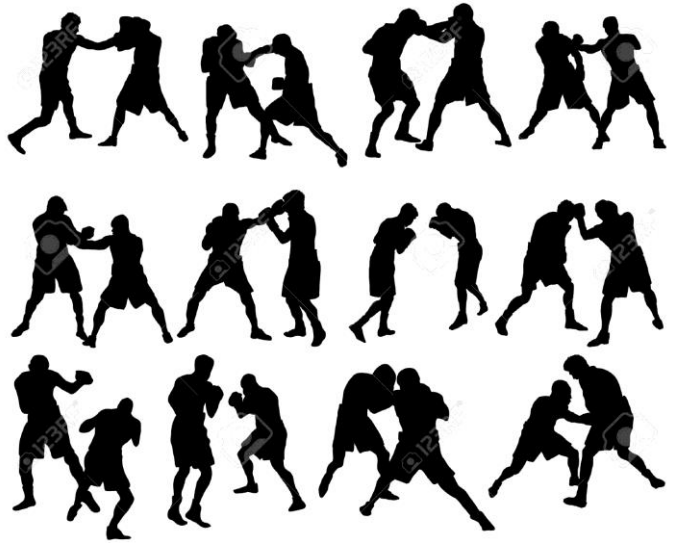
The OM is the basis of "**virtual population**" and "**virtual fishery**" in the simulation

- **Virtual population in simulation**
  - to reflect impacts of fisheries described MPs
  - to account for stochasticity (e.g. environmental factors implicitly or explicitly)

- **Virtual fishery in simulation**
  - to produce virtual data (with observation error) to be used in MPs
  - to reflect the catch (and its implementation error) from specified MPs
  - to reflect different selectivity of different fisheries

4. OM AND ASSESSMENT MODEL

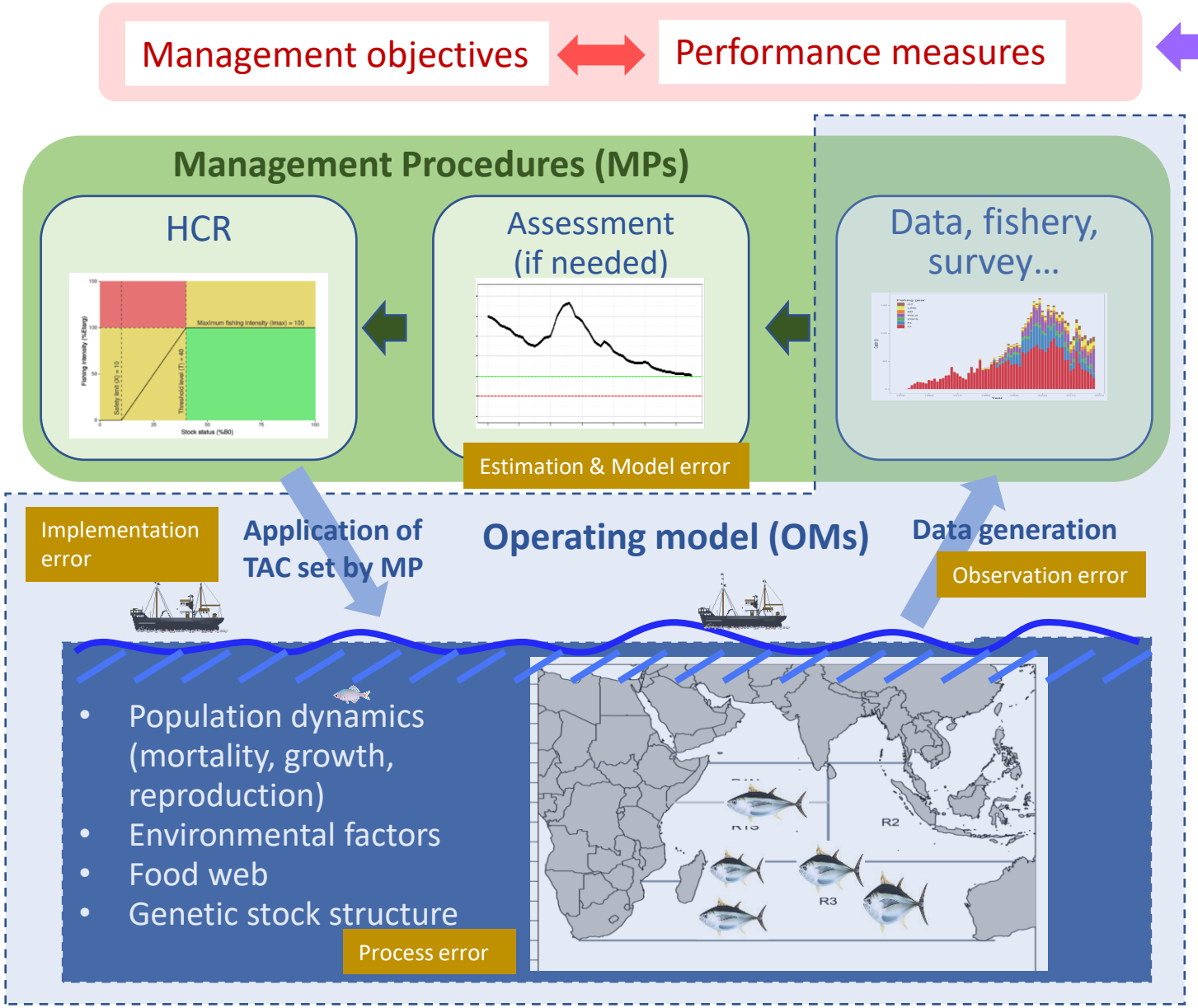
- Note: any MPs should not know the reality expressed in OMs !!
  - Like blind tests
  - If MPs know OMs, just like "judge" and "prosecutor" is a same person (no longer fair evaluation and comparison)
  - Need to train the MPs under different kinds of OMs (including robustness scenarios)

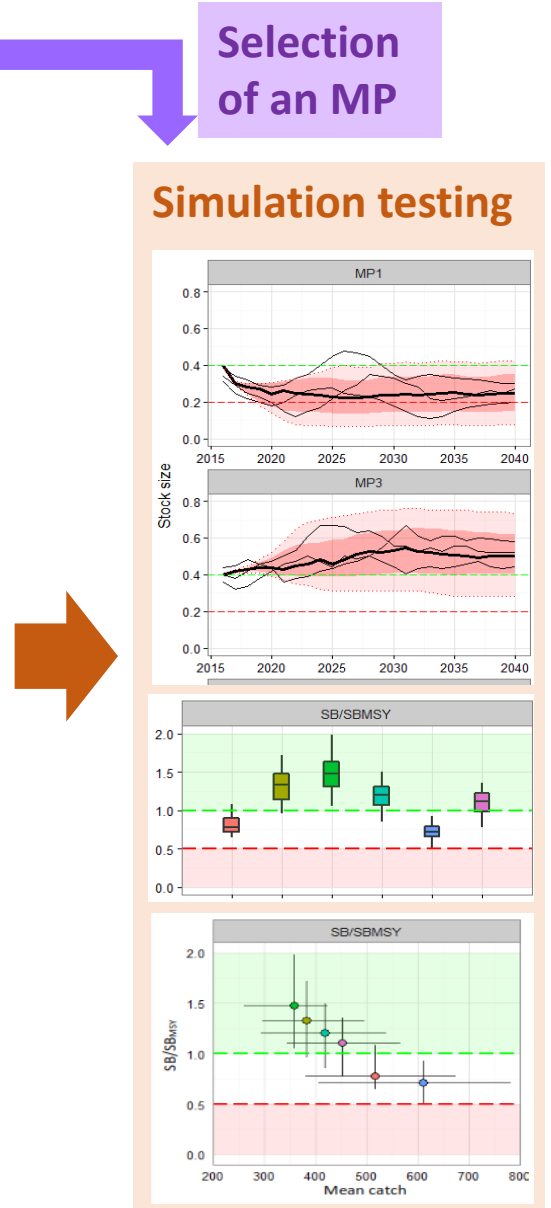


MSE IN NUTSHELL

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**



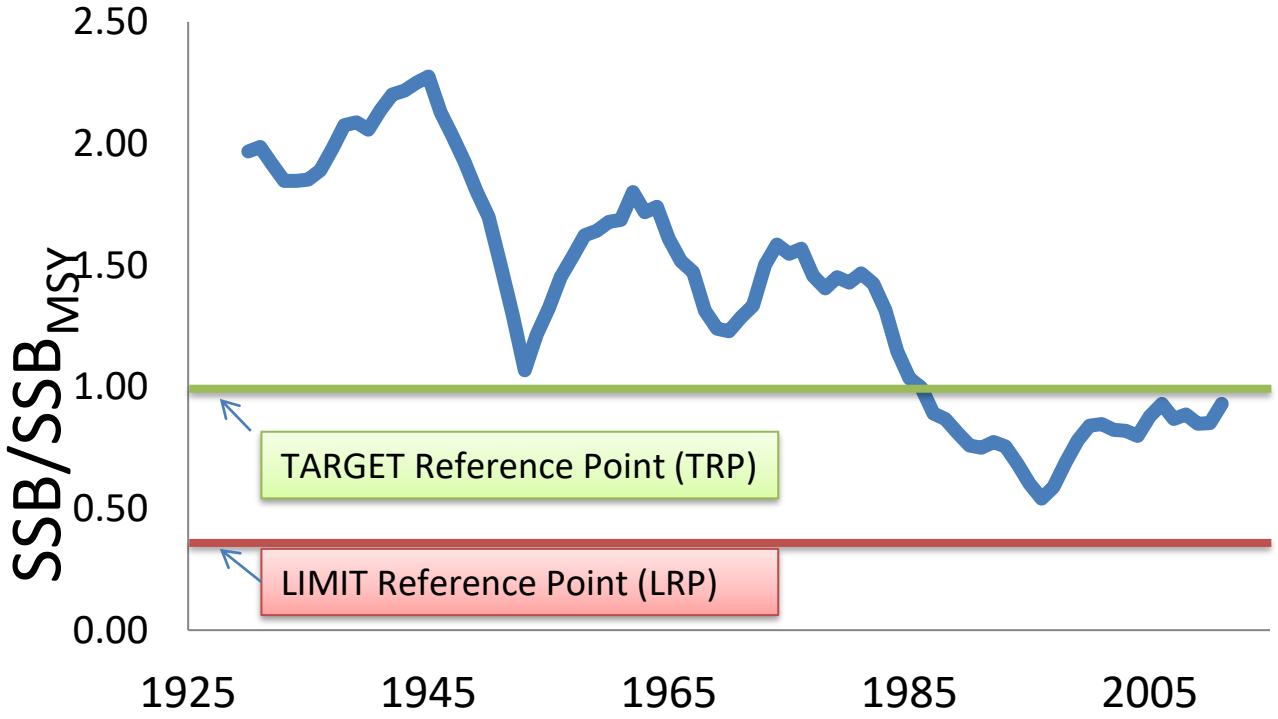


DEMO

3.2 Reference Points, stock status and risks

Reference Points

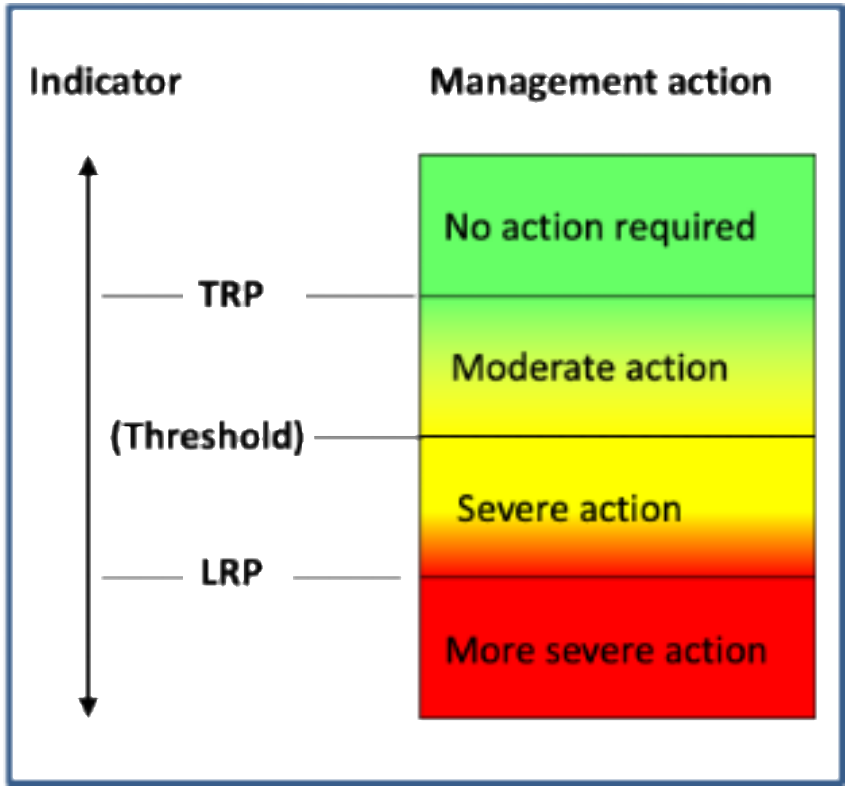
Reference Point is a **pre-determined** level of a given indicator that corresponds to a particular state of the stock that management either seeks to **achieve (TRP) or avoid (LRP).**



- **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.

THE PRECAUTIONARY APPROACH AND REFERENCE POINTS

- The UN Fish Stocks Agreement (UN, 1995) and the FAO Code of Conduct for Responsible Fisheries (FAO, 1995) provide the foundations of the Precautionary Approach (PA) to fisheries management,
- It requests the use of two types of precautionary reference points:
  - ***Conservation or limit reference points*** indicating a "biological" limit beyond the state of stock is undesirable and
  - ***Management or target reference points a "desired"*** level of harvest/biomass.
- And it states that management strategies shall ensure that there is ***very low risk of breaching limit reference points while target reference points*** should be exceeded on average.
- Ideally, RPs are included in a Management Procedure framework (along with HCR) and stock status (or any other indicator e.g. CPUE) triggers pre-agreed management actions to achieve targets while avoiding LRPs.

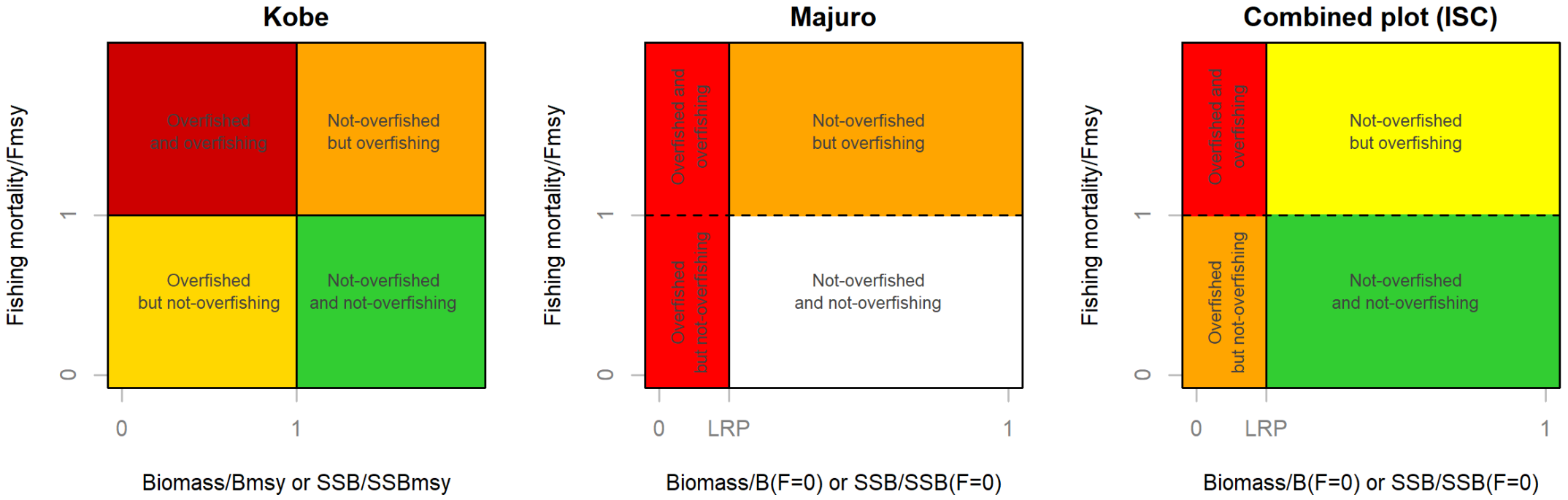


DIFFERENT TYPES OF REFERENCE POINTS IN TUNA RFMOS

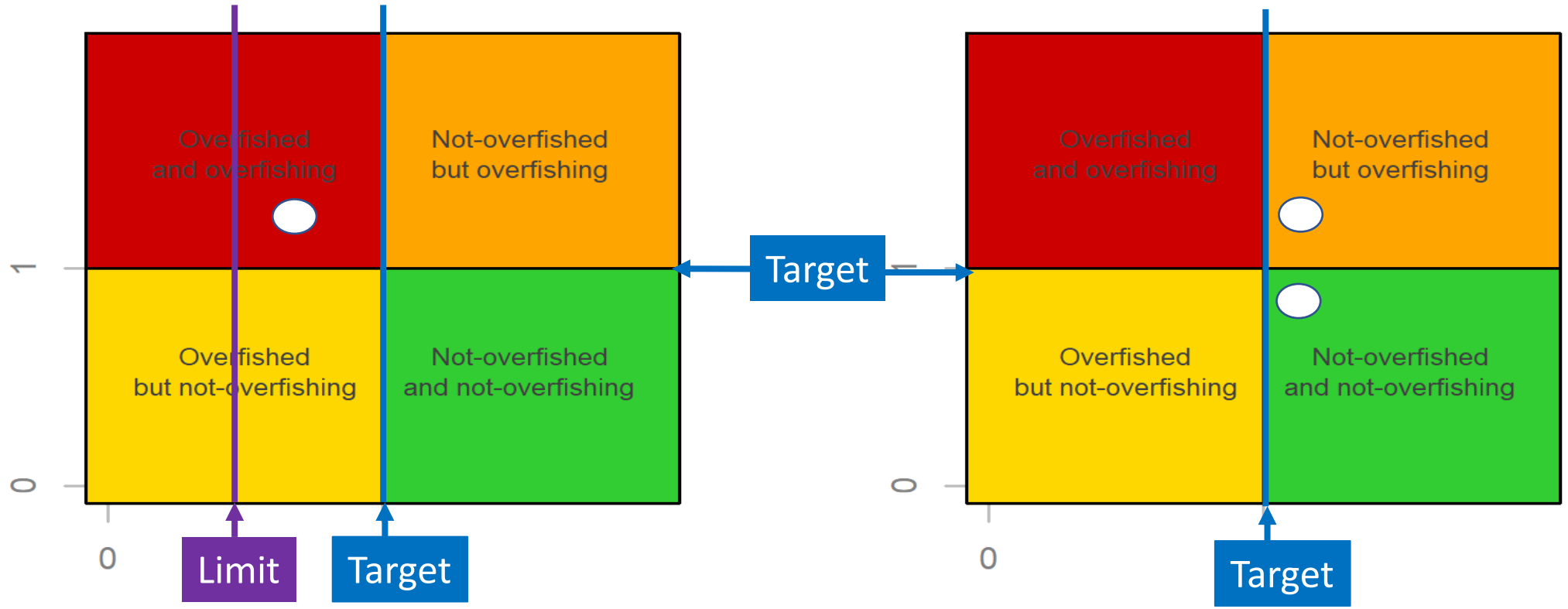
Element	IATTC	ICCAT	IOTC	WCPFC	CCSBT
Management objectives (convention)	• Population level that can produce the MSY. • Apply precautionary approach.	Maintain population at level that can permit maximum sustainable catch.	Conservation and optimum utilization of stocks.	• Long-term conservation and sustainable use of highly migratory species • Maintain stocks at levels capable of producing MSY, as qualified by environmental, economic and SIDs considerations.	Ensure, through appropriate management, the conservation and optimum utilization of SBT.
Target Reference Points	Interim target reference points for BET, SKJ and YFT = F_{MSY} and B_{MSY} are an implied TRP.	• F_{MSY} and B_{MSY} are an implied TRP. • For Northern Albacore 60% probability to be in Kobe green	Interim target reference points for ALB, BET, YFT and SWO (B_{MSY}, F_{MSY}), and SKJ (40% B_0, E_{TARG})	• Interim target reference points for: • SKJ: 50% SBcurrent, F=0 • Southern ALB: 56% SBcurrent, F=0	Interim rebuilding objective: 20% SSB0. A long-term TRP will be considered once stock is rebuilt to 20%SSB0.
Limit reference Points	Interim Limit Reference Points for BET and YFT = 7.7 % of SSB_0	None yet. For Northern Albacore Blim = 0.4*B_{MSY}	Interim limit reference points for ALB, SWO and YFT (0.4 B_{MSY}, 1.4 F_{MSY}), BET (0.5 B_{MSY}, 1.3 F_{MSY}, and SKJ (20% B_0	ALB, BET, SKJ and YFT: 20%SBcurrent, F=0 (defines overfished)	• 20% SSB0 would become a limit at the end of the rebuilding program. • The 2011 decision identifies the lowest observed stock size as the limit.
Type of RPs	**MSY based**	**MSY based**	**MSY based (except SKJ)**	**Depletion based**	**Depletion based**

STOCK CHARACTERIZATION PLOTS IN tRFMOs: KOBE vs. MAJURO

- Kobe plots used extensively to represent stock status since 2007 (when no TRPs and LRPs where available),
- Yet, there is no standard way of representing stock status relative to both target and limit reference points levels,
- Based on those differences on how to define overfished stock status, different plots have been developed in tRFMOs to characterize the stock status and provide management advice.

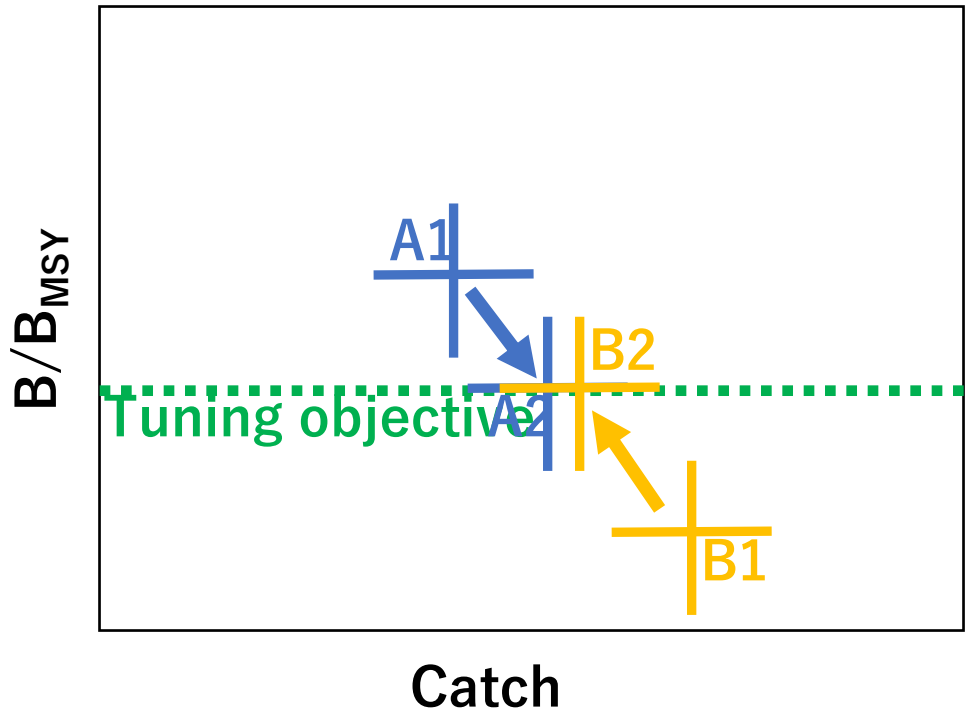


BACKGROUND


Overfished
and overfishing
Not-overfished
but overfishing
Overfished
but not-overfishing
Not-overfished
and not-overfishing
1
0
0
Limit
Target
Target
Overfished
and overfishing
Not-overfished
but overfishing
Overfished
but not-overfishing
Not-overfished
and not-overfishing
1
0
0
Target

TUNING OF MP WITH A PRIMARY TARGET

- 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

3.3 Potential issues regarding MSE for Pacific saury (and small pelagic fish in general)

2019 BRP-HCR-MSE workshop in NPFC

NPFC-2019-WS BRP_HCR_MSE01-Final Report

North Pacific Fisheries Commission
Biological Reference Point/Harvest Control Rule/Management Strategy Evaluation
Workshop

4-5 March 2019
Yokohama, Japan

Item 1. Opening of the Workshop
Item 2. Adoption of Agenda
Item 3. Basic information about NPFC priority species
Item 4. Review of the general concept and best practices of BRP, HCR and MSE
Item 5. Overview of the outcomes of literature reviews on BRPs and HCRs that have been applied to small pelagic fish stock management
Item 6. Potential directions on application of BRPs, HCR and MSE to the management of NPFC priority species
Item 7. Recommendations to the SC and its subsidiary bodies
Item 8. Adoption of the Report
Item 9. Close of the Workshop

PS-related issues discussed in 2019 BRP-HCR-MSE workshop in NPFC

- Dr. Butterworth …. argued that pristine biomass (B0) is not always well estimated for short-lived and highly variable stocks, such as small pelagic species, and B0-based reference points should not be used for such species. (para 12)

- Dr. Kell … pointed out the importance of tailoring reference points to life history characteristics such as growth and maturity and also to variability in recruitment; understanding the weaknesses and uncertainties inherent in reference points; and testing the robustness of reference points for fishing mortality and spawning stock biomass. (para 13)

- The invited experts suggested that age-structured stock assessment models would be more appropriate than age-aggregated models and that age-structured operating models were preferable to length-based operating models. (para 22)

Recommendations in 2019 BRP-HCR-MSE workshop in NPFC

(a) The Workshop recommended conducting MSE for only one species at a time due to the resource-intensive and complex nature of the process. Because chub mackerel is a longer-lived species than Pacific saury and more stock assessment data are available, enabling the operating model to be conditioned, the Workshop recommended conducting MSE for chub mackerel as the first priority.

(b) For Pacific saury, the Workshop recommended to consider developing an age-structured operating model for use in simulation work to identify and evaluate potential reference points (for example Blim and Ftarget). It is suggested that initial simulation work focus on constant F runs (e.g. to investigate MSY-based reference points, Blim and Ftarget) and empirical HCR (e.g. taking a constant proportion of the estimated survey biomass). Model-based and empirical HCRs could both be considered when a full MSE is undertaken.

Recommendations in 2019 BRP-HCR-MSE workshop in NPFC

(c) For chub mackerel, the Workshop recommended considering to conduct initial assessments with a range of models, which could be used in a subsequent MSE.

(d) The Workshop recommended that the SC propose to the Commission to explore the possibility of creating an intermediary group consisting of scientists, managers and stakeholders, as needed, when conducting an MSE.

(e) Consideration could be given to the role of small pelagic fish in the ecosystem as key low trophic level stocks and also to climate variability when setting the reference points.

Objectives stipulated in ToR of SWG MSE PS

Short-Term Objectives: within one to two years:

a) develop **draft interim management objectives** and a **draft interim harvest control rule (HCR)** that meets such objectives to report to the Commission (preferably before the 8th Commission annual meeting); and

b) **evaluate the robustness of the draft interim harvest control rule** with consideration of possible uncertainties including effects of climate changes.

Mid-Term Objectives: within three to five years:

a) develop **draft mid- to long-term management objectives** by setting the **target and limit reference points** for the population status as well as by defining "overfishing" and "overfished" for the sustainable use of the Pacific saury stock;

b) assess the feasibility of establishing a **management procedure through an MSE**

North Pacific
Fisheries Commission

NPFC

ITEM 4. INITIAL DISCUSSION TOWARD DEVELOPMENT OF AN INTERIM HCR FOR THE SHORT-TERM GOAL

4.1 MANAGEMENT OBJECTIVES AND SOME CONSTRAINT CONDITIONS FOR THE REGULATION OF FISHERY

4.2 TECHNICAL MATTERS ON OPERATING MODELS, HCRS, PERFORMANCE MEASURES AND SIMULATION

Objectives stipulated in ToR of SWG MSE PS

Short-Term Objectives: within one to two years:

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Overview of SSC-PS07 & PS08

- SSC-PS07 (Oct 8-11):
  38 participants from 7 Members
- SSC-PS08 (Dec 10-14):
  48 participants from 8 Members
- Larry Jacobson as an invited expert for both the meetings

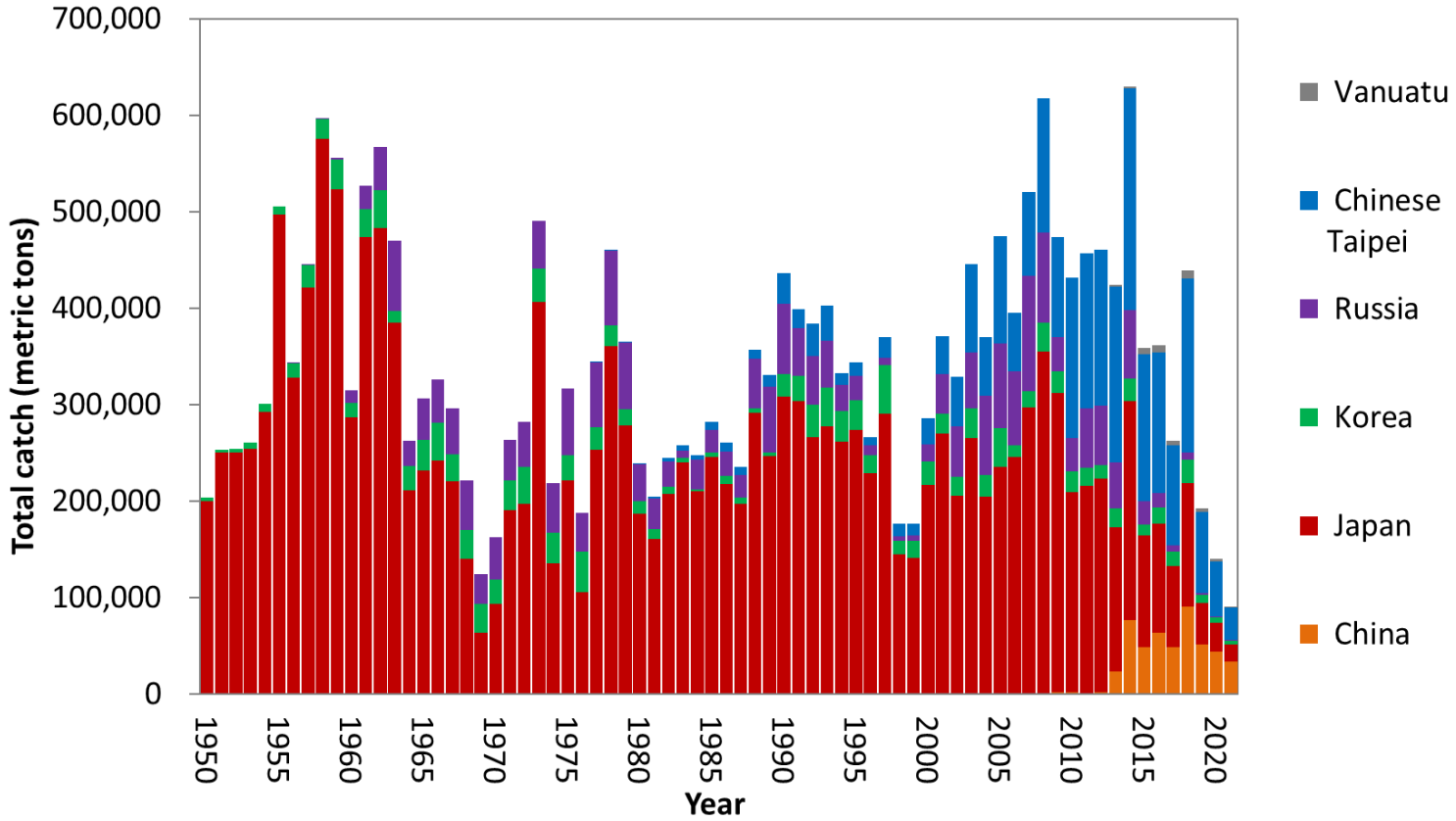
Taken by the Secretariat

Annual catch series

- **A sharp decline in catch and nominal CPUE from 2020 to 2021, continuing the declining trend in recent years**
- **Lowest catch in 2021** since 1950

- The spatial distribution of the fishing grounds has also shifted, with **fishing grounds shifting to the east** and a higher proportion of catch occurring in the Convention Area compared to previous years;

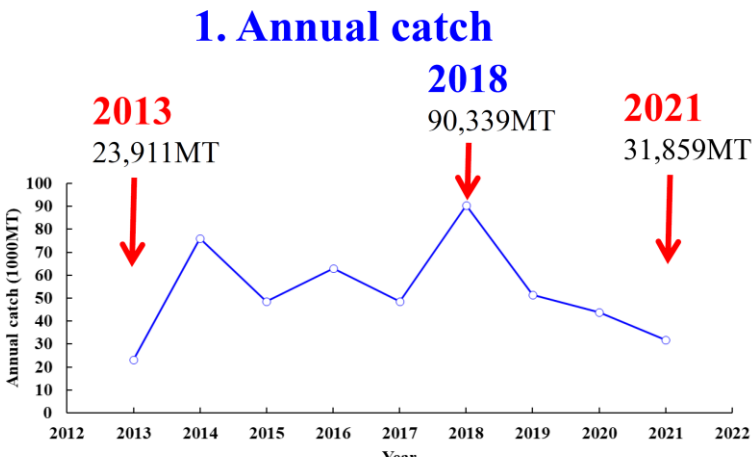
- Catch in 2021 is a preliminary number and was not used in the stock assessment



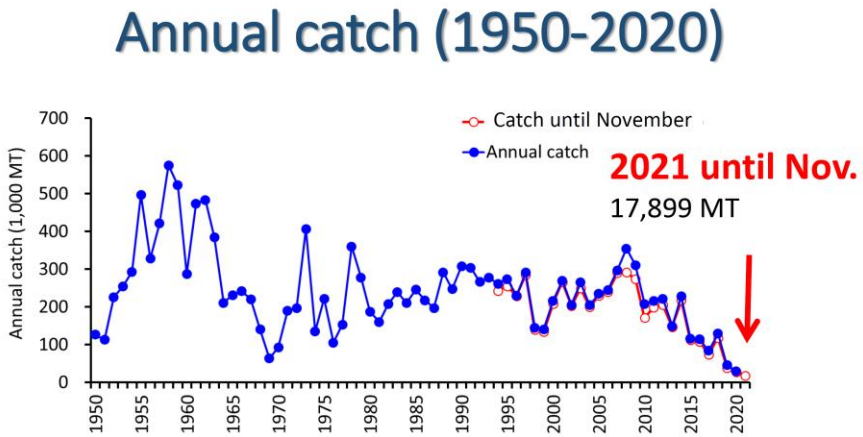
Prepared by the Secretariat

Catch by Member (including preliminary information in 2021)

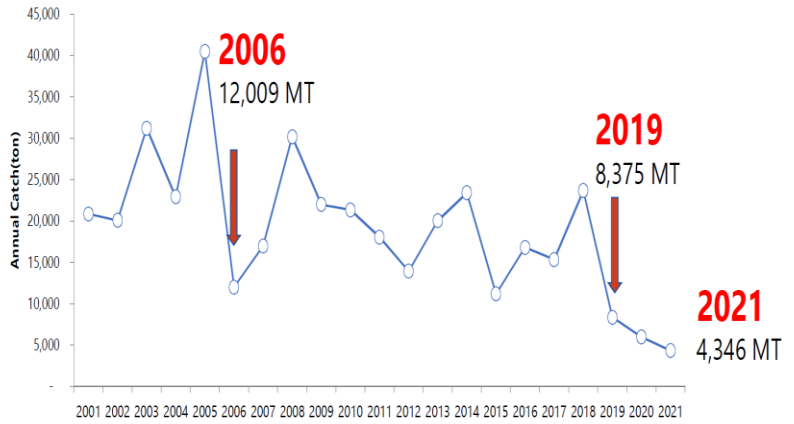
China



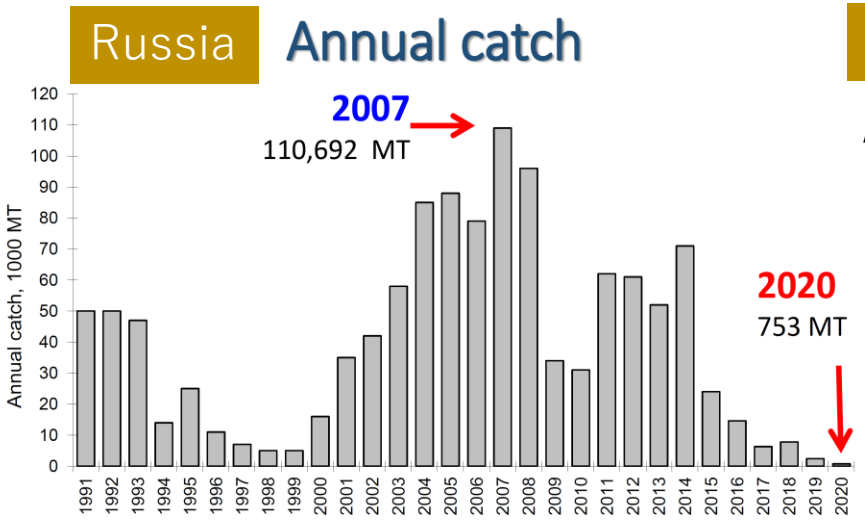
Japan



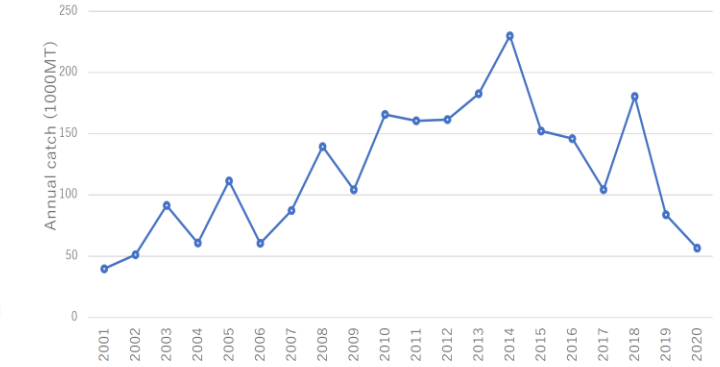
Korea



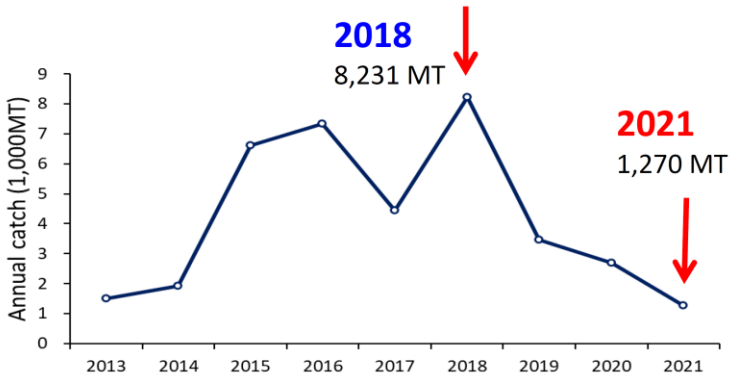
Russia



Chinese Taipei

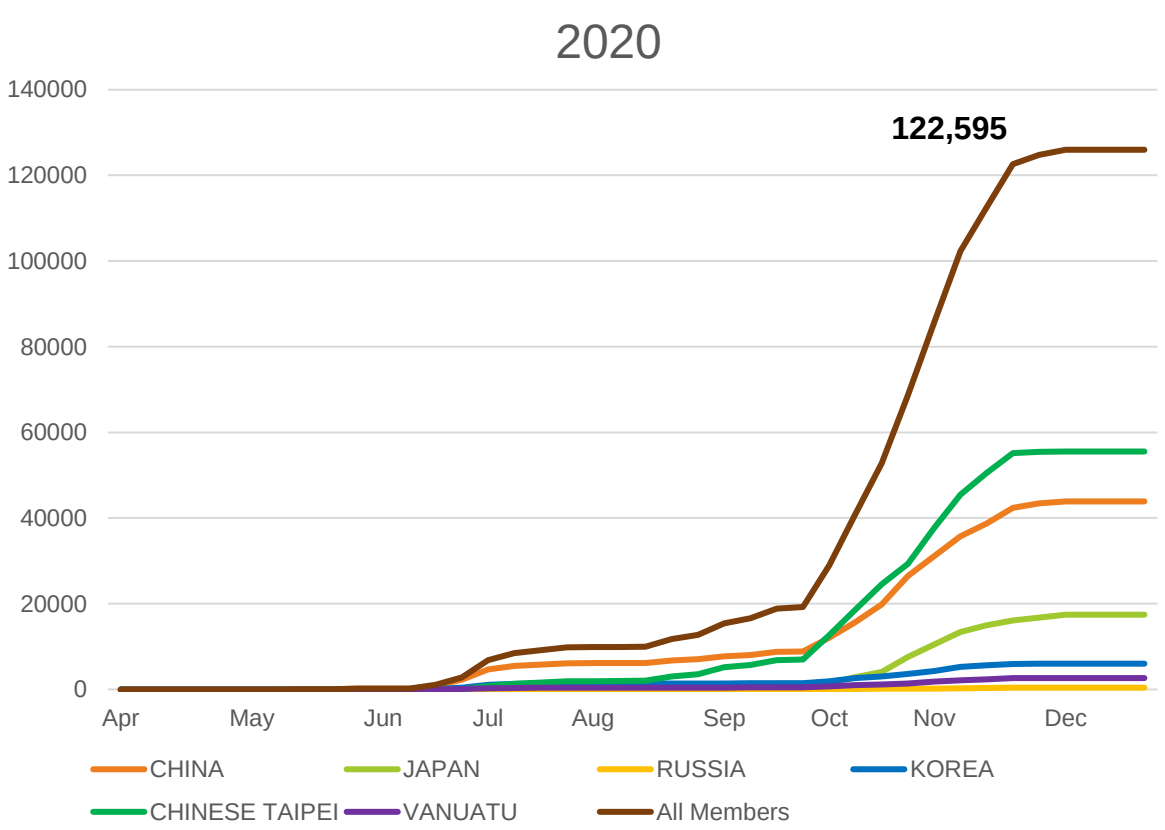


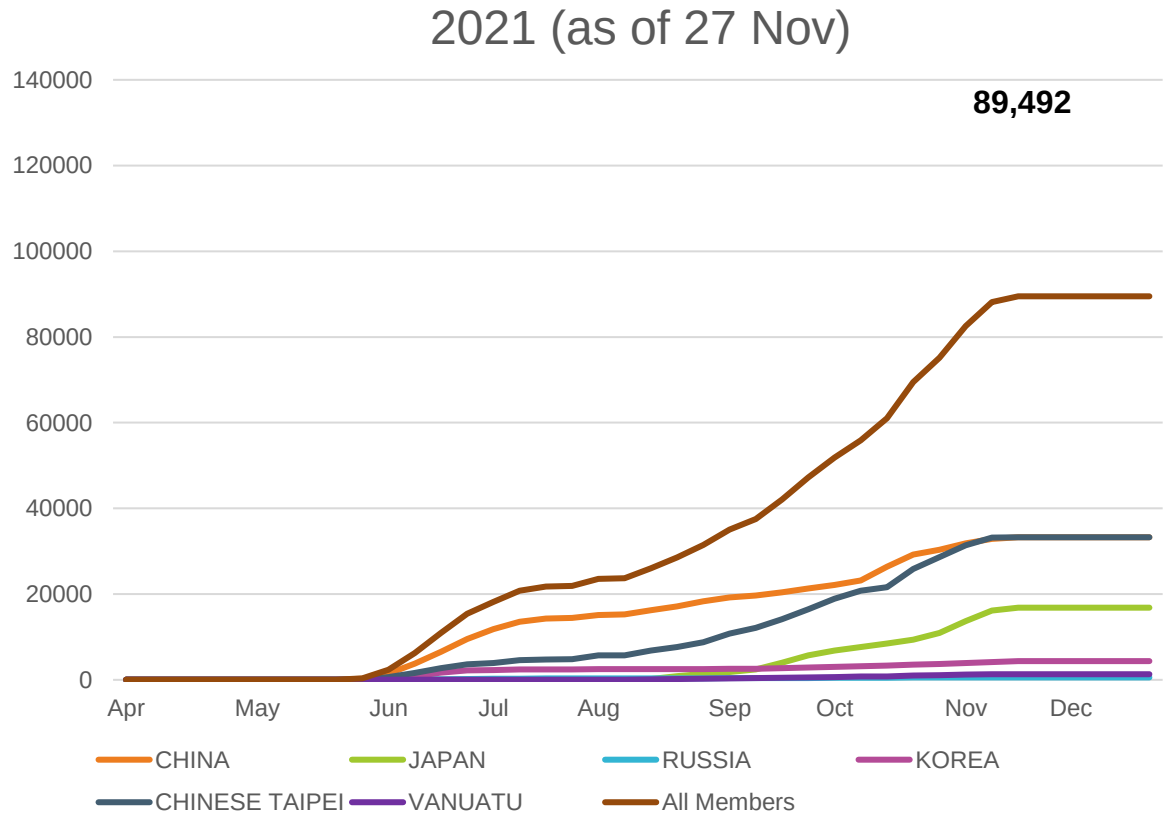
Vanuatu



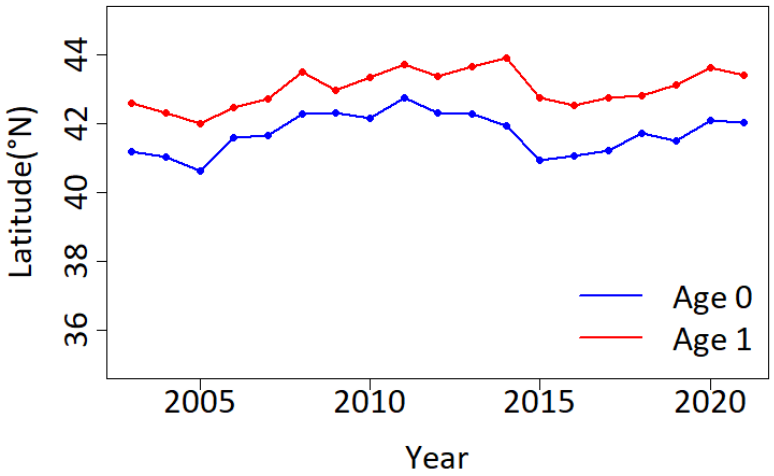
Cumulative catch in 2020 and 2021

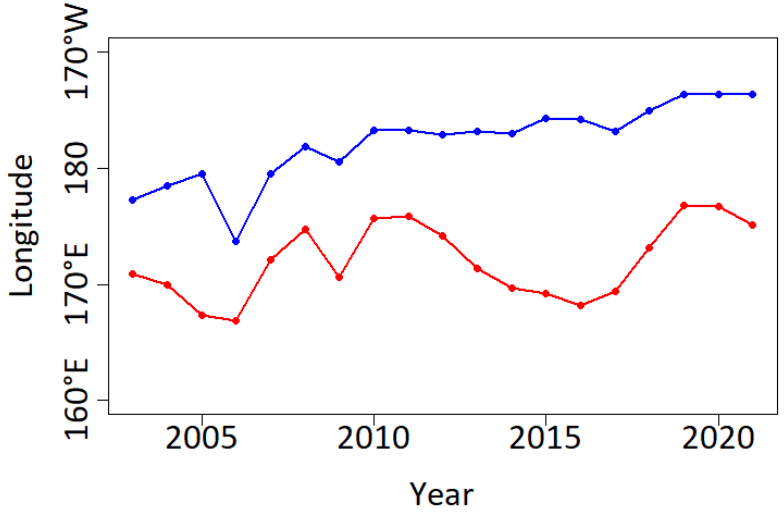
- In **autumn**, which has been the main fishing season, there was a reduced proportion of catch in 2021 compared to past years
- An **increased proportion** of catch in early summer was observed in 2021



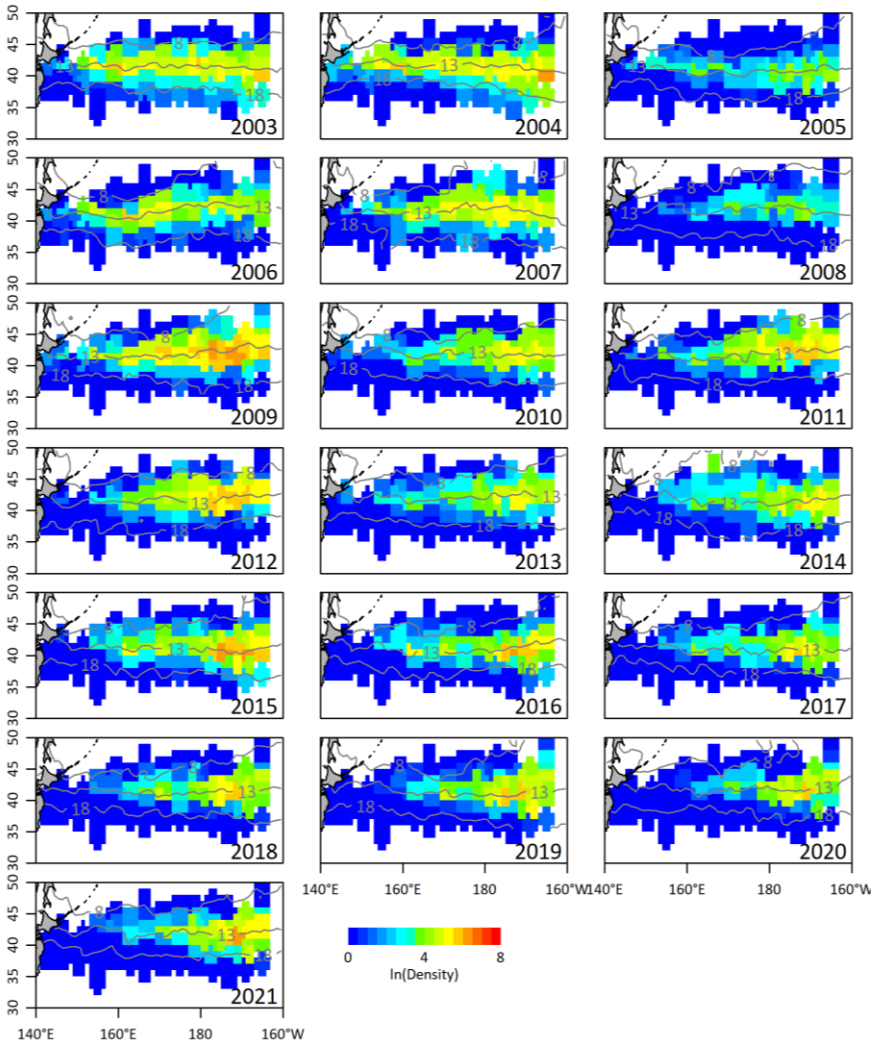


Fishery-independent abundance indices

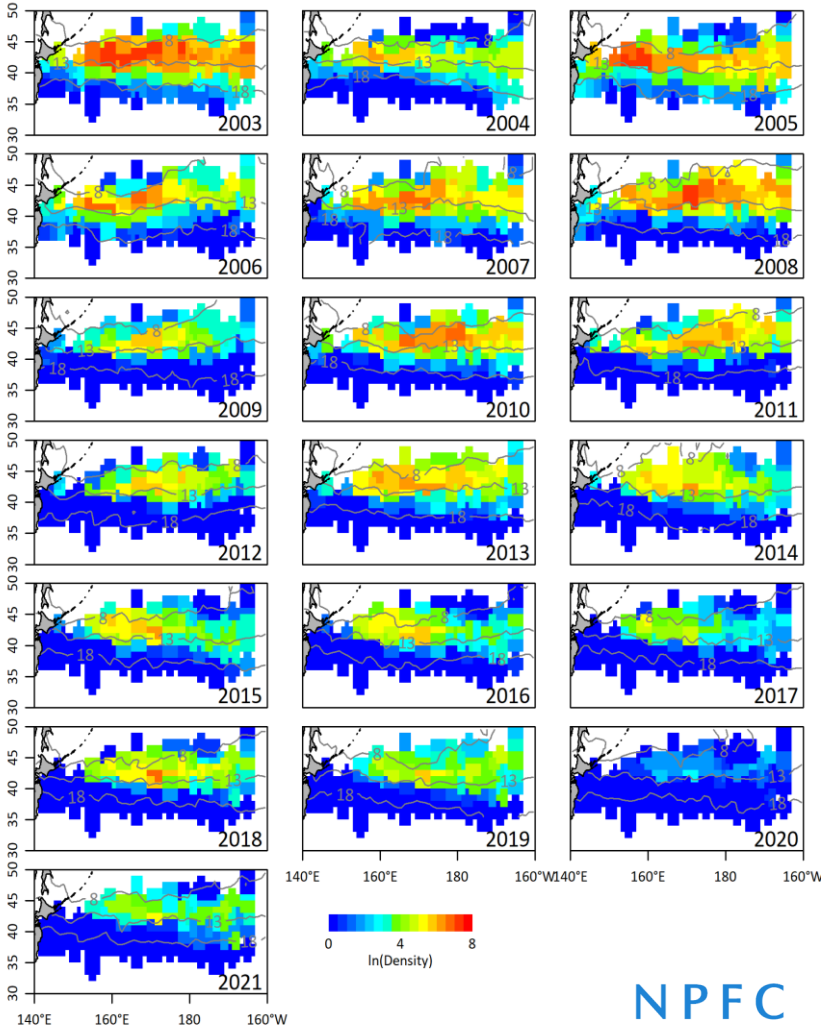




Age 0



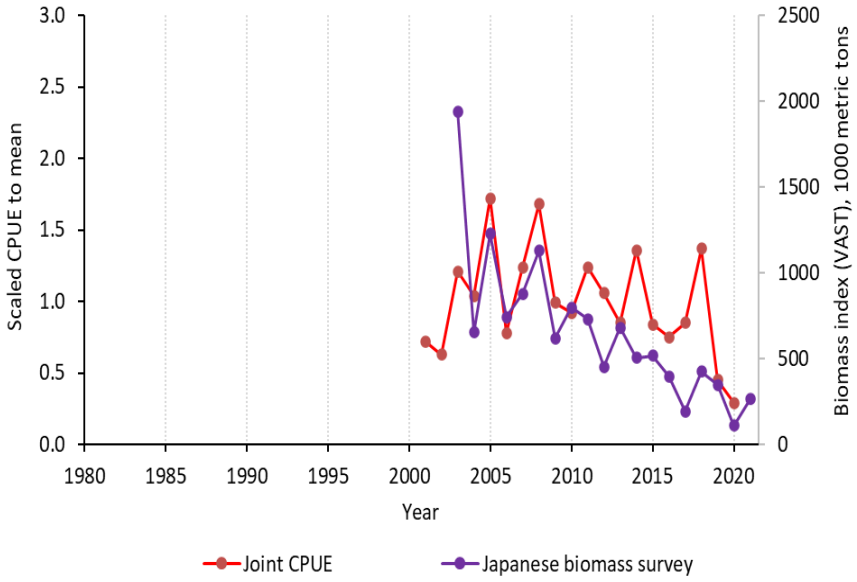
Age 1



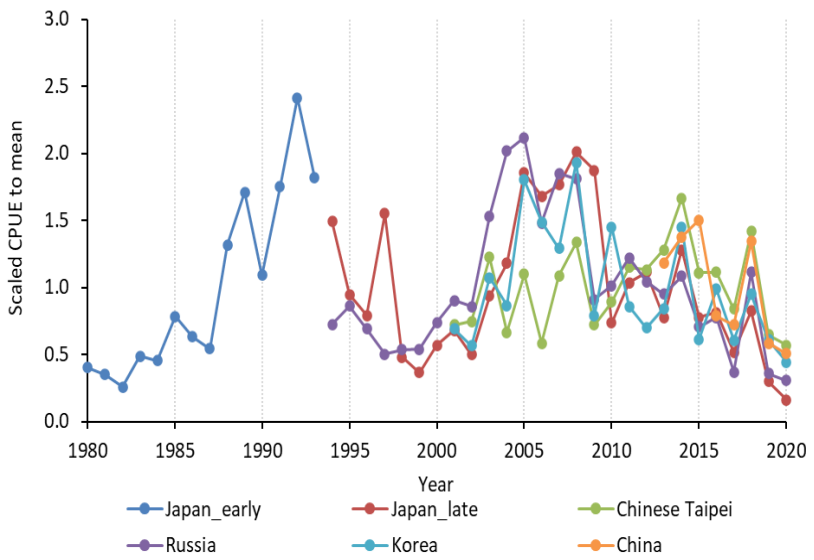
North Pacific Fisheries Commission

Summary of indices

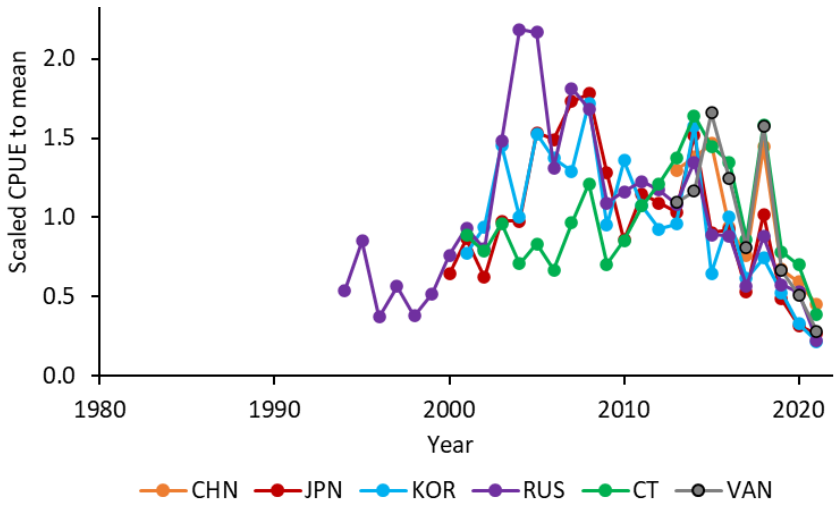
Biomass index (~2021)
and joint CPUE (~2020)



Members' standardized CPUEs
(up to 2020)



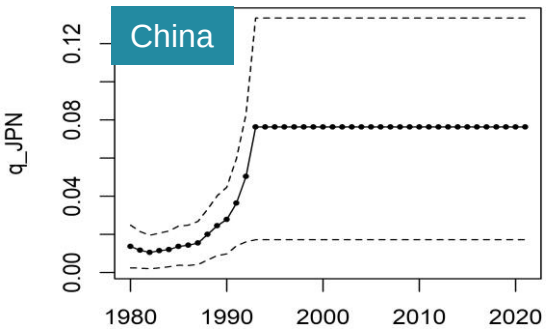
Members' nominal CPUEs
(up to 2021)

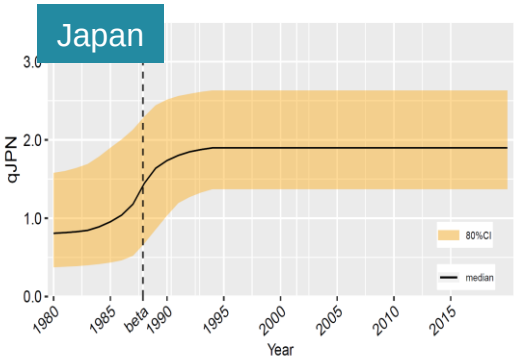


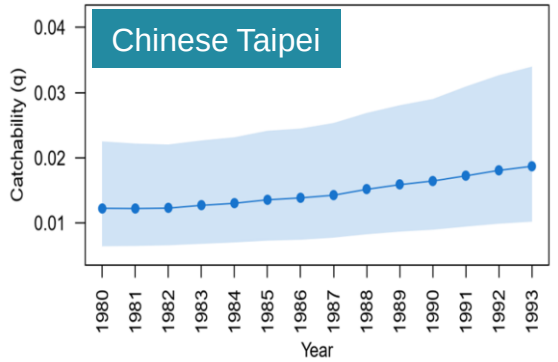
Specification of BSSPM

	Base case (B1)	Base case (B2)
Initial year	1980	Same as left
Biomass survey	$I_{t,bio} = q_{bio}\, B_t e^{v_{t,bio}}$ $v_{t,bio} \sim N(0, CV_t^2 + \sigma_{bio}^2)$ $q_{bio} \sim \mathrm{U}(0,1)$ (2003-2021)	Same as left
CPUE	CHN(2013-2020) JPN_early(1980-1993, time-varying q) JPN_late(1994-2020) KOR(2001-2020) RUS(1994-2020) CT(2001-2020) $I_{t,f} = q_f B_t^b e^{v_{t,f}}, \quad v_{t,f} \sim N(0, \sigma_f^2)$ $\sigma_f^2 = c * (ave(CVt^2) + \sigma_{bio}^2)$ $ave(CVt^2)$ is computed except for 2020 survey	CHN(2013-2020) JPN_late(1994-2020) KOR(2001-2020) RUS(1994-2020) CT(2001-2020)
Variance component	Variances of logCPUEs are assumed to be common and c=6 times of that of log biomass	Variances of logCPUEs are assumed to be common and c=5 times of that of log biomass
Hyper-depletion/ stability	A common parameter for all fisheries but JPN_early, with a prior distribution, b ~ U(0, 1) [b_JPN_early=1]	A common parameter for all fisheries with a prior distribution, b ~ U(0, 1)
Prior for other than q_{bio}	Own preferred options	Own preferred options

- China and Chinese Taipei: random walk
- Japan: parametric





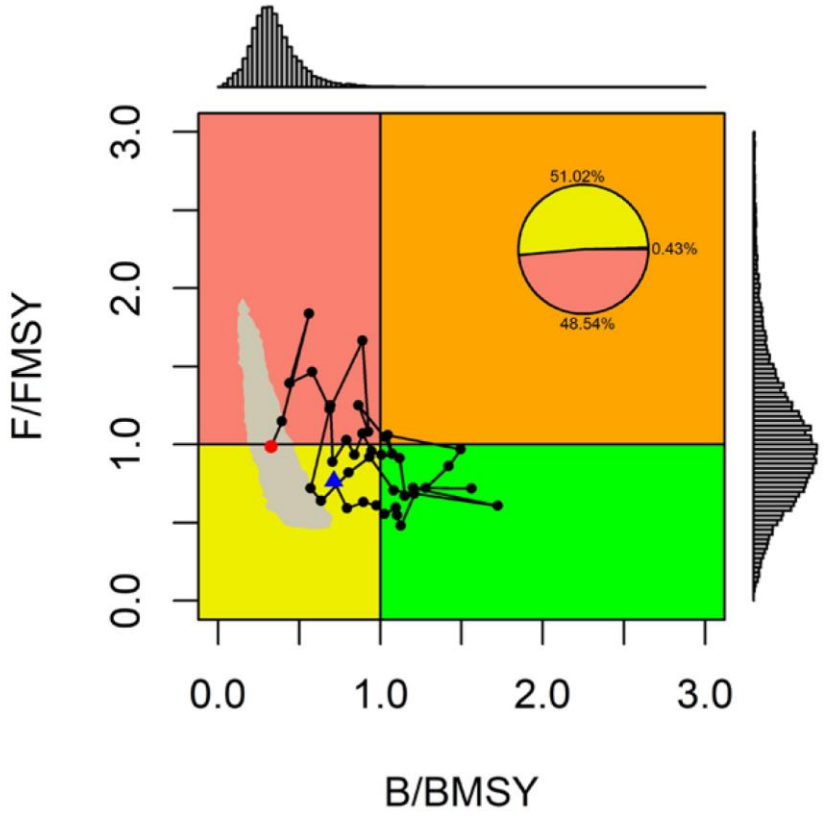


Figures extracted from NPFC-2021-SSC PS08-WP01, WP03, and provided by China

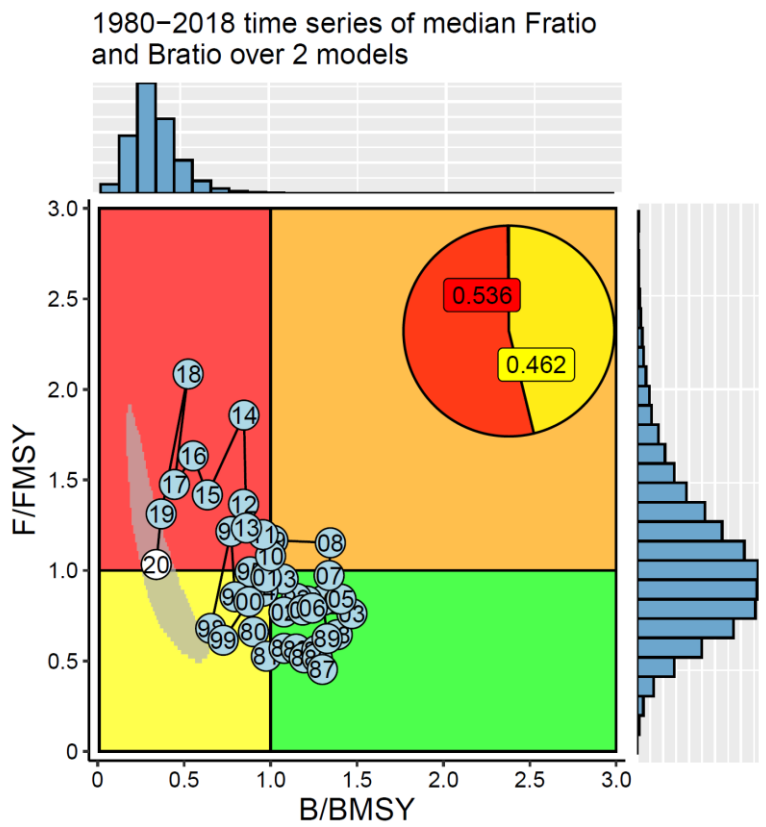
- China and Japan: Flat priors
- Chinese Taipei: Informative priors

The SSC PS received three reports of BSSPM analyses

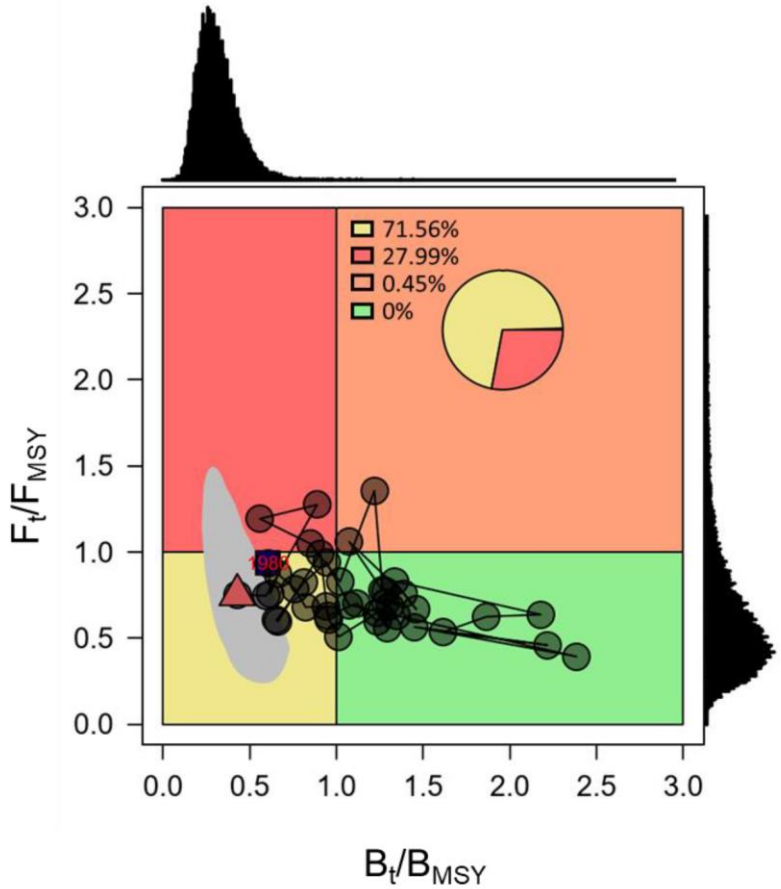
China



Japan

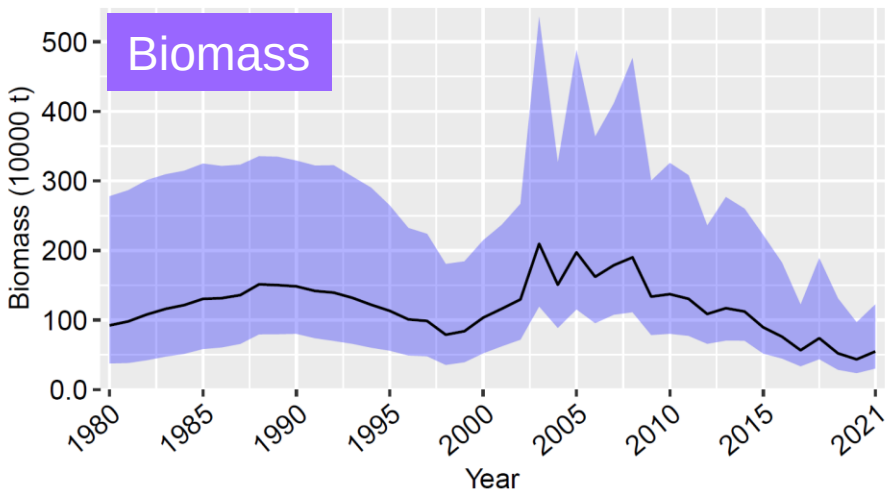


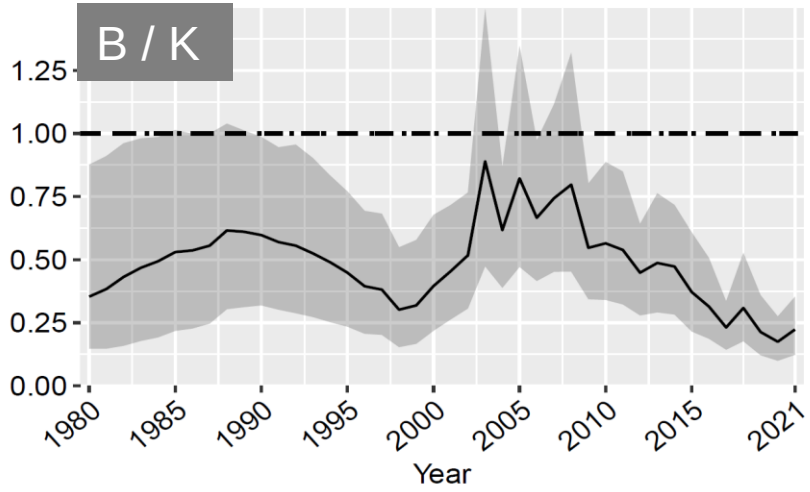
Chinese Taipei

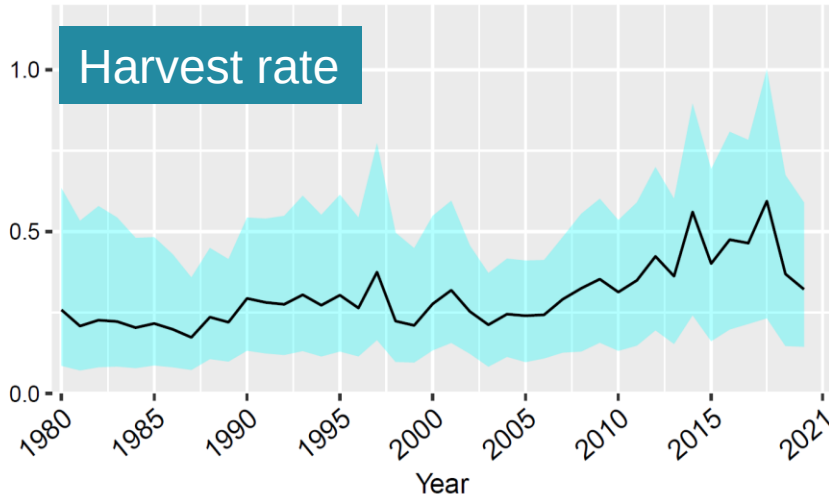


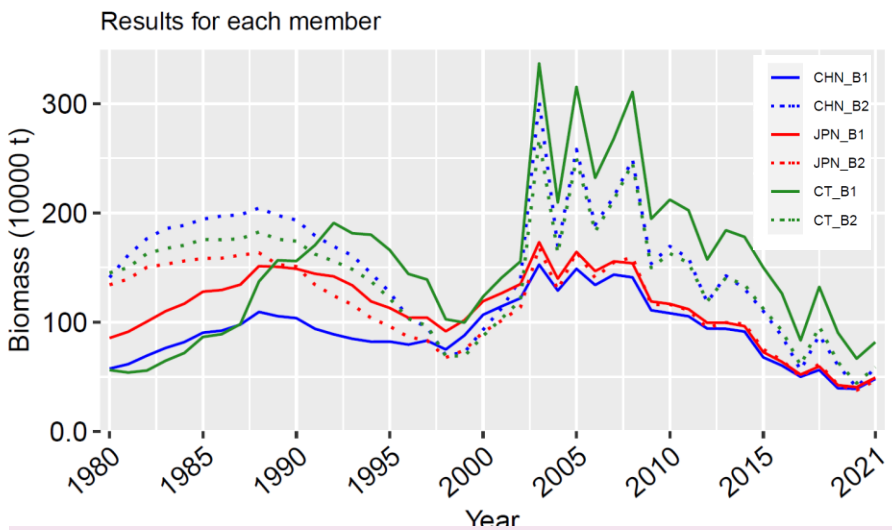
- The SSC-PS agreed that the same approach to aggregate the results over 6 runs (3 members x 2 base case runs) is used to finalize the stock assessment based on BSSPM

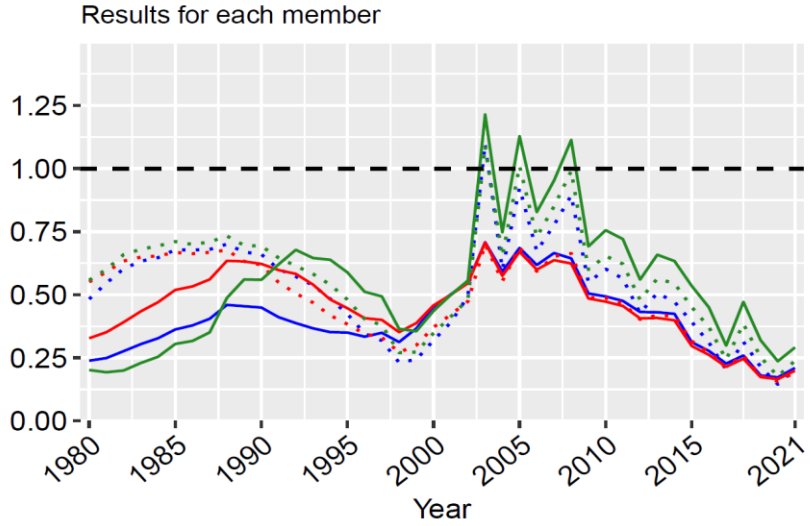
The SSC PS received three reports of BSSPM analyses (figures from SSC-PS08 report)

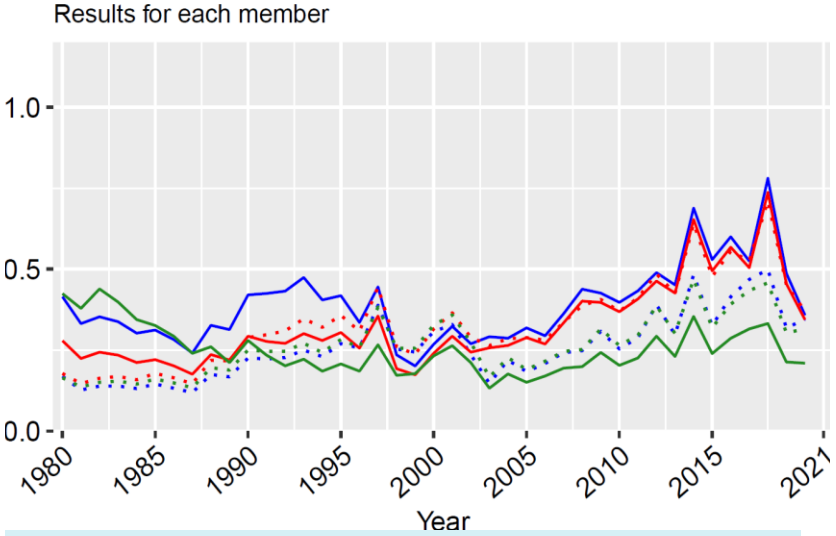








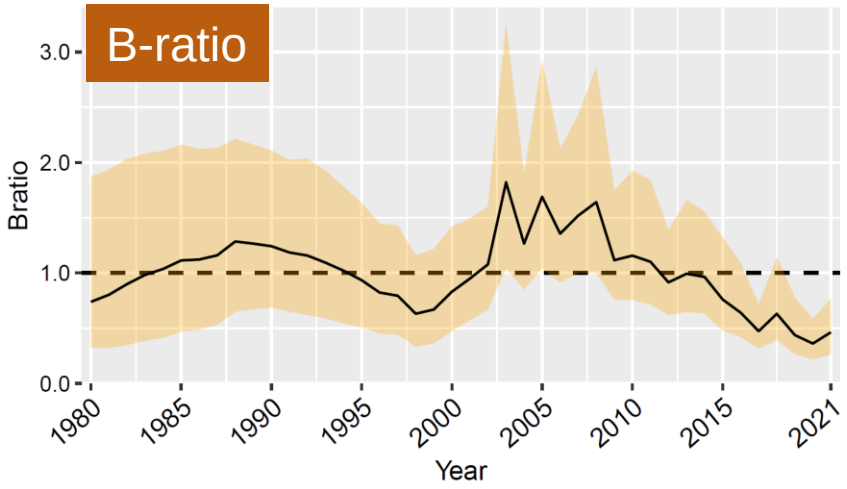


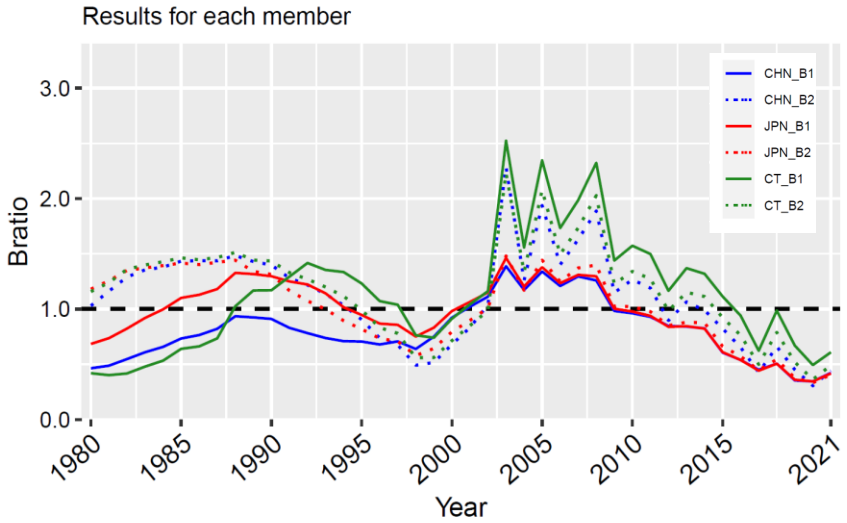


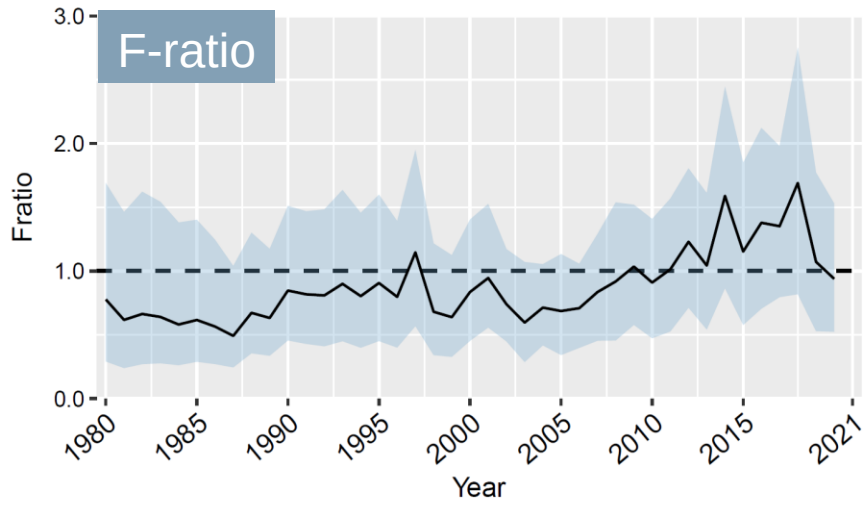
Results of combined model estimates indicate that the stock declined with an interannual variability from near carrying capacity in the mid-2000's after a period of high productivity to current low levels

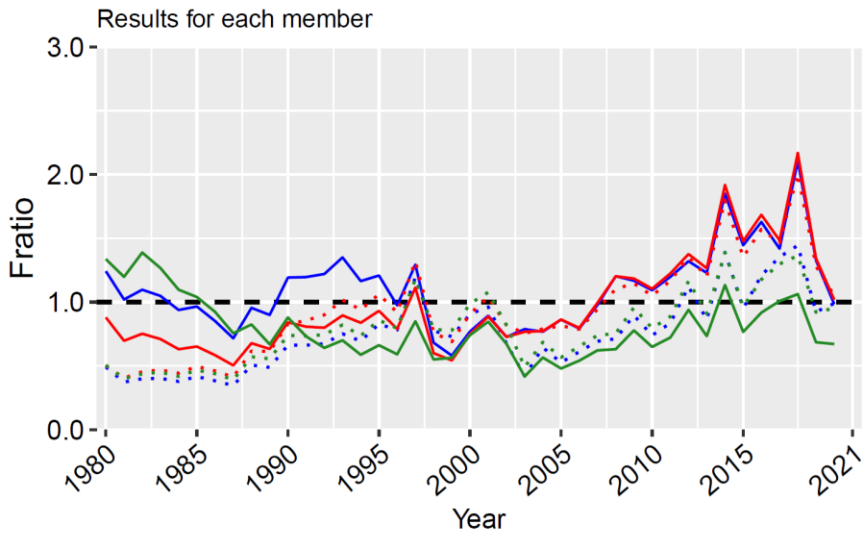
Exploitation rates were increasing slowly since 2005 except for 2019

The SSC PS received three reports of BSSPM analyses (figures from SSC-PS08 report)









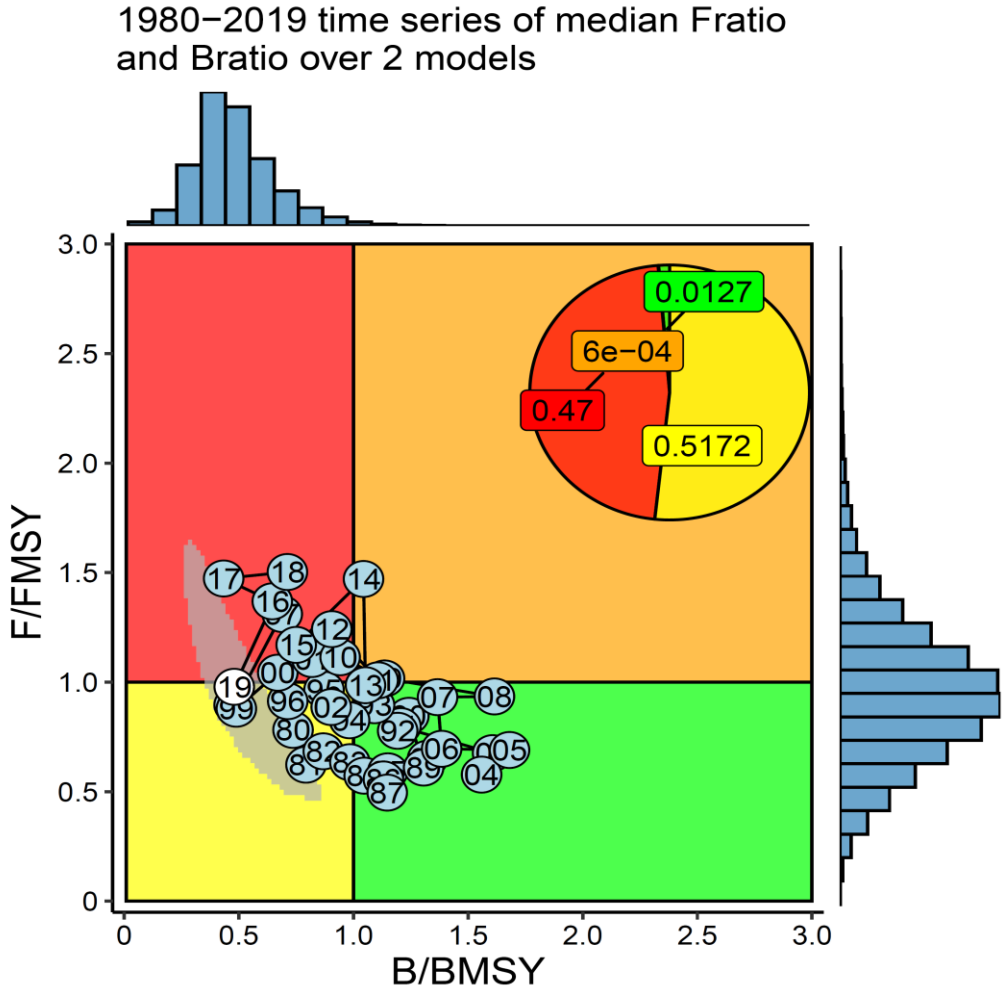
The results also indicated that

- B was below BMSY
- Average B/BMSY (2019-2021) = 0.427
- F was above FMSY
- Average F/FMSY (2018-2020) = 1.247
- The stock biomass fell to the lowest value in 2020 and has been still at a historically low level in recent years (2019-2021)

Different between 2021Jan and 2021Dec results

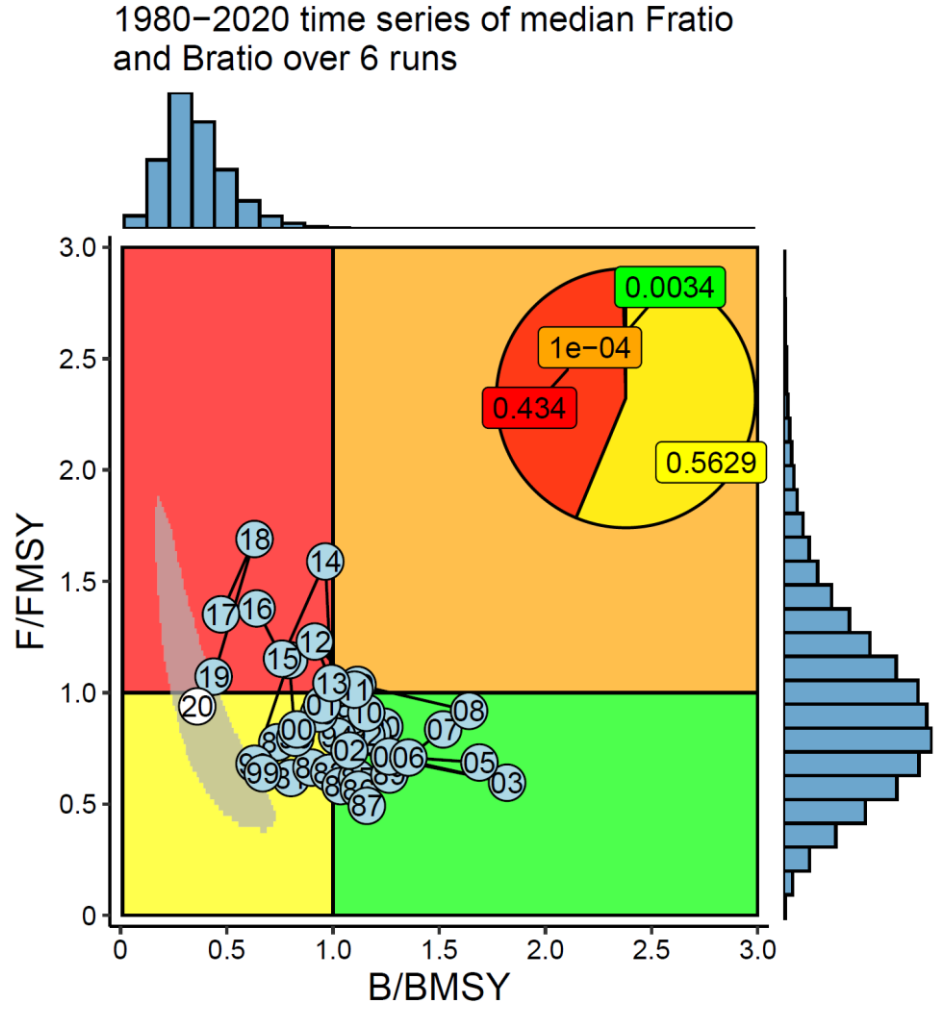
Jan 2021 results

(Biomass index up to 2019 + CPUE up to 2019)



Dec 2021 results

(Biomass index up to 2021 + CPUE up to 2020)



Combined reference points

	Median	Lower10%	Upper10%
C_2020 (10000 t)	13.968	13.968	13.968
AveC_2018_2020 (10000 t)	25.704	25.704	25.704
AveF_2018_2020	0.435	0.180	0.743
F_2020	0.322	0.144	0.590
FMSY	0.352	0.185	0.559
MSY	41.901	33.956	56.291
F_2020/FMSY	0.938	0.523	1.529
AveF_2018_2020/FMSY	1.247	0.647	1.967
K (10000 t)	255.121	157.185	517.839
B_2020 (10000 t)	43.415	23.680	96.706
B_2021 (10000 t)	54.774	30.260	122.400
AveB_2019_2021 (10000 t)	50.173	28.629	115.984
BMSY (10000 t)	120.784	76.740	236.751
BMSY/K	0.465	0.389	0.577
B_2020/K	0.175	0.099	0.275
B_2021/K	0.223	0.123	0.353
AveB_2019_2021/K	0.207	0.120	0.319
B_2020/BMSY	0.361	0.218	0.587
B_2021/BMSY	0.463	0.264	0.765
AveB_2019_2021/BMSY	0.427	0.260	0.693

Previous

F was above F_{MSY} (average F/F_{MSY} during 2017-2019 = **1.327**, 80%CI= 0.845-1.841).

Updated

F was above F_{MSY} (average F/F_{MSY} during 2018-2020 = **1.247**, 80%CI= 0.647-1.967).

Previous

B was below B_{MSY} (average B/B_{MSY} during 2017-2019 = **0.544**, 80%CI=0.376-0.803)

Updated

B was below B_{MSY} (average B/B_{MSY} during 2019-2021 = **0.427**, 80%CI=0.260-0.693)

Summary of stock status

The results also indicated that

- **B was below BMSY**
  - median average B/BMSY during 2019-2021 = 0.427, 80%CI=0.260-0.693
- **F was above FMSY**
  - average F/FMSY during 2018-2020 = 1.247, 80%CI= 0.647-1.967
- Stock biomass fell to the **lowest value since 1980 in 2020**
  - median B/BMSY = 0.361, 80%CI=0.218-0.587
  - has been still at a historically low level in recent years (2019-2021)
- Information of the nominal CPUE series further indicated that **Pacific saury stock biomass has likely been near a record low level in 2021**

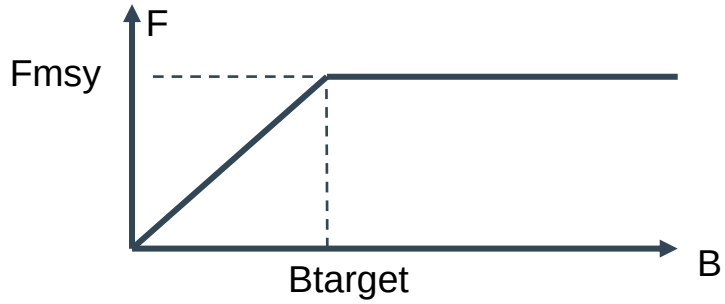
[Paragraph 37 of SSC-PS08 report]
Recommendations to the Commission to improve conservation and management

	Median
C_2020 (10000 t)	13.968
AveC_2018_2020 (10000 t)	25.704
AveF_2018_2020	0.435
F_2020	0.322
FMSY	0.352
MSY	41.901
F_2020/FMSY	0.938
AveF_2018_2020/FMSY	1.247
K (10000 t)	255.121
B_2020 (10000 t)	43.415
B_2021 (10000 t)	54.774
AveB_2019_2021 (10000 t)	50.173
BMSY (10000 t)	120.784
BMSY/K	0.465
B_2020/K	0.175
B_2021/K	0.223
AveB_2019_2021/K	0.207
B_2020/BMSY	0.361
B_2021/BMSY	0.463
AveB_2019_2021/BMSY	0.427

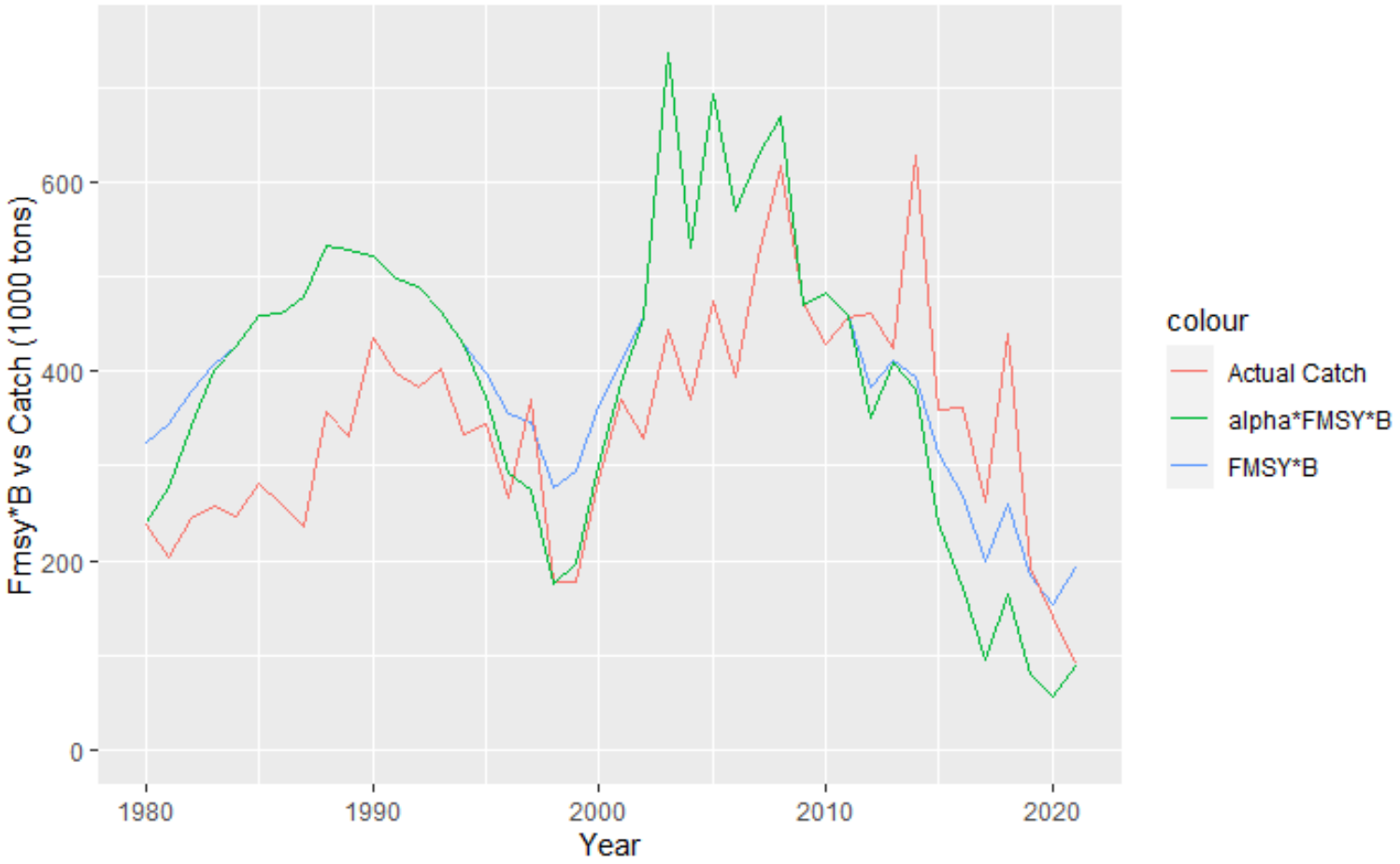
The SSC PS **recommends** that the SC consider and endorse the following rationale and approach in its scientific advice to the Commission:

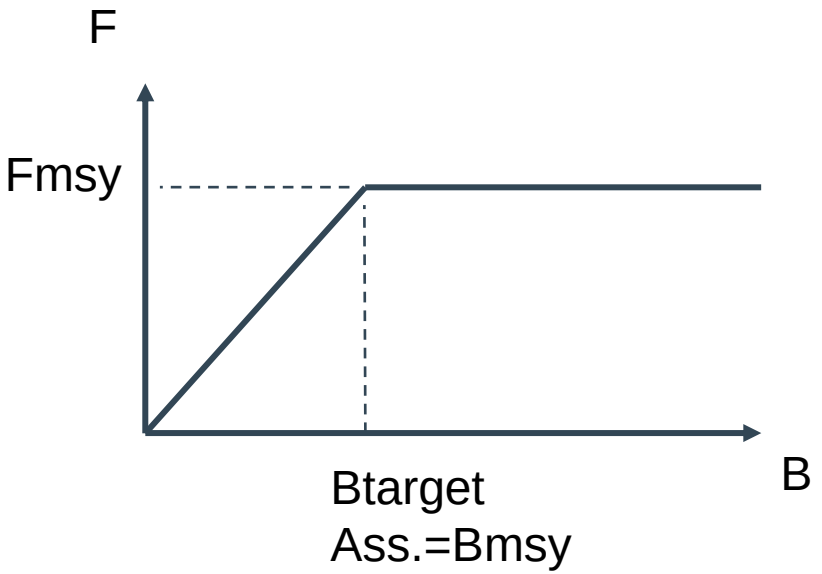
(a) The current annual TAC for 2021-2022 specified in CMM 2021-08 for Pacific saury (333,750 tons) is much larger than the TAC would be based on the F_{MSY} catch approach (B_{2021}*F_{MSY} = 192,804 tons) and the current biomass is much lower than B_{MSY}. **Reducing F in the short term may increase the probability of achieving long-term sustainable use of Pacific saury** (i.e. higher long-term catch closer to MSY of around 419,000)

(b) A HCR that reduces the target harvest rate and TAC when biomass falls below its target level may be appropriate for PS. This type of HCR is used in managing many fisheries around the world.

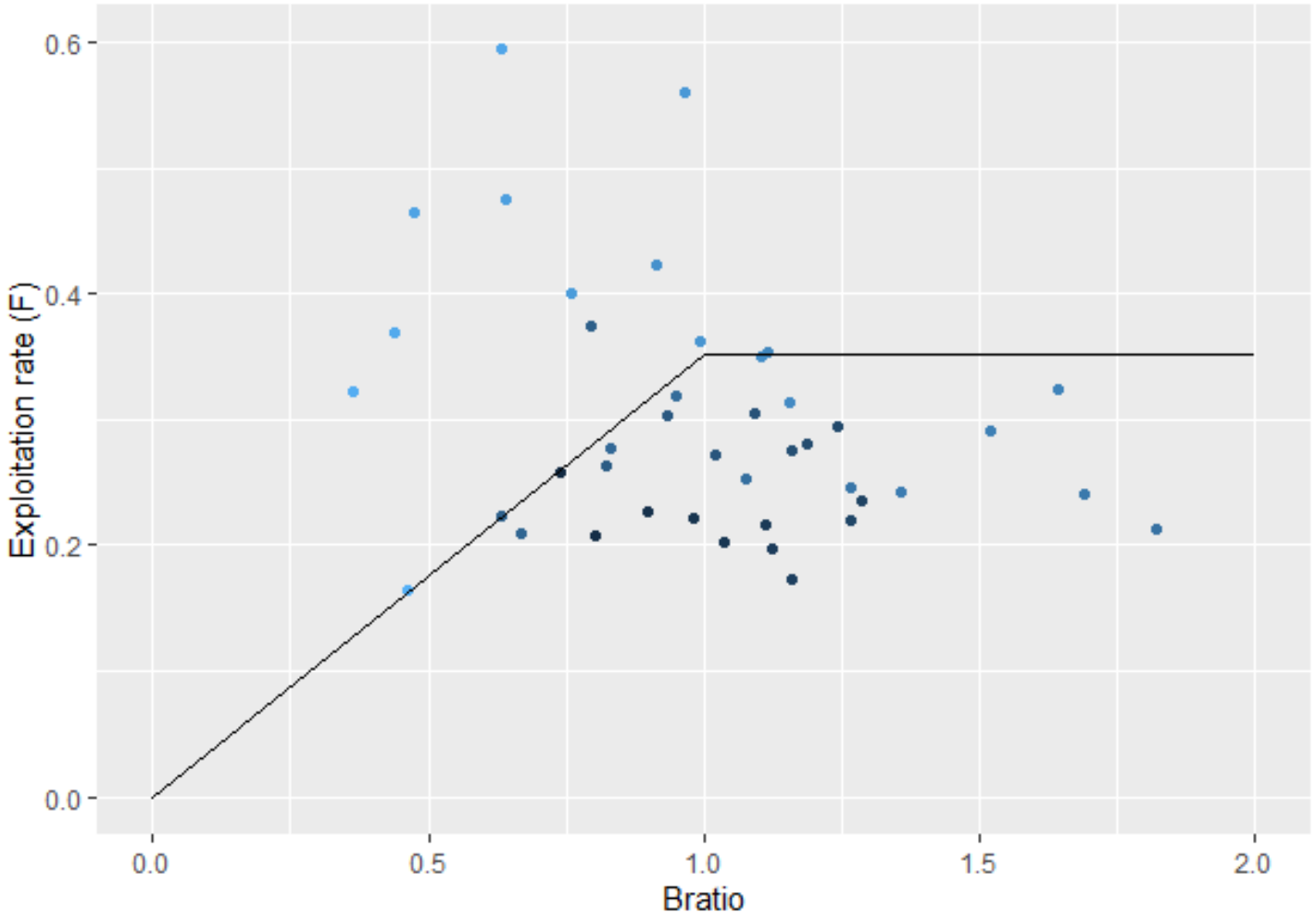


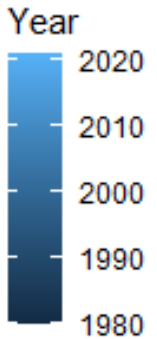
Combined reference points (this time)

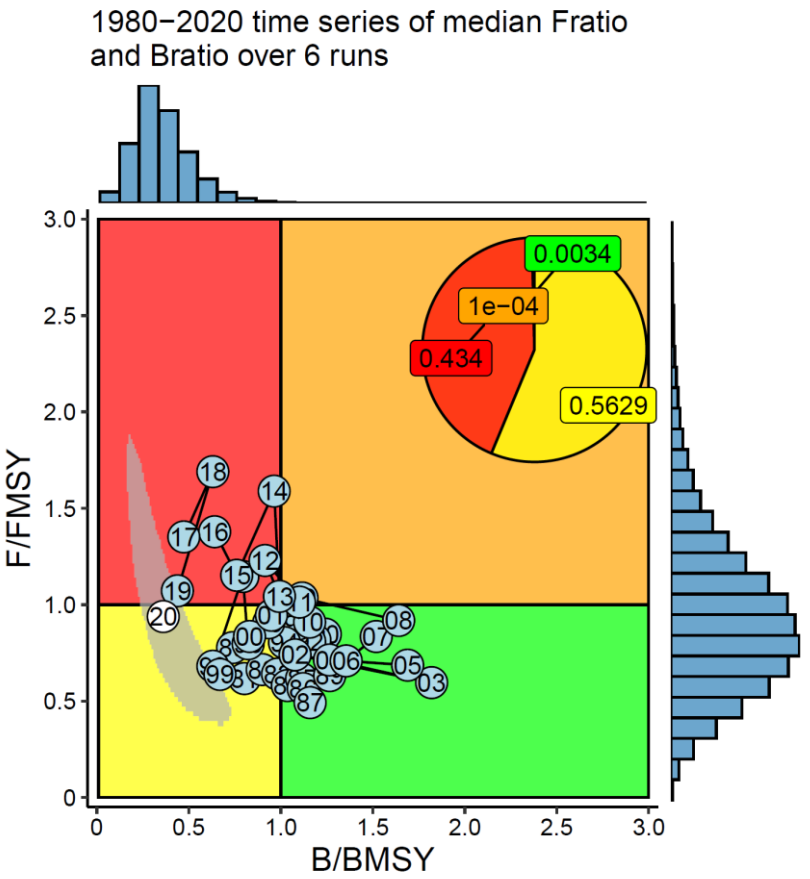




Additional information







Future work on BSSPM

- **Environmental factors:**
  the relative importance of fishing and **environmental factors** on the population dynamics of PS is unknow, but changing environmental conditions may have contributed to the decline and current low stock size for Pacific saury. Development of modeling procedures to incorporate **environmental change** is an important area for future research

- **HCR:**

  - any new HCR for PS should include concrete definitions of **overfishing** (F too high) and **overfished** stock status (biomass too low) based **on clearly defined reference points (targets and limits)**. The Commission may consider what actions it will take if overfishing or overfished stock status occur.

  - New HCRs should be evaluated in future work. For example, TAC calculations such as Fmsy catch (C=Fmsy x B) may be sensitive to uncertainty in the scale of the biomass estimates from models. It will be useful to consider index-based HCR approaches for Pacific saury such as those that use biomass trend information from a survey or model and catch data

Reference points (samples)

- Target and limit reference points for the stock:

  Btar = c*Bmsy or c*K

  Blim = c*Bmsy or c*K

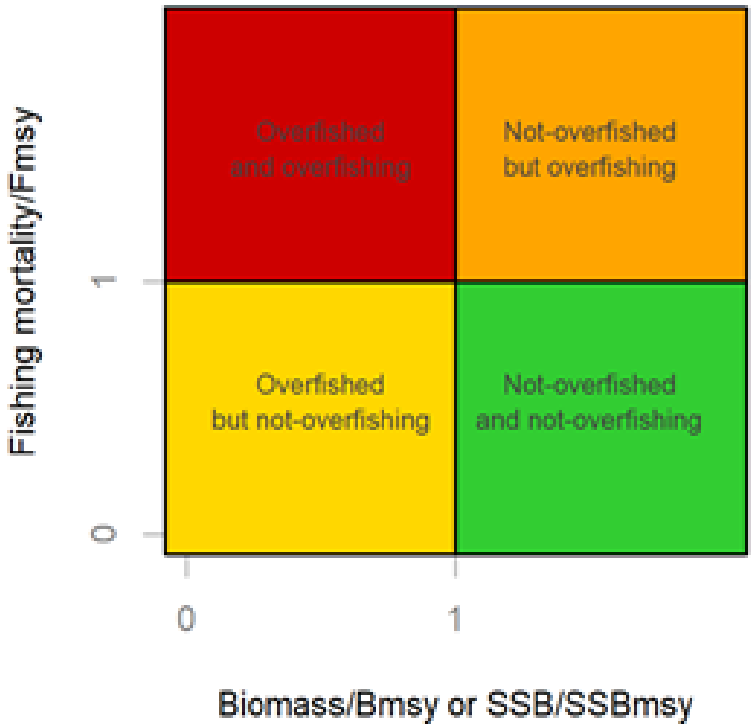
- Target and limit reference points for the fishing intensity:

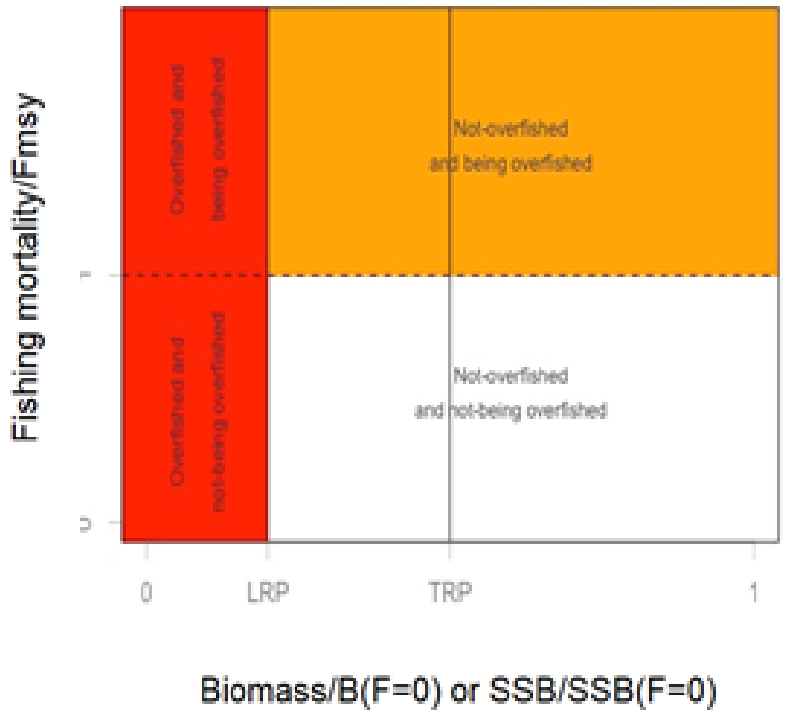
  Ftar = c*Fmsy

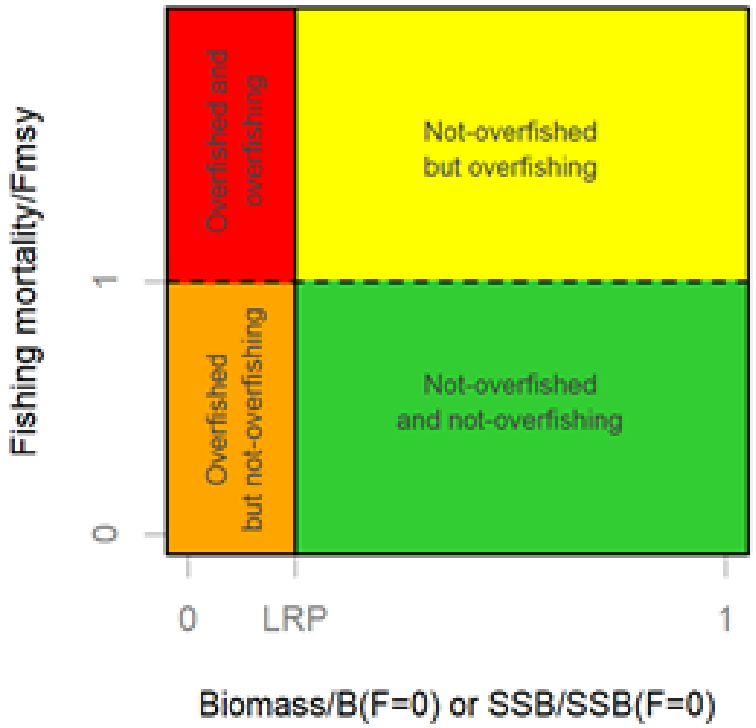
  Flim = c*Fmsy

- Note that the evaluation of estimation accuracy for Bmsy, K and Fmsy are needed when discussing the selection of reference points.

Note that further discussion is needed to define “overfishing” and “overfished” by linking with the reference points. The Kobe quadrants can be used, but other options can be developed (see Figure 3).


Fishing mortality/Fmsy
Overfished and overfishing
Not-overfished but overfishing
Overfished but not-overfishing
Not-overfished and not-overfishing
1
0
0
1
Biomass/Bmsy or SSB/SSBmsy


Fishing mortality/Fmsy
Overfished and being overfished
Not-overfished and being overfished
Overfished and not-being overfished
Not-overfished and not-being overfished
0
LRP
TRP
1
Biomass/B(F=0) or SSB/SSB(F=0)


Fishing mortality/Fmsy
Overfished and overfishing
Not-overfished but overfishing
Overfished but not-overfishing
Not-overfished and not-overfishing
1
0
0
LRP
1
Biomass/B(F=0) or SSB/SSB(F=0)

(again) PS-related issues discussed in 2019 BRP-HCR-MSE WS

- Dr. Butterworth …. argued that pristine biomass (B0) is not always well estimated for short-lived and highly variable stocks, such as small pelagic species, and B0-based reference points should not be used for such species.

- Dr. Kell … pointed out the importance of tailoring reference points to life history characteristics such as growth and maturity and also to variability in recruitment;

- The invited experts suggested that age-structured stock assessment models would be more appropriate than age-aggregated models and that age-structured operating models were preferable to length-based operating models.

(again) Suggestions/Recommendations in 2019 BRP-HCR-MSE WS

- Dr. Butterworth …. argued that pristine biomass (B0) is not always well estimated for short-lived and highly variable stocks, such as small pelagic species, and B0-based reference points should not be used for such species.
- Dr. Kell … pointed out the importance of tailoring reference points to life history characteristics such as growth and maturity and also to variability in recruitment;

(b) For Pacific saury, the Workshop recommended to consider developing an age-structured operating model for use in simulation work to identify and evaluate potential reference points (for example Blim and Ftarget). It is suggested that initial simulation work focus on constant F runs (e.g. to investigate MSY-based reference points, Blim and Ftarget) and empirical HCR (e.g. taking a constant proportion of the estimated survey biomass). Model-based and empirical HCRs could both be considered when a full MSE is undertaken.

(e) Consideration could be given to the role of small pelagic fish in the ecosystem as key low trophic level stocks and also to climate variability when setting the reference points.

Document as a strawman proposal

North Pacific Fisheries Commission

NPFC-2022-SWG MSE PS01-WP01

Development of HCR for Pacific saury for meeting the short-term objective set in the Terms of Reference of the SWG MSE PS
(discussion paper with focusing on Operating Models and Harvest Control Rules)

Toshihide KITAKADO

Possible objectives (samples)

[Recovery of stock]

- The stock status is recovered above Btar within “xx” years with “pp” probability and maintained above the Btar level over “yy-yy” with “qq” probability.
- The stock status is recovered in Kobe green zone within “xx” years with “pp” probability and maintained in it over “yy-yy” with “qq” probability.

[Avoiding overfishing]

- The annual probability that the stock drops below Blim should not exceed “pp” probability.
- …

[Achieving high and stable catch]

- Catch is high and stable as much as possible
- …

OMs

- OMs should play a role of the virtual population dynamics with accounting for stochasticity (e.g. environmental factors implicitly or explicitly) and virtual fishery to reflect impacts of fisheries speculated by the candidate management procedures.
- OMs are also used in simulation to produce virtual data (with observation error) to be used in MPs, to reflect the catch (and its implementation error) from specified MPs, to reflect different selectivity of different fisheries.
- OMs are primarily based on the stock assessment results but should not be completely equal to the assessment models.
- Several kinds of uncertainties in key parameters are accounted for.
- Also, other uncertainties are considered to evaluate the robustness not only to seek for the optimality but also to guarantee some sort of robustness.

OMs

Technical details can be discussed possibly in a task force group or SSC-PS especially reference scenarios as well as robustness scenarios in any options below.

[Option A]

- Use the current interim stock assessment model (BSSPM, age-aggregated and yearly time step) with consideration of uncertainties in estimated parameters and process errors as the basis.
- The model can be extended through accounting for some changes in environmental conditions and/or auto-correlation in the process error terms or incorporating stochastic variation into key parameters (r and/or K). Fishery-independent and dependent indices are produced with associated levels of uncertainty.
  - Pros: relatively easier conditioning of OMs, some consistency with the current assessment results, etc.
  - Cons: too simple as the virtual population dynamics, less prediction skill unless the link between productivity and environmental condition can be cleared

OMs

[Option B]

- Use an extended model (age-structured model, yearly time step) with consideration of uncertainties in estimated and key input parameters (natural mortality and steepness) as well as recruitment process errors.
- The model can be further extended for consideration of environmental changes like in Option A. Fishery-independent and dependent indices are produced with associated levels of uncertainty and fishery-selectivity.
  - Pros: possible to account for recruitment and age-composition, some link with the current development of new assessment models, etc.
  - Cons: need to spend time for conditioning of OMs, some delay to proceed with simulation, etc.

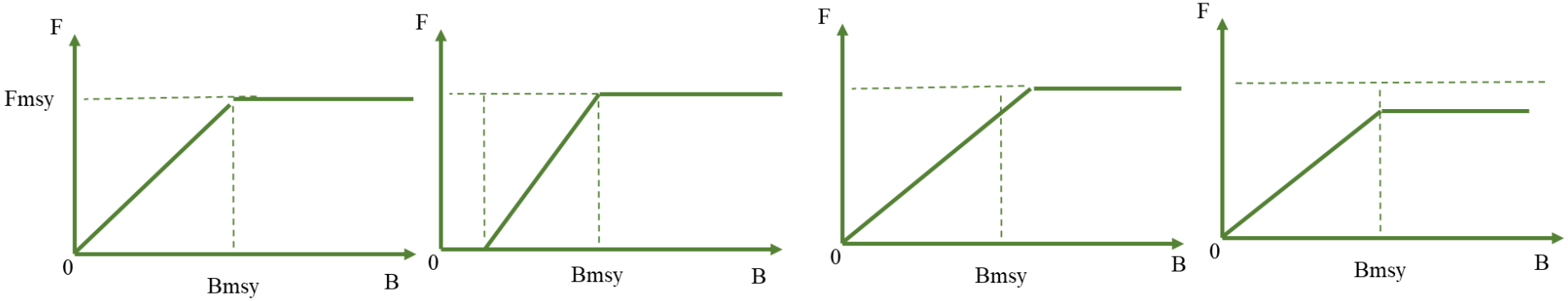
OMs

[Option C]

- Possible to consider further complicated models to account for migration patterns and difference in space and time in Member's fishing operations.
  - pros: this is of course scientifically interesting
  - cons: considering the limited time, this may not be a good option for meeting the short-term objective.

HCRs

- Below shows an example of simple HCR to set a TAC based on the biomass level.
- These rules describe that, if the population is depleted, catch is not allowed, and if the population is very healthy, an optimal fishing intensity is allowed, and there need to be some proportional reduction of fishing intensity in between.
- These are typical HCRs, but the point is, at each time step, that HCR can work for setting TAC only if a biomass estimate is provided.
- To make the HCR activated, extra information of the biomass is needed and therefore it should be clearly defined how to estimate biomass.
- To define a management procedure as the whole bunch of the process, it is required to consider what kind of inputs as well as HCR, so management procedure is a package of all these processes (data acquisition, assessment if needed, and HCR) to set the quota.



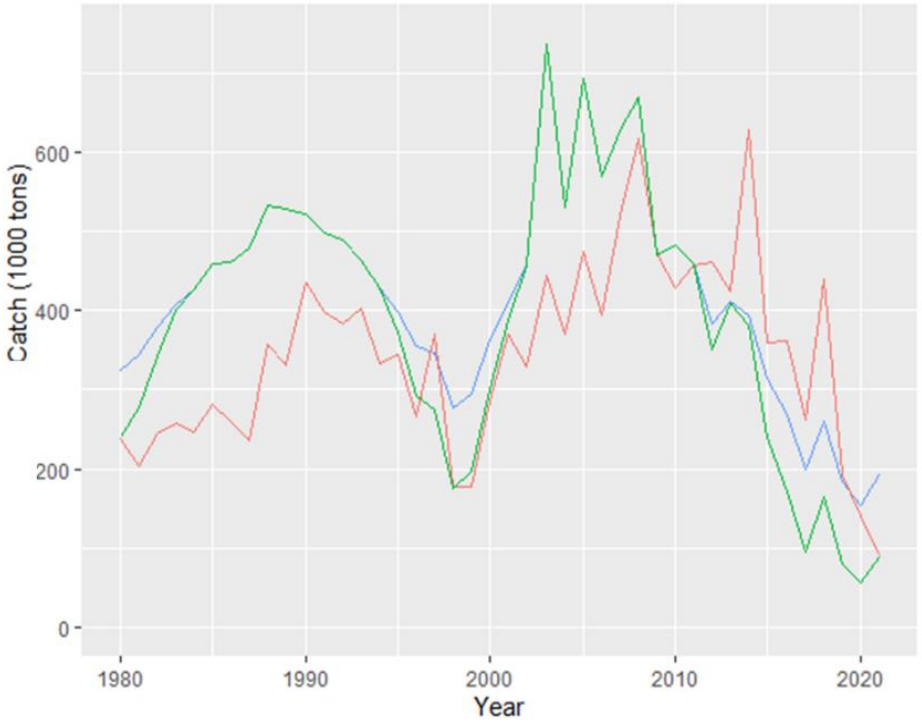
HCRs

The MSE is, in a nutshell, a framework to test candidate MPs, but the full process can be skipped temporally to concentrate on the development of HCR provided that an input on the biomass to the HCR is straightforward (like in the case of existing interim stock assessment method, BSSPM).

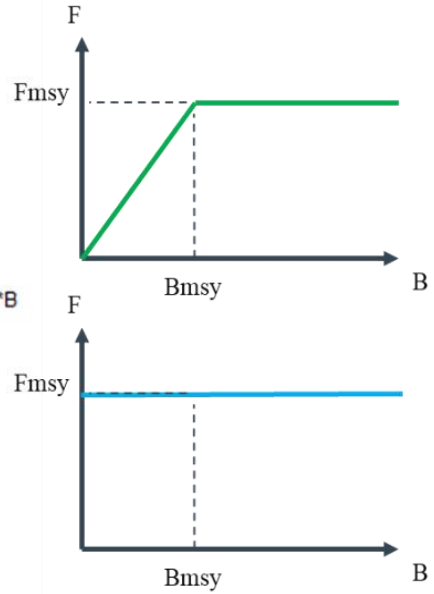
Nevertheless, the following points are considered:

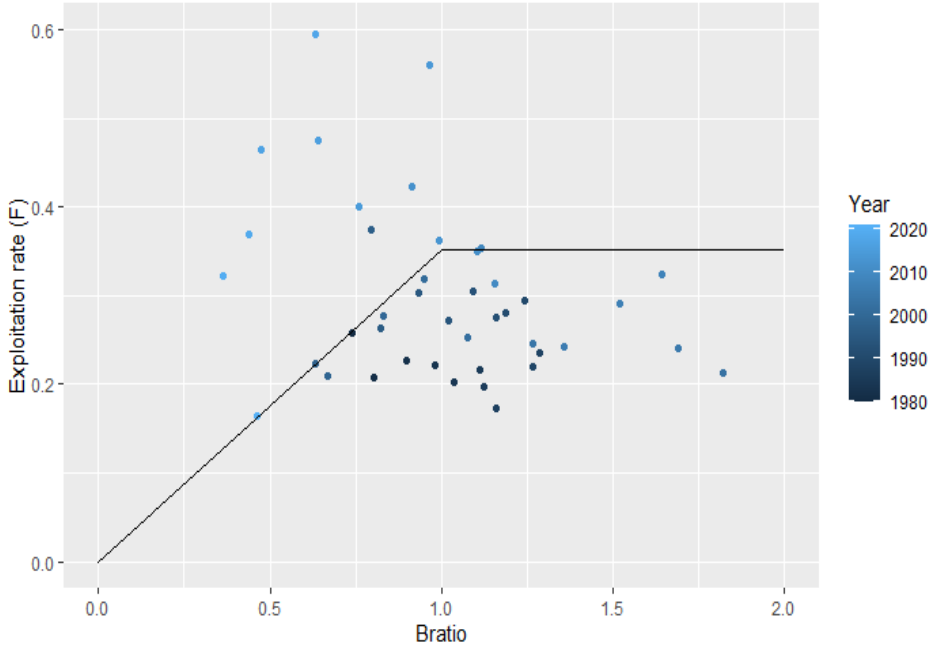
- Selection of an input of “B” for HCR (single recent year or 2- or 3-years average?)
- Maximum change in TAC over two consecutive years (within “xx” %). Figure 5 shows that high fluctuation may occur if simply applying only a mathematical for of HCR for setting TAC.
- Parameters can be tuned to meet a priority objective over the reference scenarios.
- Frequency of application of MP (HCR in this case). Every year considering the nature of short-live species and environmental concern?
- Allocation over Members (or space)
- Safeguards for the exceptional circumstances

HCRs


Catch (1000 tons)
600
400
200
0
1980
1990
2000
2010
2020
Year


colour
Actual Catch
alpha*FMSY*B
FMSY*B


F
Fmsy
Bmsy
B
F
Fmsy
Bmsy
B


Exploitation rate (F)
0.6
0.4
0.2
0.0
0.0
0.5
1.0
1.5
2.0
Bratio
Year
2020
2010
2000
1990
1980

HCRs

Hybrid version?

- Currently, the stock assessment is conducted, say for year “y”, using Japanese fishery-independent index up to year “y” and fishery-dependent indices and catch up to year “y-1”, to produce the estimate of biomass in year “y” and management related quantities. These pieces of information can then be used in setting a TAC in year “y+1” once an HCR has been adopted (say X).
- If some biomass-related information (like trend or level from Japanese fishery-independent index) is available timely before or at the beginning of fishing season in year “y+1”, TAC X can be

- adjusted according to the most recent information (this mechanism should be speculated as a hybrid version of HCR)

- calculated based on information available up to year “y+1”

This sort of hybrid HCR or no-lag approach may work for this short-lived species for which the population size might be influenced by environmental condition and has been fluctuating. This is a part of discussion for the implementation.

HCRs

Hybrid version?

- Currently, the stock assessment is conducted, say for year “y”, using Japanese fishery-independent index up to year “y” and fishery-dependent indices and catch up to year “y-1”, to produce the estimate of biomass in year “y” and management related quantities. These pieces of information can then be used in setting a TAC in year “y+1” once an HCR has been adopted (say X).
- If some biomass-related information (like trend or level from Japanese fishery-independent index) is available timely before or at the beginning of fishing season in year “y+1”, TAC X can be

- adjusted according to the most recent information (this mechanism should be speculated as a hybrid version of HCR)

- calculated based on information available up to year “y+1”

This sort of hybrid HCR or no-lag approach may work for this short-lived species for which the population size might be influenced by environmental condition and has been fluctuating. This is a part of discussion for the implementation.

Item 5. Initial discussion toward development of MPs for the mid-term goal

5.1 Management objectives and some constraint conditions for the regulation of fishery

5.2 Technical matters on OMs, MPs, performance measures and simulation

Objectives stipulated in ToR of SWG MSE PS

Short-Term Objectives: within one to two years:

a) develop **draft interim management objectives** and a **draft interim harvest control rule (HCR)** that meets such objectives to report to the Commission (preferably before the 8th Commission annual meeting); and

b) **evaluate the robustness of the draft interim harvest control rule** with consideration of possible uncertainties including effects of climate changes.

Mid-Term Objectives: within three to five years:

a) develop **draft mid- to long-term management objectives** by setting the **target and limit reference points** for the population status as well as by defining "overfishing" and "overfished" for the sustainable use of the Pacific saury stock;

b) assess the feasibility of establishing a **management procedure through an MSE**

ITEM 6. FUNCTIONING WITHIN NPFC

6.1 ROLES AND SCIENTIFIC CONTRIBUTIONS FROM THE SC AND SSC-PS

6.2 ROLES AND CONTRIBUTIONS FROM THE TCC

According to the ToR

SECTION 4 – FUNCTIONS

6. The functions of the SWG-MSE-PS are to:

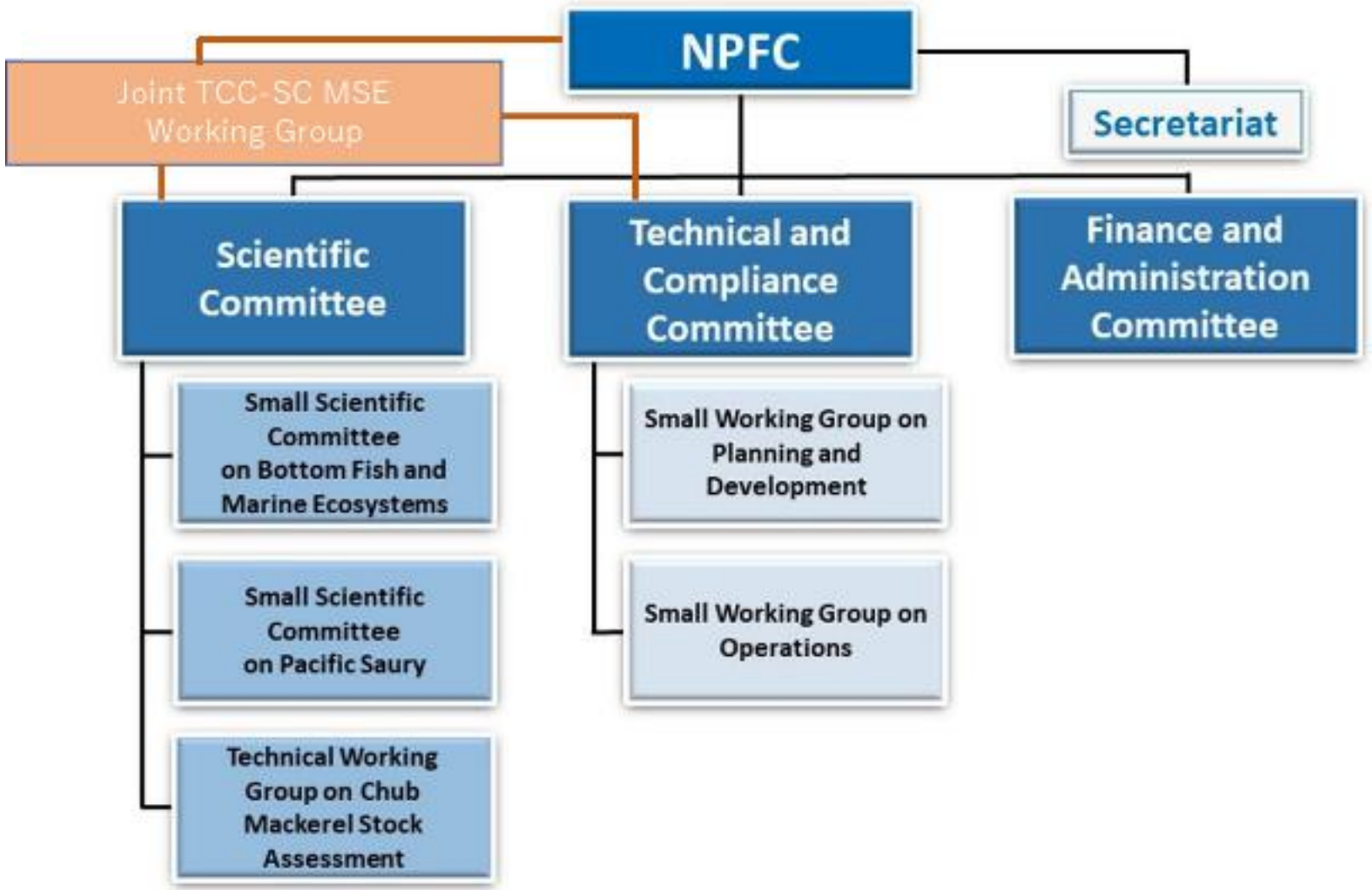
a) develop and submit recommendations to the Commission on a draft interim harvest control rule, draft management objectives, key sources of uncertainty, and, if feasible, candidate management procedures;

b) facilitate communications among commissioners, scientists, managers, stakeholders and observers and provide relevant information to the Committees and their subsidiary bodies;

c) propose to the Commission on the operation of the SWG-MSE-PS including the timeline and additional work to be conducted; and

d) provide relevant information to other subsidiary bodies including SC, TCC, and FAC.

Structure of NPFC Commission



According to the ToR

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ITEM 7. OTHER MATTERS

7.1 SELECTION OF AN EXTERNAL EXPERT
7.2 CAPACITY BUILDING (GLOSSARY AND DEMONSTRATION)
7.3 OTHERS

7.1 Selection of an external expert

- Many MSE experts around the world (and in this meeting room)
- Larry have been contributed to the discussion on PS stock assessment and management since 2018 meeting (in 2018Nov, 2019Mar, 2019Nov, 2020Jun, 2020Nov, 2021Jan, 2021Oct, 2021Dec)

7.2 Glossary

The 2018 Joint tuna RFMO Management Strategy Evaluation Working Group Meeting in Seattle, USA – 13-15 June 2018

NPFC-2022-SWG MSE PS01-IP01

Glossary of terms for harvest strategies, management procedures and management strategy evaluation

- This glossary was developed to encourage a consistent use of terms associated with harvest strategies, management procedures and management strategy evaluation processes underway across the five tuna RFMOs.
- It was developed from a range of sources, including ISSF, Rademeyer *et al*. 2007, IOTC, PEW Charitable Trust and a range of MSE practitioners with broad experience across tuna and other fisheries.
- A draft of the glossary was reviewed by participants in the 2018 Joint tuna RFMO Management Strategy Evaluation Working Group Meeting in Seattle and adopted for the purposes of improving consistency and clarity of communication in tRFMO MSE processes.
- The glossary is available for use by others with appropriate acknowledgement. (Anon. 2018. Glossary of terms for harvest strategies, management procedures and management strategy evaluation, http://www.tuna-org.org/Documents/MSEGlossary_tRFMO_MSEWG2018.pdf.)

7.2 Glossary

Terms commonly used in Management Strategy Evaluation or Management Procedure literature

Term	Definition	Abbreviation/Symbol
Average Annual Variation (in catch/TAC)	The absolute value of the proportional TAC change each year, averaged over the projection period.	**AAV**
Biomass	Stock biomass, which may refer to various components of the stock. Often spawning stock biomass (SSB) of females is used, as the greatest conservation concern is to maintain the reproductive component of the resource.	**B**
Candidate Management Procedure	An MP (defined below) that has been proposed, but not yet adopted.	**CMP**
Conditioning	The process of fitting an Operating Model (OM) of the resource dynamics to the available data on the basis of some statistical criterion such as a Maximum	

- Several RFMOs prepared their own glossary
- Do we need to prepare for it for our own purposes?

7.2 Capacity building

(Document: NPFC-2022-SWG MSE PS01-OP01)

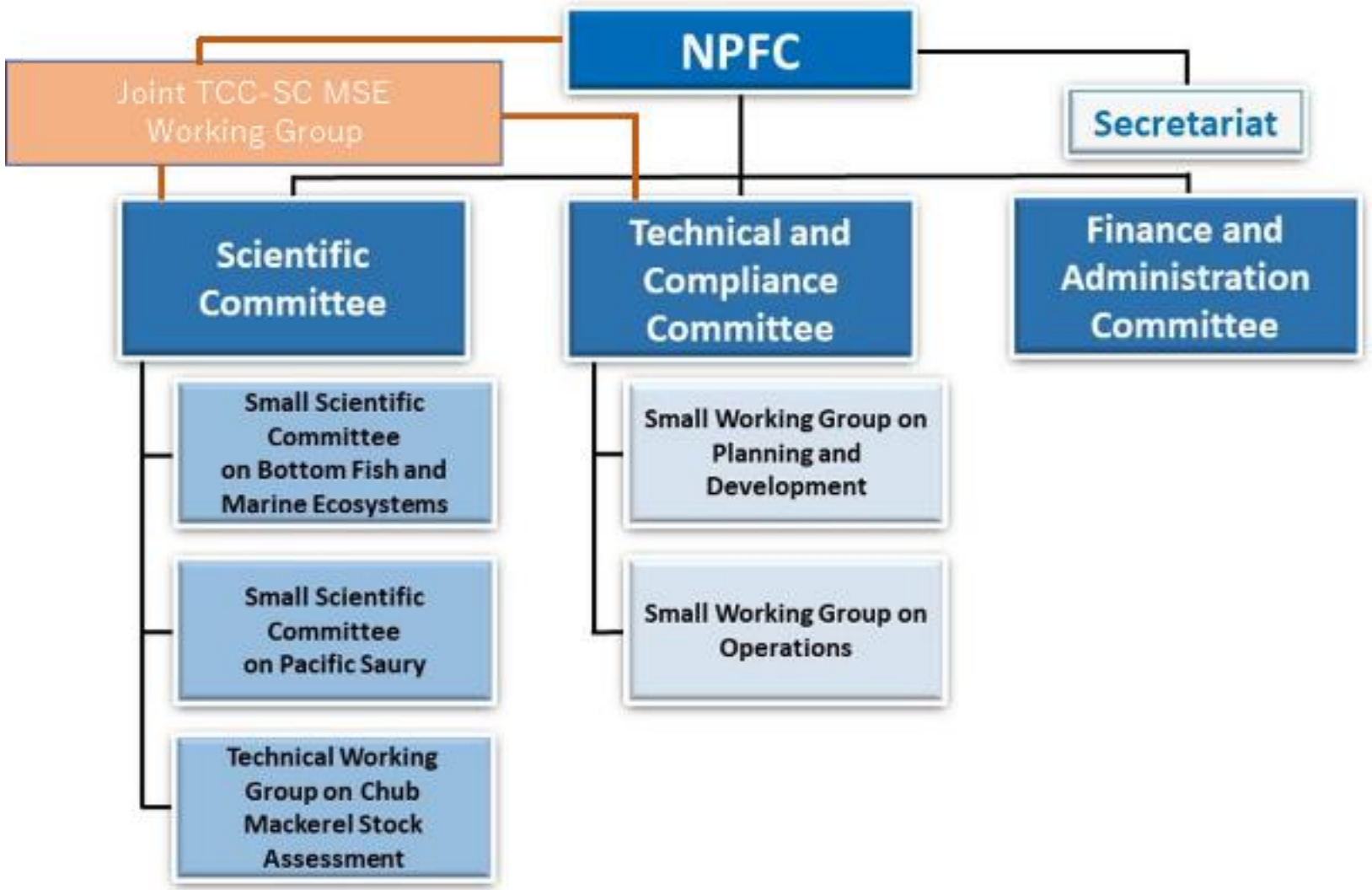
ITEM 8. TIMELINE AND FUTURE PROCESS

(DOCUMENT: NPFC-2022-SWG MSE PS01-IP02)

8.1 TIMELINE

8.2 FUTURE MEETINGS

Structure of NPFC Commission



Schedule (just proposal)

Meeting	Date	Task	Note
SWG MSE PS 01	Feb 21-22, 2022	• Objectives, timeline and workplan • Establishment of a (small) Task Force for technical works?	Virtual
COM07	Mar 28-30, 2022	• Review of management advice from SC • Review and endorsement of SWG MSE PS 01 report • Funding request	Virtual
Task Force teamwork	Intersessional	• Develop concrete proposal of reference points and management objectives • Start technical work for developing and evaluating HCRs as a short-term task (conditioning of OMs and list up possible/candidate HCRs)	
SSC PS09	Aug 30-Sep 2, 2022	• Review standardized CPUE up to 2021 • Review Japanese survey estimates incl. 2022 • Review progress on new assessment models and finalize a set of models and specification • Start discussion on development and evaluation of HCR as a short-term task	
SWG MSE PS 02	Sep 2022?	• Feedback on outcomes of Task Force and SSC PS09 • Capacity building	
Task Force teamwork	Intersessional	• Continue discussions on reference points and management objectives and technical work for developing and evaluating HCRs as a short-term task	
SSC PS10	Dec 12-15, 2022	• Update BSSPM analyses and provide recommendations to the SC/COM • Review progress on new assessment models and finalize a set of models and specification (relevant to the mid-term MSE work as conditioning of operating models) • Continue discussion on development and evaluation of HCR as a short-term task	
SWG MSE PS 03	Feb 2023?	• Objectives, reference points, timeline and workplan • Recommendations to the Commission	
COM08	Mar 2023?	• Review of management advice from SC • Review and endorsement of SWG MSE PS 02 and 03 reports • Funding request	
To be determined….			