Capacity Building on Management Strategy Evaluation (MSE)/Harvest Strategies (HS) in the Indian Ocean Region

FINAL REPORT
International Seafood Sustainability Foundation

12th March 2020

The Project

This project was part of the "Sustainable Management of Tuna Fisheries and Biodiversity Conservation in Areas Beyond National Jurisdiction" (GCP/GLO/365/GFF) funded by the Global Environmental Facility (GEF). The objective of the project is to achieve responsibility, efficiency, and sustainability in tuna production and biodiversity conservation in the ABNJ, through the systematic application of an ecosystem approach in tuna fisheries. The overarching project focuses on four component areas:

1) Promotion of Sustainable Management of tuna fisheries, in accordance with an ecosystem approach,

2) Strengthening and Harmonizing Monitoring, Control and Surveillance (MCS) to address Illegal, Unreported and Unregulated (IUU),
3) Reducing ecosystem impacts of tuna fishing, including bycatch and associated species,
4) Information and Best Practices Dissemination, Monitoring and Evaluation.

Under Component 1 and Output 3.2.2, the project aimed to organize and implement two workshops on tuna Management Strategy Evaluation/Harvest Strategies in the Indian Ocean region. Capacity building on tuna Management Strategy Evaluation/Harvest Strategies is important for Indian Ocean coastal states. As such, Capacity Building Workshops for Harvest Strategies (HS, also called Management Procedures (MPs)), and Management Strategy Evaluation (MSE, a methodology to evaluate trade-offs for different MPs), directed outreach for specific countries were organized. These workshops were implemented by the International Seafood Sustainability Foundation (ISSF) with contributions from in-country institutions and the Indian Ocean Tuna Commission (IOTC).

Workshop Aims

The goal of these workshops was to create a better understanding among Indian Ocean States regarding MSE and MP to ensure sustainable management of tunas. Specifically, to leverage the understanding of IOTC process, in general, but for the IOTC MP discussions, in particular, of specific IOTC members.

Project Activities

The project organized, implemented and facilitated two workshops on tuna MP/MSE in the Indian Ocean region. The first workshop was organized in Thailand with participation of Maldives, both important coastal developing states in the Indian Ocean. The second workshop was organized in Republic of Korea considering the importance of Korean tuna fisheries in the Indian Ocean region, in particular, and in all tuna RFMOs in general. The workshop curriculum included review of the MP/MSE framework and the principles of sound fisheries management. The workshops provided a platform and background knowledge for enhancing engagement in the Indian Ocean regional level MP development and adoption of robust MPs which best achieve the objectives of IOTC members and stakeholders.

Workshop 1 - Furthering Capacity Building for Harvest Control Rules and Management Strategy Evaluation: Indian Ocean Tuna Management Workshop

Location.- Department of Fisheries (DoF), Bangkok, Thailand
Dates.- 21-22 January, 2020
Indian Ocean CPCs.- Thailand and Maldives
Participants.- 32

Organizers.- Pavarot Noranarttragoon (DoF Thailand) and Hilario Murua (ISSF)
Facilitators.- Toshihide Kitakado (Tokyo University of Marine Science and Technology - TUMSAT), Dan Fu (IOTC), and Hilario Murua (ISSF)
Agenda.- Appendix 2 of Annex 1 Final Report Thailand WS 1 (submitted to FAO on 16th January 2020)
Report.- Annex 1 Final Report WS 1 (submitted to FAO on 10th February 2020)

Workshop 2 - Furthering Capacity Building for Harvest Control Rules and Management Strategy Evaluation: Indian Ocean Tuna Management Workshop

Location.- National Institute of Fisheries Science, Busan, Republic of Korea
Dates.- 19-20 February, 2020
Indian Ocean CPCs.- Republic of Korea
Participants.- 24
Organizers.- Doo Nam Kim (National Institute of Fisheries Science) and Hilario Murua (ISSF)
Facilitators.- Toshihide Kitakado (TUMSAT) and Hilario Murua (ISSF)
Observer.- Janne Fogelgren (FAO)
Agenda.- Appendix 2 of Annex 2 Final Report Republic of Korea WS 2 (submitted to FAO on 10th February 2020)
Report.- Annex 2 Final Report WS 2 (submitted to FAO on 10th March 2020.

Conclusions

Based on attendees participation in discussions as well their engagement in the activities, where they showed a good understanding of different concepts of the MPs; the objective of the workshops to create a better understanding among Indian Ocean region CPCs of the Management Strategy Evaluation (MSE) and Management Procedure (MP) process was achieved.

As MSE/MP involves complex concepts and processes, IOTC Technical Committee on Management Procedures at its 2019 meeting underlined the need to organize capacity building workshops on MSE to increase the engagement in the process of adoption of IOTC MPs by all IOTC CPCs. Considering the success of these workshops, ***it is RECOMMENDED that the next Common Oceans ABNJ FAO Tuna project (phase 2) provides support to more MP/MSE, both country-specific and regional, capacity building workshops.***

ANNEX 1

Report of the "Furthering Capacity Building for Harvest Control Rules and Management Strategy Evaluation: Indian Ocean Tuna Management Workshop"
Department of Fisheries (DOF), Bangkok, Thailand, 21st – 22th January 2020

Hilario Murua
International Seafood Sustainability Foundation

27th January 2020

The workshop was part of the "Sustainable Management of Tuna Fisheries and Biodiversity Conservation in Areas Beyond National Jurisdiction" (ABNJ Tuna Project). The overarching project focuses on three component areas:

1) Supporting implementation of sustainable and efficient fisheries management and fishing practices,
2) Reducing illegal, unreported and unregulated (IUU) fishing through strengthened and harmonized monitoring, control and surveillance,
3) Reducing ecosystem impacts from tuna fishing, including bycatch and associated species.

Under Component 1, Capacity Building Workshops for Management Procedures (MPs) and Management Strategy Evaluation (MSE) directed outreach to specific countries are organized. Under a Letter of Agreement with FAO, these workshops are implemented by the International Seafood Sustainability Foundation (ISSF) with contributions from in-country institutions and regional tuna RFMOs.

Moreover, the IOTC Technical Committee on Management Procedures at its 2019 meeting, considered that MP/MSE involves complex concepts and agreed there is need to capacity building in support of the next TCMP to clarify key issues in Management Strategy Evaluations for IOTC stocks. Furthermore, the TCMP requested that Intersessional capacity building on MSE be conducted to increase understanding of the MSE process and to increase the engagement in the process of adoption of IOTC MPs by all CPCs. The IOTC Secretariat is collaborating with ISSF and FAO in organizing and implementing of CPC specific WSs planned for the region.

Workshop Aims

The goal of this workshop was to create a better understanding among Indian Ocean States regarding Management Strategy Evaluation (MSE) and Management Procedures (MP, also called Harvest Strategies) to ensure sustainable management of tunas. Specifically, in this workshop, to leverage the understanding of IOTC process, in general, but of the IOTC MP discussions, in particular, of Thailand. Moreover, as recommended by TCMP, the invitation to participate in the workshop was extended to Maldives as they showed interest in participating in any capacity building exercises as recommended by TCMP.

Ultimately, the objective of this workshop was to leverage the participation of Thailand and Maldives in the process of development of tuna MPs within the Indian Ocean. Participation in this workshop will empower Thailand and Maldives to meaningfully engage in the process of MP development already occurring at the Indian Ocean Tuna Commission (IOTC).

The Event

The workshop program included revision of the Management Procedure framework and the principles of sound fisheries management. The workshop provided a platform and background knowledge for engagement in the Indian Ocean regional level MP development and will contribute to the adoption of robust MPs which best achieve the objectives of IOTC members and stakeholders.

The workshop provided an introduction to the process of MP development; the elements of a MP, for example management objectives, timeframes and risk; how to interpret the trade-offs between different objectives and the use of MSE to evaluate performance of alternative MPs. But for setting the context and increase the understanding of those complex concepts, the workshop firstly focused on the IOTC Management Framework with the introduction of the provision of fisheries management advice; including the description of the Kobe plots, Target and Limit Reference Points and IOTC Decision Framework as per Resolution 15/10. Although the agenda was comprehensive, the objective was to have an open and lengthy discussion on the various elements that require more attention from participants. The goal was to discuss relevant needs and issues for Thailand and Maldives specific to Indian Ocean tunas and allow for more in-depth understanding of how the concepts and tools presented in the workshop may assist in increasing Thailand and Maldives participation in the process of the IOTC Technical Committee on Management Procedures.

The Workshop was one of capacity building on MPs targeted at decision-makers and scientists from Thailand and Maldives. The Workshop was organized by Hilario Murua (ISSF) with the collaboration of Pavarot Noranarttragoon (Department of Fisheries Thailand) and Paul de Bruyn (IOTC) and it was given by Dan Fu (Stock assessment expert IOTC), Toshihide Kitakado (IOTC Scientific Committee Chair) and Hilario Murua (ISSF). The list of participants is included in **Appendix 1**. And the agenda for the workshop is in **Appendix 2**.

The Workshop was opened by Pavarot Noranarttragoon (Department of Fisheries Thailand), who emphasizes the importance of this type of Workshop to increase the capacity of Thai delegation in IOTC discussions on MPs and, hence, to leverage the participation of Thailand in the process of development of tuna MPs within the Indian Ocean. He welcomed participants, including those from the Fishery Ministry of Maldives, and he was very supportive of MP development at IOTC.

The workshop was guided by various presentations, but it was planned in a way that presentations would not be the main capacity building tool. Instead the presentations were used to foster discussion and engage participants, and presentations were combined with group activities such as developing conceptual maps between the various concepts and components of stock assessment process and MPs so as to understand their differences. Moreover, a question poll was also used to discuss management objective prioritization, timeframes for actions and tolerable risks of failure in achieving objectives as well as the IOTC management decision framework. Finally, a Shiny Application developed by the ABNJ was used to develop and test different alternative harvest control rules and management procedures to review and understand the trade-off between conflicting objectives related to safety, catch stability, yield, etc.

The first morning was focused on an introduction to the IOTC Management Framework and a brief of IOTC stocks status, the IOTC consensus-based process for adoption of Management Procedures, the status of the Thailand and Maldivian fisheries to understand possible contrasting objectives amongst various stakeholders, and to contrast the differences between current stock assessment approach for providing management advice and that used to test performance of alternative Management Procedures. These presentations were followed by rich discussions that allowed the organizers to gauge the level of understanding among participants to adjust the contents of subsequent presentations and discussions (**all presentations are included in Appendix 3**). As the knowledge and experience of participants were quite diverse, from those that work in data collection to those attending IOTC Stock assessment meetings or are responsible for the stock assessment of other fishery resources of Thailand, and other attending as advisors at Commission meetings, the rest of the day was focused on presenting the basic principles of Management Procedure approach, components and concepts, including Kobe plots, target and limit reference points, the IOTC management decision framework in Resolution 15/10, overview of objectives, timeframes, probabilities and risk, trade-offs, performance statistics, the roles and responsibilities of scientists and managers in MP development and the MP process of dialogue and feedback. At this point, the agenda was adjusted to spend more time reinforcing basic, but fundamental concepts to increase audience understanding and engagement for the second day, and, in general, for their participation in IOTC MP process.

The second day was focused on practical exercises and discussing responses to the question poll (**Appendix 4**), development of conceptual maps of Stock Assessment and Management Procedures (**Figure 1**), and the Shinny App for examining MP examples with different objectives to discuss performance statistics and the trade-offs between different objectives. There were many discussions related to objectives (economic, social, biological and ecological), and their prioritization. Participants were very engaged in the 3 exercises at all levels: asking questions, presenting their ideas and the conceptual maps developed, participating in the various activities, developing HCRs/MPs to achieve various fishery management objectives. Overall, the level of knowledge about the MP process improved considerably by the end of the workshop (**Figure 2**).

Conclusion

Based on participants participation in discussions as well their engagement in the activities, where they showed a good understanding of different concepts of the MPs and developing the conceptual maps of Stock Assessment vs. MP; the objective of the workshop to create a better understanding among Thai and Maldivian participants of the Indian Ocean Management Strategy Evaluation (MSE) and Management Procedure (MP) process was achieved.

Participants recognized that their understanding increased and suggested that similar types of workshops should be organized to address IOTC process of management decision, stock assessment, and other themes to increase their capacity to contribute to the process. Participants showed positive feedback in terms of workshop content and format, and comments and recommendations for improvement were received. Moreover, Thai Department of Fisheries showed interest about organizing a second round of the workshop focused on other fisheries of the country such the mixed demersal fisheries and coastal fisheries, which demonstrates the usefulness of this exercise and their willingness to participate in the implementation of sound Management Procedures in their fisheries.

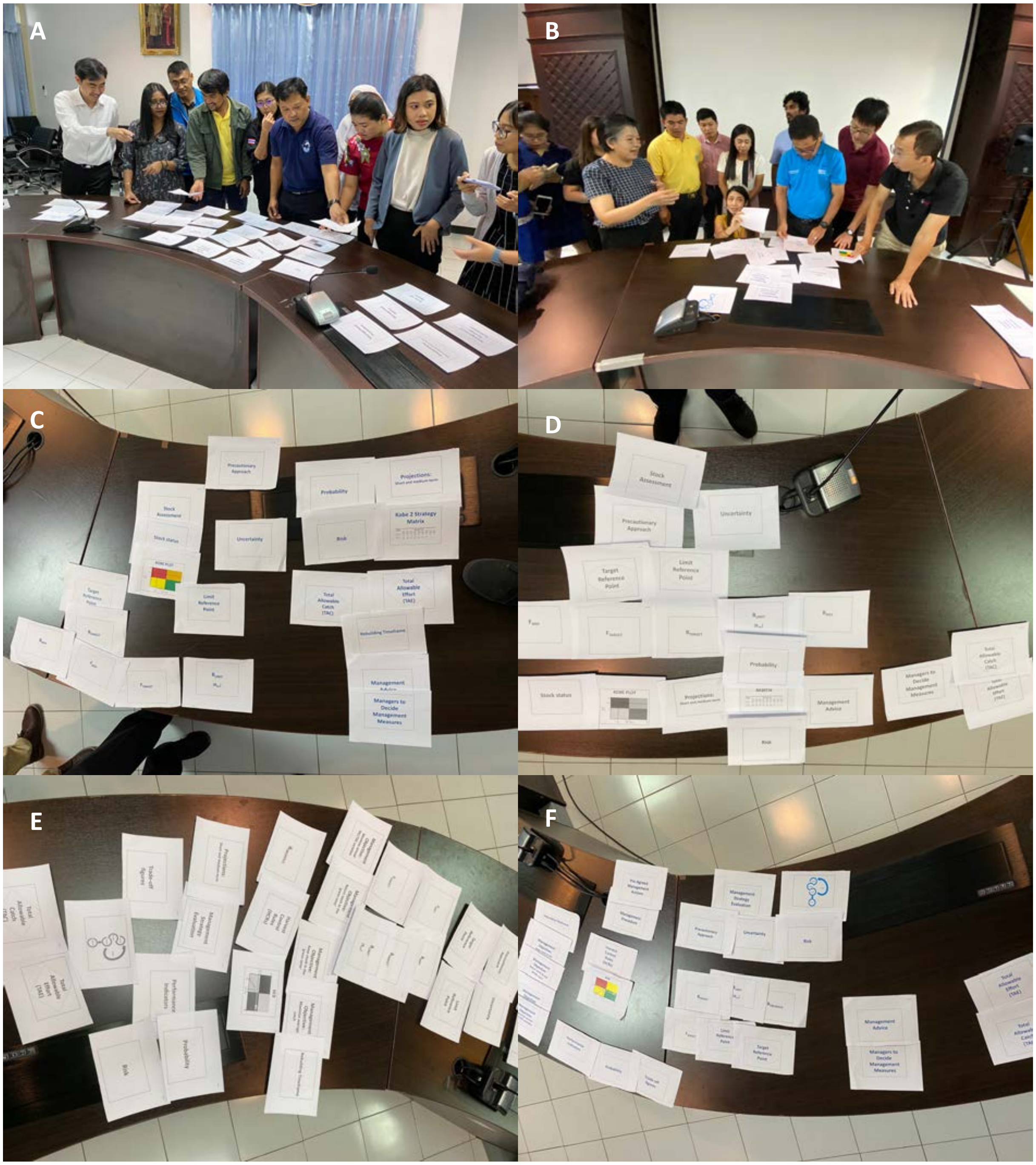

Figure 1. Example of group activity where groups of participants arrange the different elements of Stock Assessment (C and D) and Management Procedure (E and F) in a conceptual map as they understand the process. A: group 1 discussion, B: group 2 discussion, C: group 1 Stock Assessment conceptual map, D: group 2 Stock Assessment conceptual map, E: group 1 Management Procedure conceptual map, F: group 2 Management Procedure conceptual map.

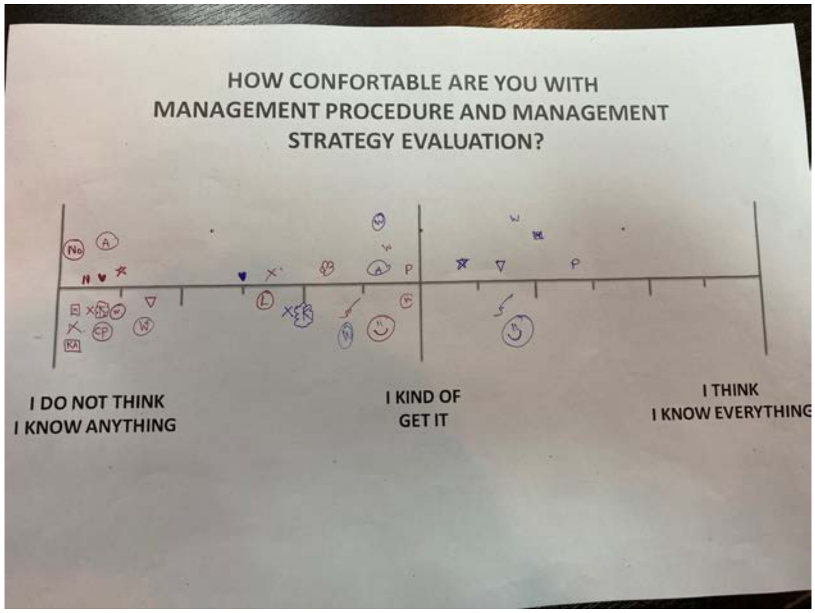

Figure 2. Distribution of participants' own perception of how much they understand Management Procedures at the start of the meeting (red marks) and by the end of the workshop (blue marks).

Appendix 1. List of Participants

NAME	AFFILIATION	e-mail
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Toshihide Kitakado	TUMSAT	kitakado@kaiyodai.ac.jp
Dan Fu	IOTC	dan.fu@fao.org
Hilario Murua	ISSF	hmurua@iss-foundation.org

Appendix 2. Workshop Agenda

Furthering Capacity Building for Harvest Control Rules and Management Strategy Evaluation: Indian Ocean Tuna Management Workshop

21-22 January, 2020
Department of Fisheries, Bangkok, Thailand

Workshop Context

The workshop is part of the "Sustainable Management of Tuna Fisheries and Biodiversity Conservation in Areas Beyond National Jurisdiction" (ABNJ Tuna Project). The overarching project focuses on three component areas:

4) Supporting implementation of sustainable and efficient fisheries management and fishing practices
5) Reducing illegal, unreported and unregulated (IUU) fishing through strengthened and harmonized monitoring, control and surveillance
6) Reducing ecosystem impacts from tuna fishing, including bycatch and associated species

Under the Component 1, Capacity Building Workshop for Management Procedures and Management Strategy Evaluation directed to specific countries outreach are organized. These workshops are implemented by the International Seafood Sustainability Foundation (ISSF) with contribution from country institutions and regional tuna RFMOs.

Workshop Aims

The goal of this workshop is to create a better understanding among Indian Ocean States of the Management Strategy Evaluation (MSE) and Management Procedure (MP, also called Harvest Strategies) to ensure sustainable management of tunas.

Ultimately, the objective of this workshop is to leverage the participation of Thailand in the process of development of tuna MPs within the Indian Ocean. Participation in this workshop will empower Thailand to engage meaningfully in the process of MP development that are occurring in the Indian Ocean Tuna Commission (IOTC).

The Event

The workshop program will include discussion of Management Procedure framework and the principles of sound fisheries management. This workshop will provide the platform and background knowledge for participation in the Indian Ocean regional level MP work, and will contribute to the development of robust Management Procedures that are most likely to meet the objectives of IOTC members and stakeholders.

This workshop will provide introduction to the process of MP development; the elements of a MP, for example management objectives, timeframes and risk; how to interpret the trade-offs between different objectives and the use of MSE to evaluate MPs. Although the agenda is comprehensive, the objective is to have an open and lengthy discussion on the various elements that will require more attention from participants. The goal is to discuss relevant needs and issues for Thailand specific to the Indian Ocean tunas and allow for more in-depth understanding of how the concepts and tools presented in the workshop may assist in increasing Thailand participation in the process of the IOTC Technical Committee on Management Procedures.

The Agenda

DAY ONE – 21st January, 2020

0900 – 0930	**Introduction & Objectives of the workshop**	Hilario Murua (ISSF)
0930 – 1045	**Setting the Context**	
	• Introduction to IOTC Management Framework and stock status	Hilario Murua (ISSF) & Toshihide Kitakado (TUMSAT)
	• The IOTC Process on adoption of Management Procedures	Hilario Murua (ISSF) & Toshihide Kitakado (TUMSAT)
	• Overview of national tuna fisheries	Pavarot Noranarttragoon (DoF)
	• Moving from a 'best assessment' approach to Management Procedures	Dan Fu (IOTC)
1045 – 1115	BREAK	
1115 – 1230	**Introduction to the provision of Fisheries Management Advice and Management Procedure approach, components and concepts** ***<u>Fisheries Management Advice</u>*** • Basic Principles, • Kobe plots, • Target and Limit Reference Points, • IOTC Decision Framework	Hilario Murua (ISSF)/Dan Fu (IOTC)/Toshihide Kitakado (TUMSAT)
1230 – 1330	LUNCH	
1330 – 1500	**Introduction to the provision of Fisheries Management Advice and Management Procedure approach, components and concepts (continue)** ***<u>Management Procedures</u>*** • Basic Principles, • Objectives, • Timeframe & Risk, • Performance Indicators, • Roles and responsibilities, • Dialogue and feedback mechanism, • Discussion	Toshihide Kitakado (TUMSAT)/ Hilario Murua (ISSF)/Dan Fu (IOTC)

1500 – 1530	BREAK	

1530 – 1645	**Going Deeper: MP and Management objectives and performance measures to evaluate MSE results**
	
	• Objectives
	  o Types of objectives, scale, time-frame, probabilities, etc.
	  o Reference points and how they related to objectives,
	  o Trade-off between objectives
	  o National vs. Regional objectives
	  o Your objectives?
	• How to interpret the results, performance indicators and trade-off figures
		Hilario Murua (ISSF)/Dan Fu (IOTC)/Toshihide Kitakado (TUMSAT)

1645 – 1700	Questionnaire discussion Wrap up and planning 2nd day	Dan Fu (IOTC) Hilario Murua (ISSF)
1700	DAY 1 CLOSE	

DAY TWO – 22nd February, 2020

0900 - 0915	OPENING Day 1 reflections & Day 2 overview	 Hilario Murua (ISSF)
0915 - 1030	**Going Deeper: Management Strategy Evaluation (MSE) and Exploring Management Procedures** • Type of HCR, • Create and run various HCRs • Comparing results and tradeoffs: a closer look	Dan Fu (IOTC)
1030 - 1100	BREAK	
1100 - 1230	**Going Deeper: discuss an example from IOTC (e.g Bigeye)** • Present various MPs as discussed in 2019 TCMP • Comparing results and tradeoffs • Discussion	Toshihide Kitakado (TUMSAT)/ Hilario Murua (ISSF)/Dan Fu (IOTC)

1230 - 1330	LUNCH	
1330 - 1500	**Stakeholder view** • Stakeholder objectives • Trade-offs and performance indicators, how to interpret the results	Hilario Murua (ISSF)
1500 - 1530	BREAK	
1530 - 1600	**Putting all pieces together** • What we learned • How this applies to upcoming IOTC processes	All
1600 - 1630	**How did we do?** • Workshop evaluation	All
1630 - 1700	Closing	

Appendix 3. Presentations

Furthering Capacity Building for Harvest Control Rules and Management Strategy Evaluation: Indian Ocean Tuna Management Workshop

Hilario Murua (ISSF)
Toshi Kitakado (TUMSAT)
Dan Fu (IOTC)

Bangkok, Thailand, 21-22 January 2020

Furthering Capacity Building for Harvest Control Rules and Management Strategy Evaluation: Indian Ocean Tuna Management Workshop

The workshop is part of the ABNJ Tuna Project "Sustainable Management of Tuna Fisheries and Biodiversity Conservation in Areas Beyond National Jurisdiction"

The project is focused on three component areas:

1. ***<u>Promotion of sustainable management,</u>***
2. Strengthening and harmonizing Monitoring Control and Surveillance,
3. Reducing ecosystem impacts.

COMMON OCEANS

Furthering Capacity Building for Harvest Control Rules and Management Strategy Evaluation: Indian Ocean Tuna Management Workshop

- The goal of this workshop is to create a better understanding among Indian Ocean States of the Management Strategy Evaluation (MSE) and Management Procedure (MP, also called Harvest Strategies) to ensure sustainable management of tunas
- Ultimately, the objective of this workshop is to leverage the participation of Thailand in the process of development of tuna MPs within the Indian Ocean.

COMMON OCEANS

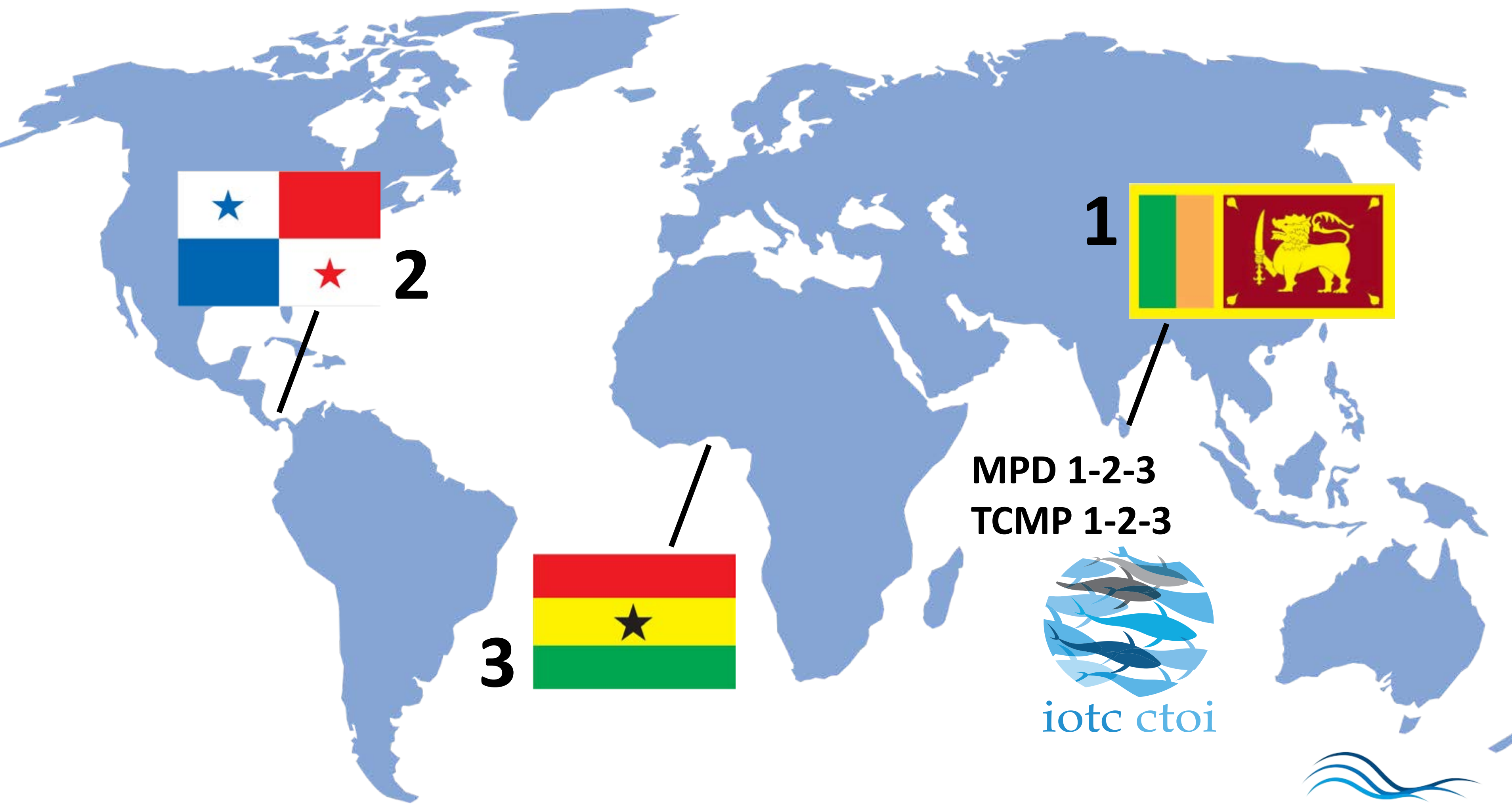
Furthering Capacity Building for Harvest Control Rules and Management Strategy Evaluation: Indian Ocean Tuna Management Workshop

This workshop builds on previous WSs to consider key elements of fisheries management issues currently relevant to IOTC members.

Participation will empower you to engage meaningfully in the ongoing discussions on Management Procedures for Indian Ocean tuna stocks over the coming years

COMMON OCEANS

Furthering Capacity Building for Harvest Control Rules and Management Strategy Evaluation: Indian Ocean Tuna Management Workshop



COMMON OCEANS

Workshop objectives

- Interpretation of IOTC tuna stock status indicators including Kobe plots and other forms of presentation,
- Understanding of Management Procedures (MPs) and the process of of MP development,
- Their components and application,
  - Management objectives,
  - Timeframes
  - Risk

COMMON OCEANS

Workshop objectives

- Open and lengthy discussion on various elements requiring more attention,
- Preparation for discussions about trade-offs between management options,
- Understanding of roles (scientists, fisheries managers, Secretariat, NGOs, industry),
- Increase meaningful participation in TCMP/Commission discussions/decisions
- **Gain understanding/confidence to speak in support of management options (including MPs) to meet national/IOTC Goals**

COMMON OCEANS

Workshop Format

- Presentations as a guide, but a lot to understand – an ambitious agenda,
- Informal set up, if something is not clear or we move quickly, please request to STOP!!
- Engagement/questions essential,
- Your WS so please free feel to change the course of actions (presentation),
- Hands on during the second day,
- Working in plenary but interaction is key,
- Flexible; if something is not working, we can change it

COMMON OCEANS

Workshop Format

- THIS IS A ITERATIVE PROCESS
  - Not be afraid to interrupt,
  - Questions help everybody,
  - Your ideas enrich everybody,
  - We are here to listen, also during coffee.
- THIS IS NOT A LECTURE OR TECHNICAL EXERCISE
  - No strange acronyms,
  - No equations (maybe just one…),
  - No modelling code,
  - No complicate figures/tables

COMMON OCEANS

Workshop Format

IN SHORT,
THE WORKSHOP IS YOURS AND FOR YOU!!!!

COMMON OCEANS

Agenda Day 1 (Morning)

Setting the Context

- Introduction to IOTC Management and stock status– *H. Murua & T. Kitakado*
- IOTC MP process – *H. Murua & T. Kitakado*
- Overview of Thailand tuna fisheries – *Pavarot Noranarttragoon*
- From best assessment to MP– *D. Fu*

COFFEE BREAK

COMMON OCEANS

Agenda Day 1 (Morning - continue)

Introduction to the Provision of Management Advice and Management Procedure approach, components and concepts – *H. Murua/T. Kitakado/D. Fu*

Fishery Management Advice

- Basic principles,
- Kobe plot,
- Target and Limit Reference Points,
- IOTC Decision Framework

LUNCH BREAK

COMMON OCEANS

Agenda Day 1 (Afternoon)

Introduction to the Provision of Management Advice and Management Procedure approach, components and concepts – *H. Murua/<u>T. Kitakado</u>/D. Fu (Continue)*

Management Procedure

- Basic principles,
- Objectives,
- Timeframes and risk,
- Performance Indicators,
- Roles and responsabilities,
- Dialogue and feedback mechanism,
- Discussion

LUNCH BREAK

COMMON OCEANS

Agenda Day 1 (Afternoon - cont.)

- **Going deeper: MPs, objectives, performance indicators evaluation– *H. Murua/T. Kitakado/D. Fu***
  - Objectives,
  - Reference points and how they relate to objectives
  - How to test decisions,
  - How to interpret results, performance indicators and trade-off figures.
  - *Questionnaire discussion* https://forms.gle/pu6rAHyzUUX7J5JC8

CLOSE

COMMON OCEANS

Agenda Day 2

- **Questionnaire**
- **Going deeper: Performance Indicators and IOTC MSE/MP adopted presentation formats**
- **(Maldivian Presentation)**
- **Exercise 1: Conceptual Map of SA vs. MPs.**
- **Going deeper: MSE and exploring MPs,– *H. Murua/T. Kitakado/D. Fu***
  - Types of HCR,
  - Create and playing with HCRs,
  - Comparing results and tradeoffs: a closer look

COMMON OCEANS

Agenda Day 2 (Afternoon)

Going deeper: MSE and exploring MPs,– ***H. Murua/T. Kitakado/D. Fu (continued)***

Stakeholder view– ***H. Murua/T. Kitakado/D. Fu***

- Stakeholder objectives,
- Comparing results and tradeoffs: a closer look.

COFFEE BREAK

Putting all pieces together – ***All***

- What we learned,
- How to apply to IOTC Process.

BACK HOME

Furthering Capacity Building for Harvest Control Rules and Management Strategy Evaluation: Indian Ocean Tuna Management Workshop

THANK YOU!

COMMON OCEANS

iotc ctoi

ISSF INTERNATIONAL SEAFOOD SUSTAINABILITY FOUNDATION

Sustainable Management of Tuna Fisheries and Biodiversity Conservation in the Areas Beyond National Jurisdiction

COMMON OCEANS

Introduction to IOTC Management Framework and stock status

Furthering Capacity Building for Harvest Control Rules and Management Strategy Evaluation: Indian Ocean Tuna Management Workshop

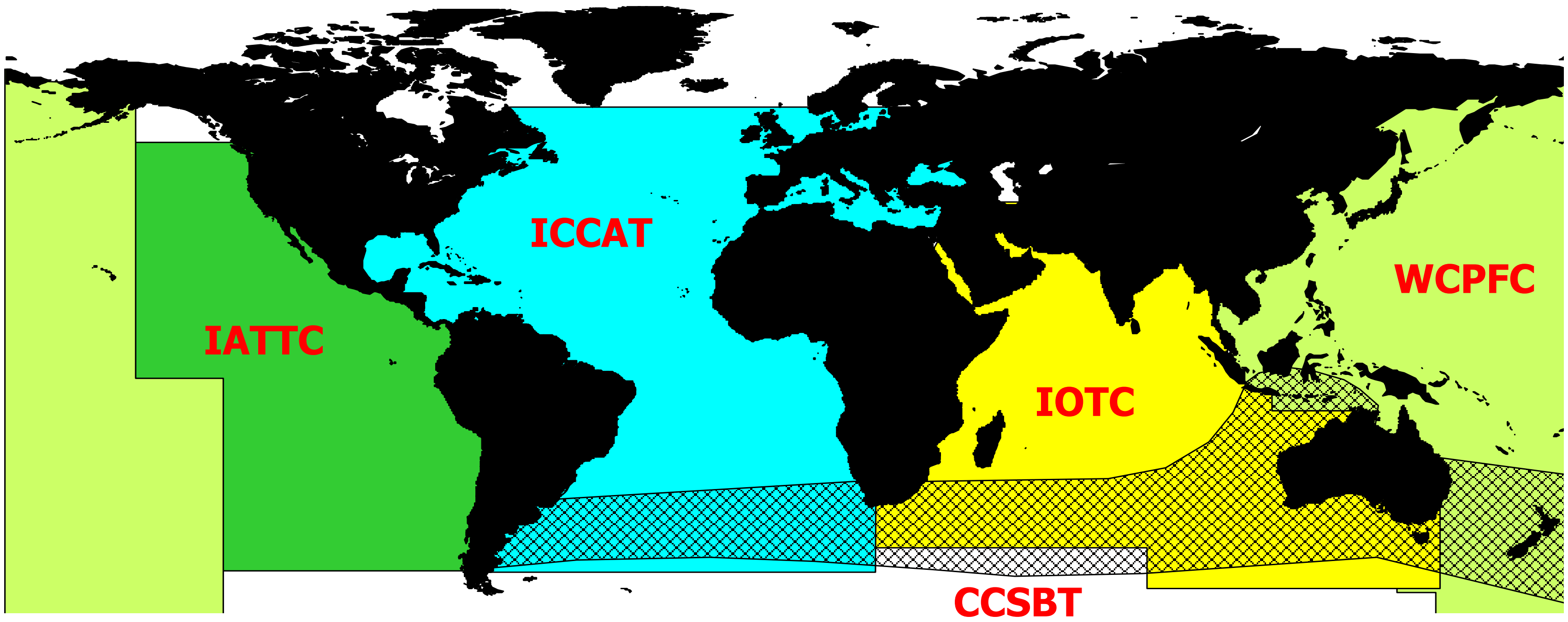
Bangkok, Thailand, 21-22 January 2020

Dr. Hilario Murua
ISSF

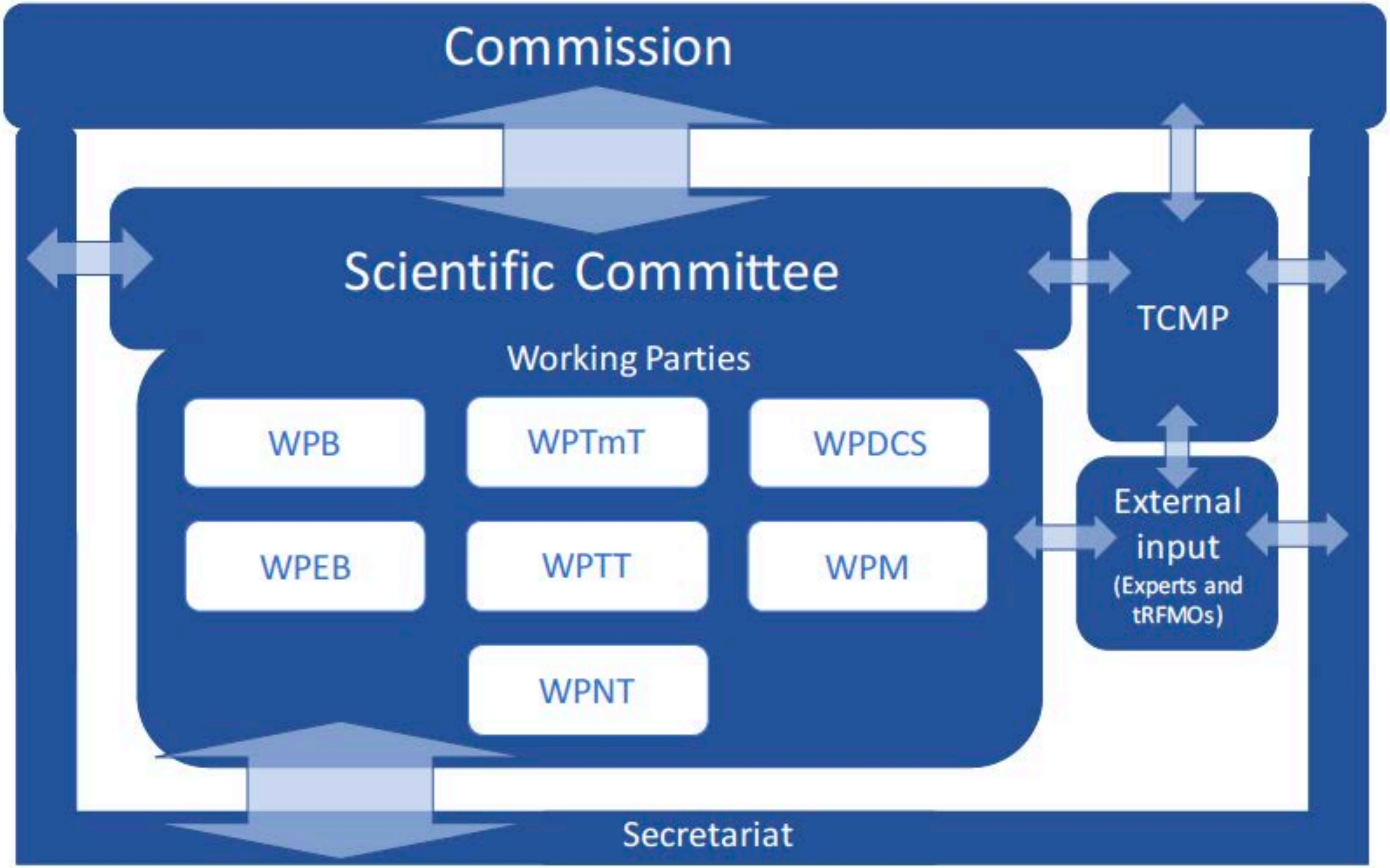
IOTC MANAGEMENT PROCECURE HISTORY

iotc ctoi

5 tuna RFMOs



IATTC: Inter-American Tropical Tuna Commission (La Jolla, USA – 1949)
ICCAT: International Comission for the Conservation of Atlantic Tunas (Madrid, España – 1969)
CCSBT: Commission for the Conservation of Southern Bluefin Tuna (Canberra, Australia – 1994)
IOTC: Indian Ocean Tuna Commission (Mahé, Seychelles – 1996)
WCPFC: Western and Central Pacific Fisheries Commission (Kolonia, Micronesia - 2004)


Commission
Scientific Committee
Working Parties
WPB
WPTmT
WPDCS
WPEB
WPTT
WPM
WPNT
TCMP
External input
(Experts and tRFMOs)
Secretariat

SOME HISTORY

- 2002: First discussion of MSE was in the WPM in 2002, recommending the development of an operating model
- 2009: PRIOTC01 Recommendation 38 to implement Precautionary Approach and uncertainty in the advice as UNFSA; which also calls for an MSE process.
- 2010 COM supported the development of a MSE by the SC as a tool to evaluate conservation and management measures
- 2010 SC Recommended to organize a meeting on MSE between scientist, managers and representatives of the industry
- 2011 COM endorsed the development of a road map for MSE
- 2012
    - Resolution 12/01 on the implementation of the Precautionary Approach
    - Resolution 12/14 on Interim Target and Limit Reference Points
    - Resolution 12/15 on the Best Available Science
- 2013 Resolution 13/10 on Interim Target and Limit Reference Points and a Decision Framework

SOME HISTORY

- 2014
  - 1st Management Dialogue Meeting
  - Resolution 14/03 on Enhancing the Dialogue between Scientist and Managers
- 2015
  - 2nd Management Dialogue Meeting
  - Resolution 15/10 on Target and Limit Reference Points and a Decision Framework
- 2016
  - 3rd Management Dialogue Meeting
  - Resolution 16/02 on HCR for Skipjack
  - Resolution 16/09 on establishing a TCMP
  - MP/MSE Workplan developed by WPM/SC.
- 2017
  - 1st Technical Committee on Management Procedure
  - MP/MSE Workplan adopted by Commission

2019	ALB/YFT/BET	SKJ	SWO
TCMP	Provide advice to Commission on elements of candidate MPs that require a decision by the Commission, including the performance of candidate MPs against Commission objectives.	Provide advice to the Commission on any outstanding issues resulting from the application of the HCR if required	Provide advice to Commission on elements of candidate MPs that require a decision by the Commission, including the performance of candidate MPs against Commission objectives
COM	Consider work and advice from subsidiary bodies. Decision and adoption of an MP or provide direction to the WPs/SC on the need to undertake further MSE of candidate or alternative MPs	Consider work and advice from subsidiary bodies and review Resolution 16/02.	Consider work and advice from subsidiary bodies and provide direction to the WPs/SC on the need to undertake further MSE of candidate or alternative MPs
WPs/ SC	Undertake MSE to provide advice on the performance of candidate MPs		Consider recommendations from the Commission and undertake MSE to provide advice on the performance of candidate MPs

TCMP 03

MSE basic principles

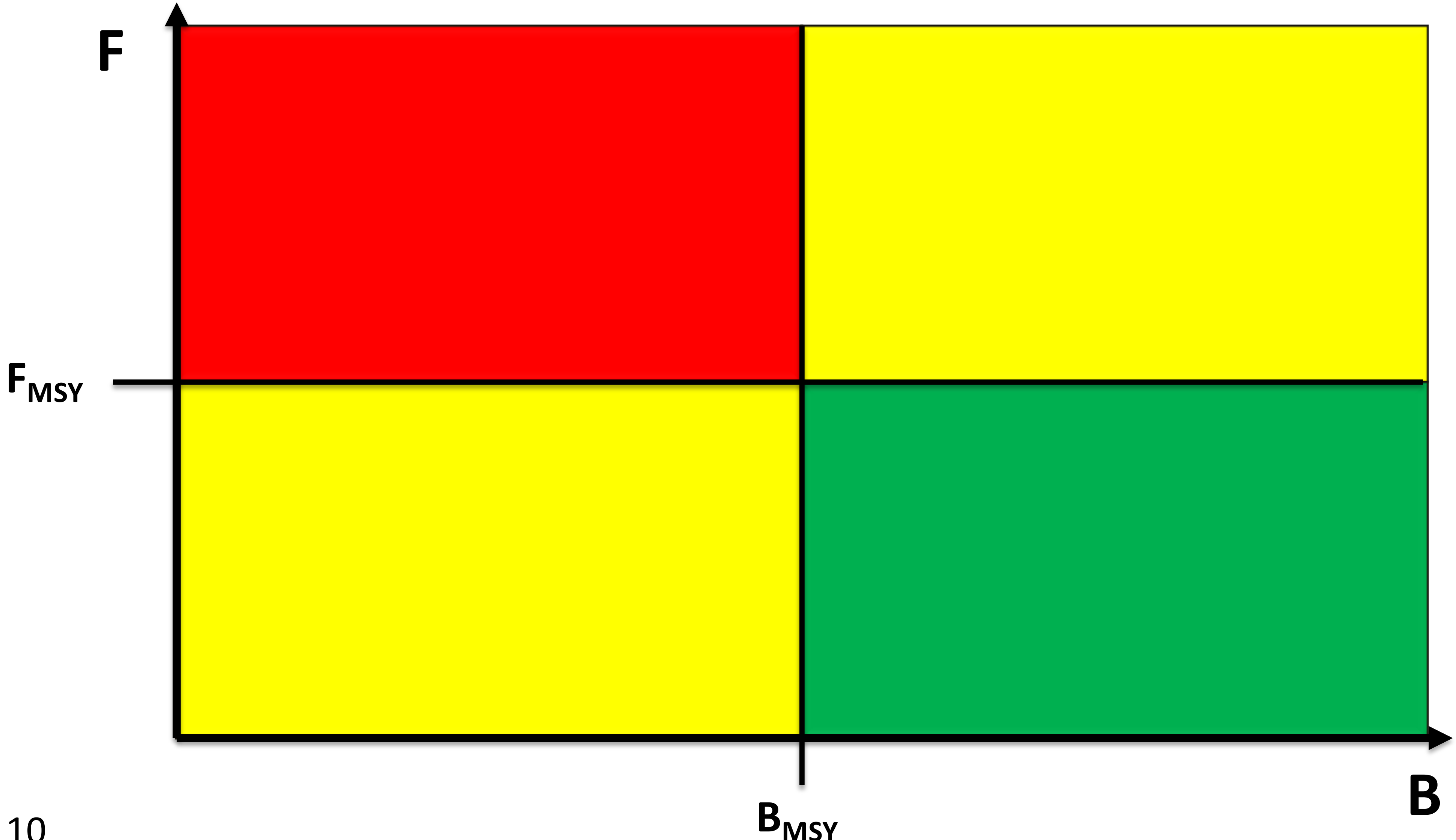
- **Complex issues presented and AGREED to maintain the science related capacity building in the next TCMP to clarify key issues in the Management Strategy Evaluation (MSE).**

- **The TCMP REQUESTED that Intersessional capacity building on MSE be conducted to increase understanding of the MSE process by all CPCs.**

IOTC MANAGEMENT FRAMEWORK

IOTC Convention Objective (Strategic or Conceptual)

The Commission shall *promote cooperation among its Members* with a view to ensuring, through appropriate management, the conservation and *optimum utilization of stocks* covered by this Agreement and *encouraging sustainable development of fisheries* based on such stocks.



Resolution 15/10: Reference Points

- **Interim Target and Limit Reference Points (TRPs and LRPs)**

When assessing stock status and providing recommendations to the Commission, the **IOTC Scientific Committee should, where possible, apply MSY-based target and limit reference points for tuna and tuna-like species**.

Stock	Target Ref. Point	Limit Ref. Point
Albacore Yellowfin Swordfish	Btarget = B_{MSY} Ftarget = F_{MSY}	Blim = 0.4 * B_{MSY} F = 1.40 * F_{MSY}
Bigeye		Blim = 0.5 * B_{MSY} F = 1.30 * F_{MSY}
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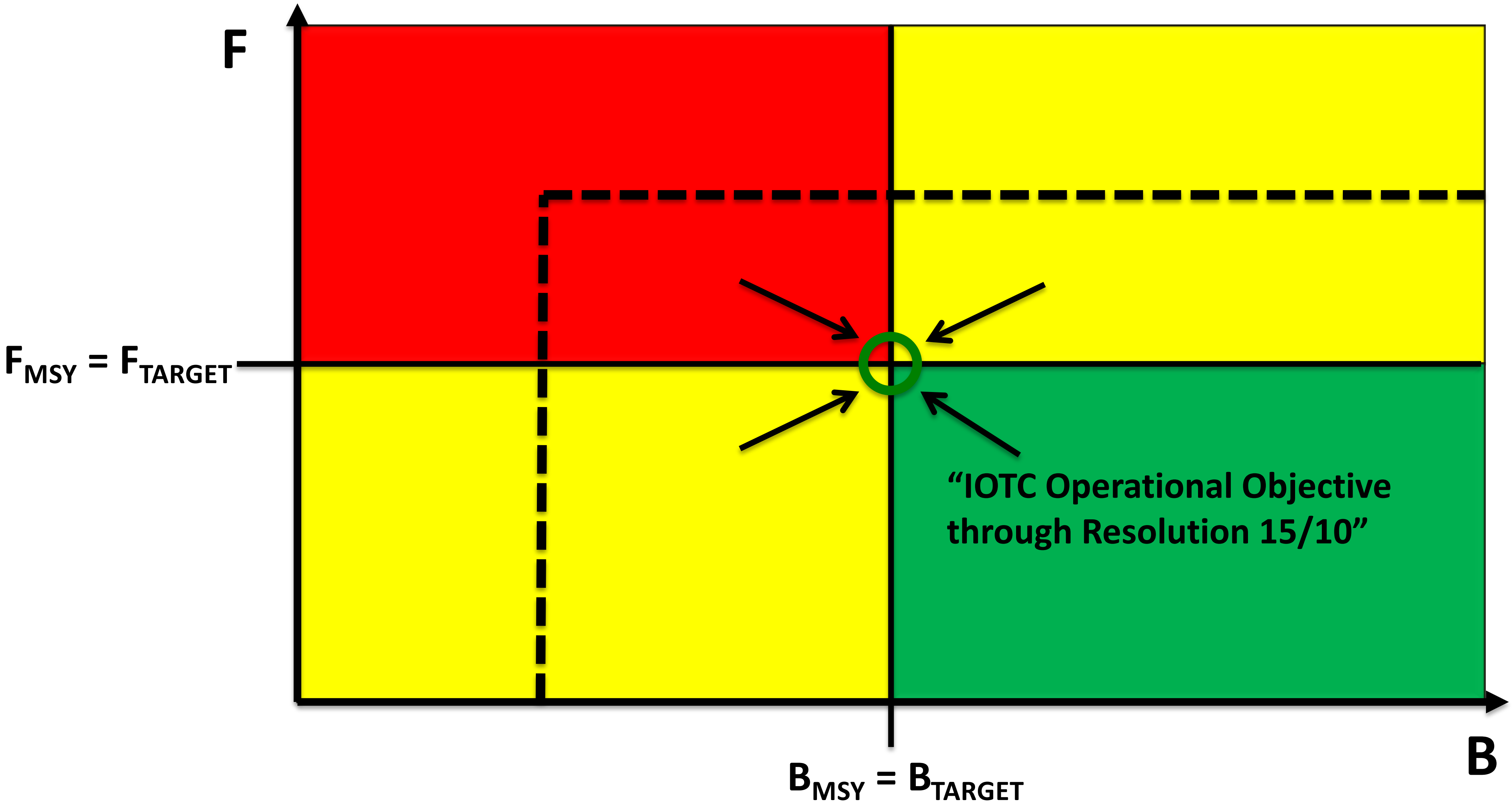
Resolution 15/10: Reference Points (Operational Objectives)



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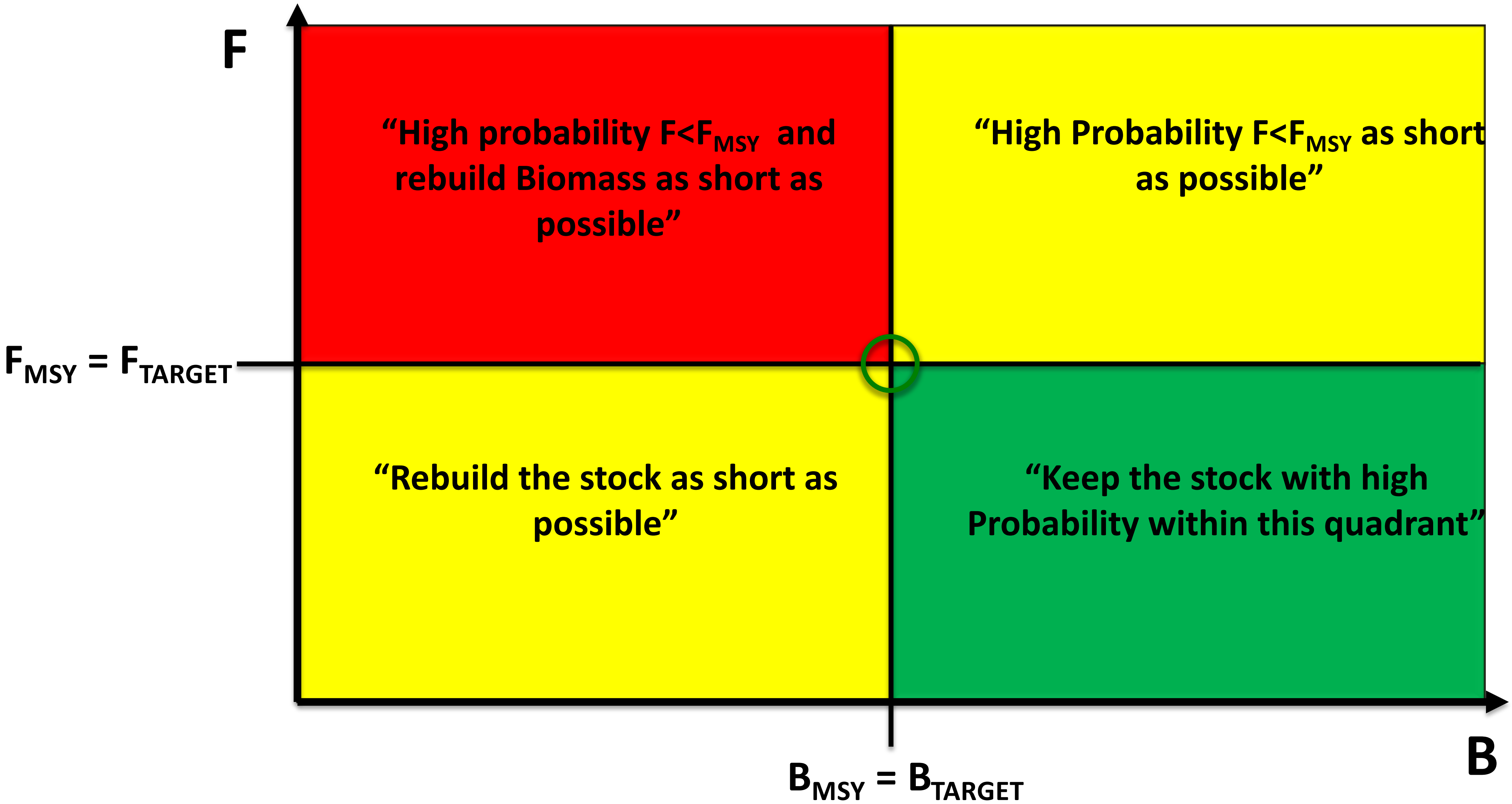


IOTC STOCK STATUS

iotc ctoi

TROPICALS & ALBACORE

Species	Last SA	Status		MSY	Catch 2018	Catch 2014-2018	Catch Trend	Management Advice
		Prev	Last					
Albacore	2019	16	19	35,700	41,603	38,030		**Catch reduction**
Bigeye	2019	16	19	87,000	81,413	89,720		**10 % Catch reduction**
Skipjack	2017	14	17	510,100	606,197	484,993		HCR 16/02 – **Catch limit = 470,029 t.**
Yellowfin	2019	18	19	403,000	437,422	407,377		**Res. 19/01**

NERITICS

Species	Last SA	STAT US	MSY	Catch 2017	Catch 2013-2017	Catch Trend	Management Advice
Kawakawa	2015		152,000	159,881	157,326		Catches reduce ˜10 % ˜136,000
Longtail	2017		140,000	138,403	139,856		Catches = 2016 levels 138,403
IP King-mackerel	2016		Unknown	52,455	46,814		Catches < 46,787 (2009-2011)
Narrow-based SP mackerel	2017		130,720	159,370	160,812		Catches reduce 30 % ˜ 110,000
Bullet	NO SA		Unknown	11,094	**9,959**		Catches < 8,870 (2009-2011 average)
Frigate	NO SA		Unknown	74,886	**86,157**		Catches < 94,921 (2009-2011 average)

BILLFISHES

Species	Last SA	Status	MSY	Catch 2017	Catch 2013-17	Catch Trend	Management Advice
Swordfish	2017		**31,590**	34,782	31,405		**Catch < MSY**
Black marlin	2018		**12,930**	21,250	18,673		**Res. 18/05**
Blue marlin	2019		**9,980**	9,969	**11,382**		**7,800 t.**
Striped marlin	2018		**4,730**	3,082	3,587		**Catch 1,500 and 2,200**
Indo-Pacific Sailfish	2015		**23,900**	36,911	31,267		**Res. 18/05**

Introduction to Management Strategy Evaluation with TunaMSE: Stock assessment vs MPs

Dan Fu (IOTC)

Bangkok, Thailand, 21-22 January 2020

Fishery management

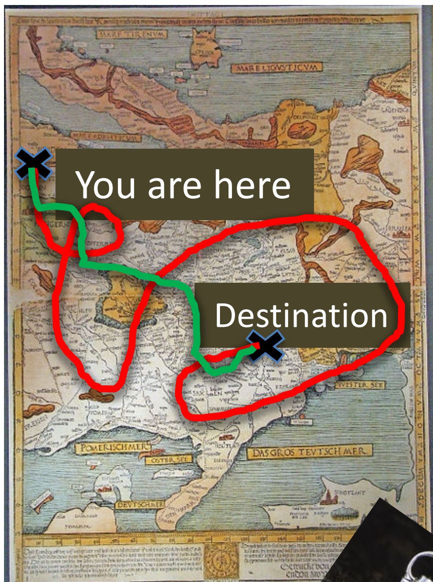
Goals

- Generate sustainable economic and social benefit
- Conserving productivity of the fish stock
- Minimizing direct and indirect impact on wider ecosystem

Requires

- Assessment of stock status ad sustainable level of harvest
- Management measures to control fishing in response to changes in the resource

Fishery management challenges



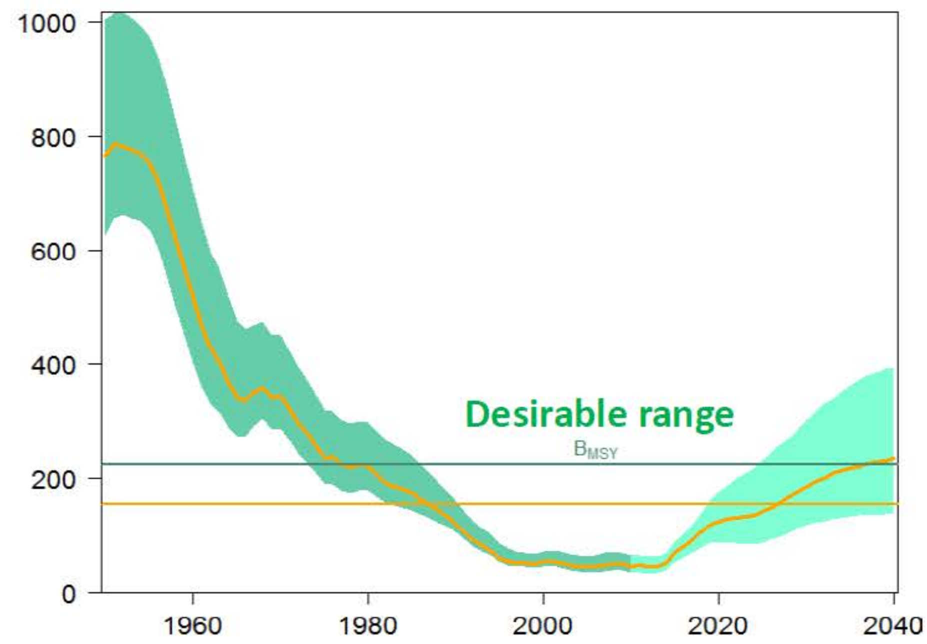
- Assessing the status of the stock and predicting future catch levels
- Monitoring and predicting impacts of the fishery on the recourses
- Setting reasonable harvest levels and providing catch advice
  - Making decisions under large uncertainty
  - Making trade-offs between short and long-term objectives

Fishery management elements

- Availability of information on resource status and trends relative to desirable levels
- Capacity to adjust harvest controls in response to changes in stock abundance
- Ability to implement and enforce harvest regulations

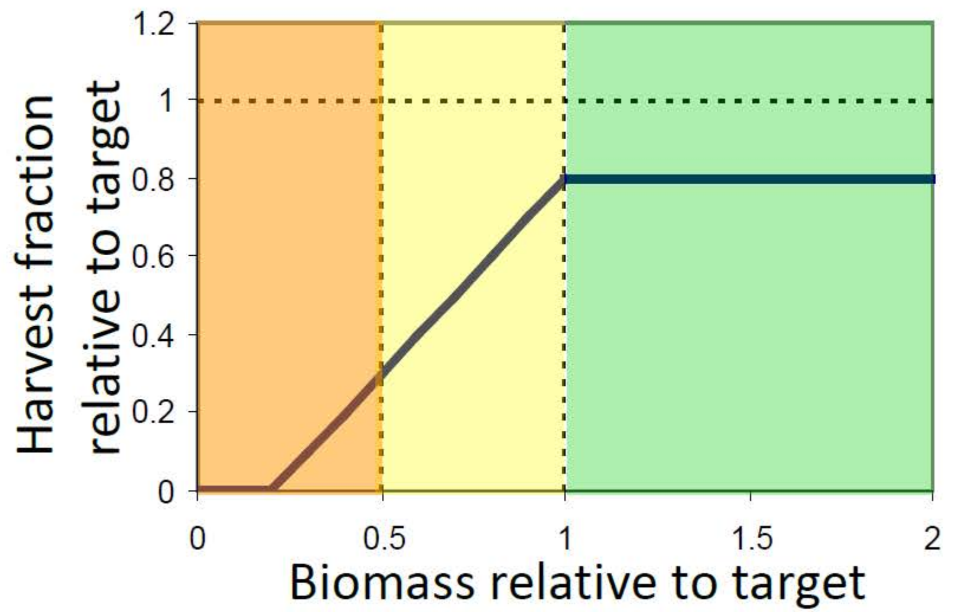
Information on resource status relative to desirable levels

- Analyze data collected using population models
- Estimate historical and current stock status
- Estimate desirable levels of stock size



Adjust harvest controls in response to stock abundance

- Set annual catch limit using harvest control rules or management procedures

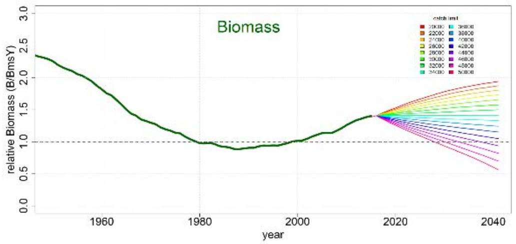


Catch advice

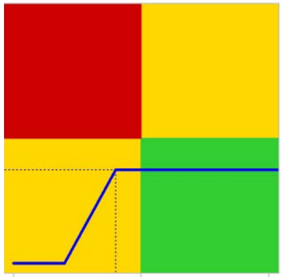
Fishing

Data collection

Stock Assessment

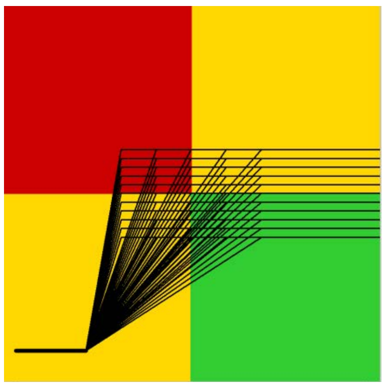


Agreed management procedure



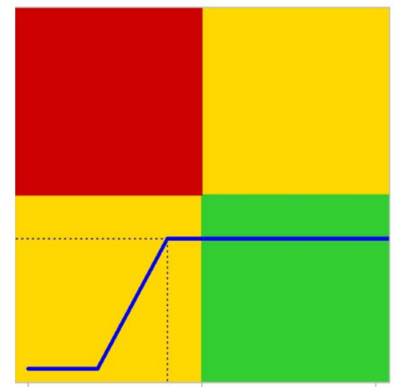
Management strategy evaluation

Candidate management procedures



MSE

Agreed management procedures



- Management objectives
- Operating models
- Simulation testing
- Performance measures

Being there is everything

Status

Yield

Stability

Safety

- Stock assessment – where we are now
- Management procedure – How to get there
- MSE – What's the best way

Stock assessment

- Mathematic representation of population processes
- Provide “best fit” to observations
- Reconstruct population history
- Estimate stock size and reference quantities

Population dynamics

A (very) simple summary:

$$B_{current} = B_0 - F - M + Y$$

Current state

"Initial" state

Fishing mortality

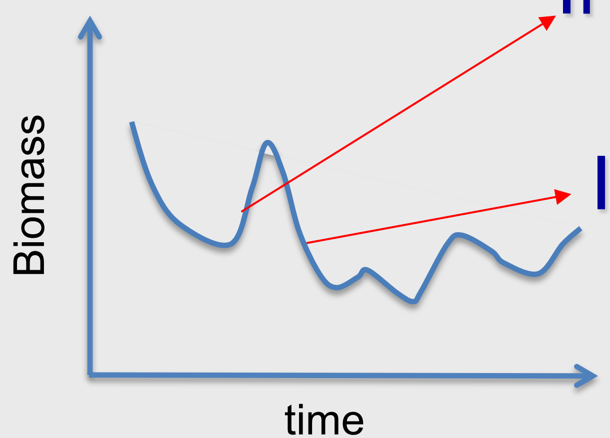
Natural mortality

Recruitment (Births)+Growth

Stock assessment –
Reconstruct population history

If F + M < Y, population increases

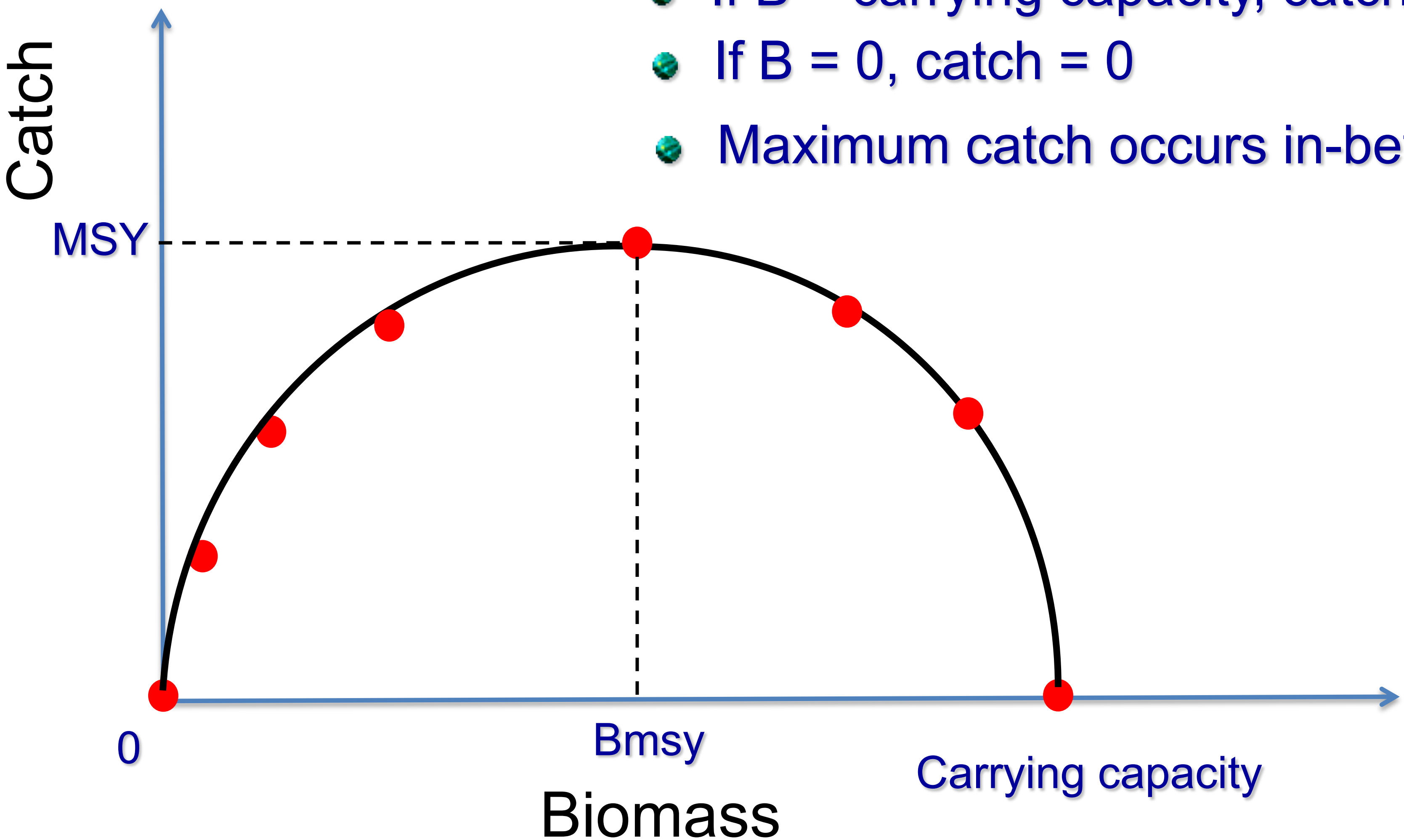
If F + M > Y, population decreases



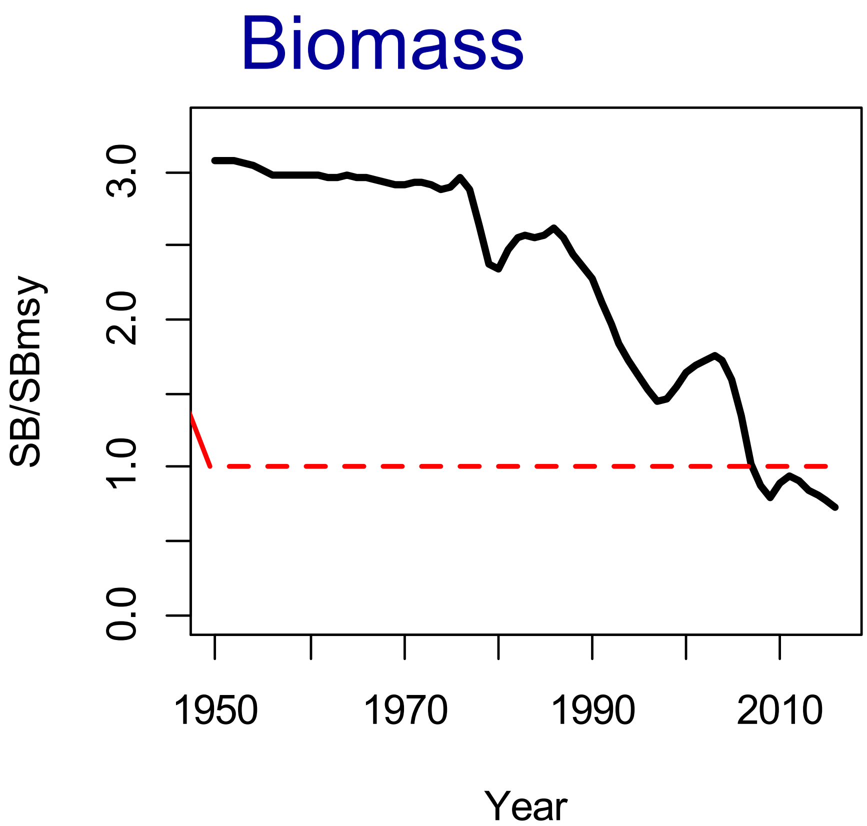
- MSY – maximum catch that can be taken sustainably
- Bmsy – biomass level that support MSY
- Fmsy – MSY / Bmsy

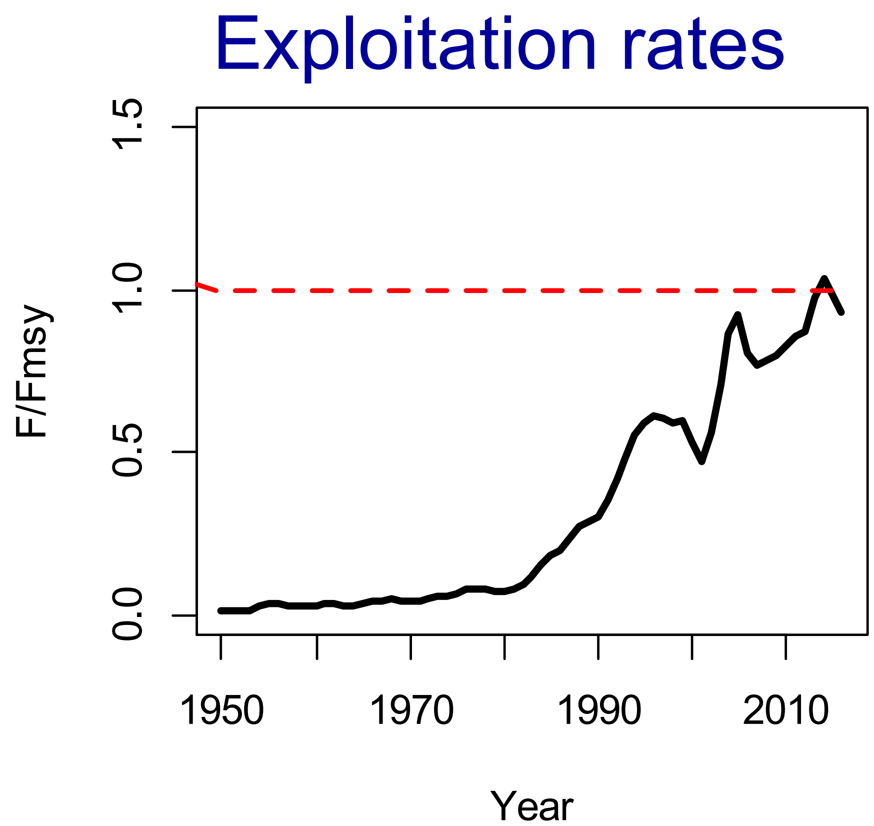
Maximum sustainable yield (MSY)

- If B = carrying capacity, catch = 0
- If B = 0, catch = 0
- Maximum catch occurs in-between

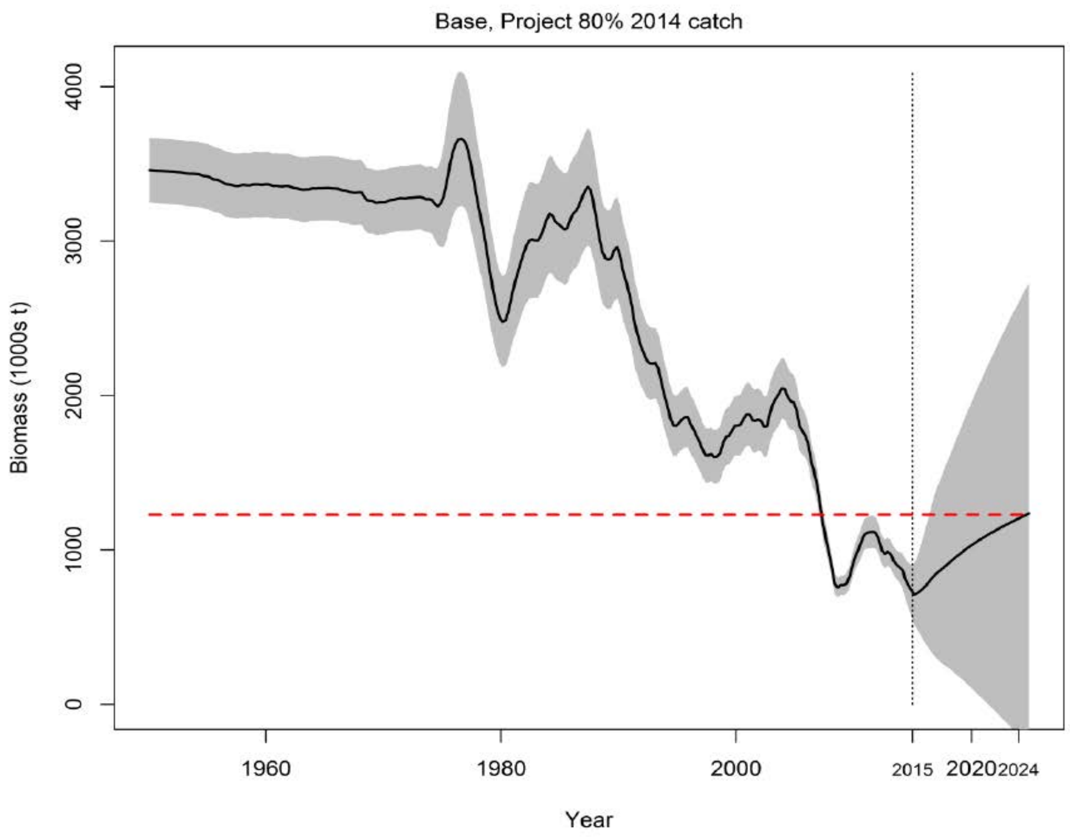


Stock assessment (Yellowfin example*)





Stock assessment – Projection



YFT assessment

At 20% catch reduction, biomass rebuilds to Bmsy after 10 years (50% probability)

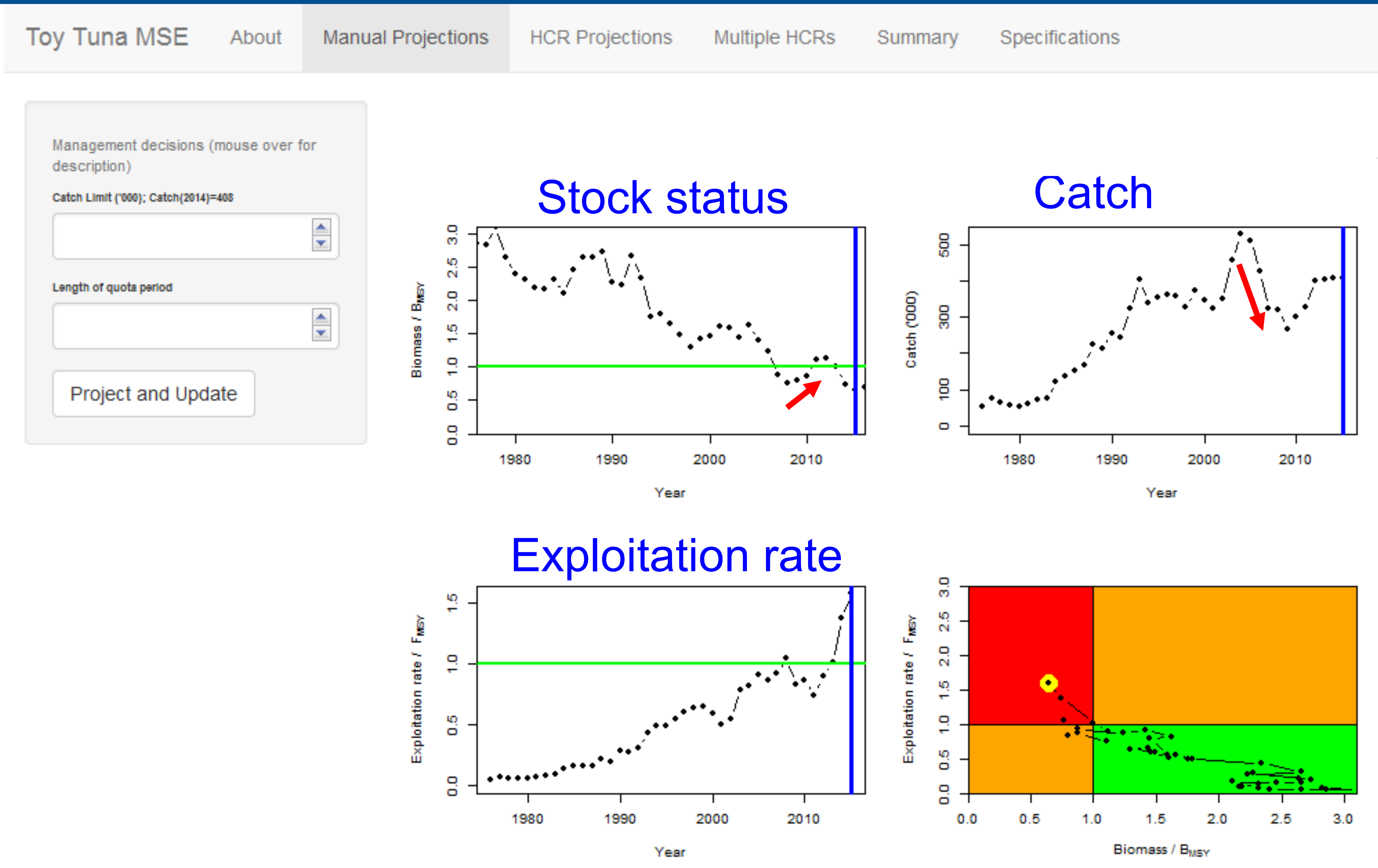
Kobe II Strategy Matrix

TAC	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
0	38%	56%	74%	86%	91%	94%	96%	97%	98%	98%	99%	99%	99%	99%	100%	100%	100%	100%
20000	29%	38%	45%	54%	63%	69%	75%	79%	83%	85%	87%	89%	90%	92%	93%	93%	94%	95%
22000	28%	36%	43%	50%	58%	64%	70%	75%	78%	81%	84%	85%	87%	89%	89%	91%	92%	92%
24000	27%	35%	40%	46%	53%	59%	64%	69%	73%	76%	79%	81%	83%	84%	86%	87%	88%	89%
26000	26%	33%	38%	43%	49%	54%	59%	63%	67%	70%	73%	76%	78%	79%	81%	83%	84%	84%
28000	25%	31%	36%	39%	44%	49%	53%	57%	61%	63%	66%	69%	71%	73%	75%	76%	77%	79%
30000	24%	29%	34%	37%	39%	43%	47%	50%	54%	57%	59%	61%	63%	65%	66%	68%	69%	71%
32000	23%	27%	31%	34%	36%	39%	41%	44%	47%	49%	51%	53%	55%	57%	58%	59%	61%	62%
34000	22%	24%	27%	30%	32%	34%	36%	38%	40%	41%	43%	45%	47%	48%	49%	50%	52%	52%
36000	21%	22%	23%	25%	27%	29%	31%	32%	33%	34%	35%	36%	38%	39%	40%	40%	41%	42%

Stock assessment summary

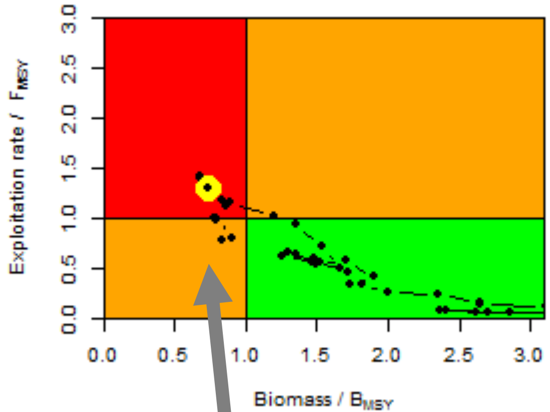
- Reconstruct population history
- Estimates of current stock status
  - Overfished ? (Biomass < Bmsy)
  - Overfishing? (F > Fmsy)
- Forecast of future stock status

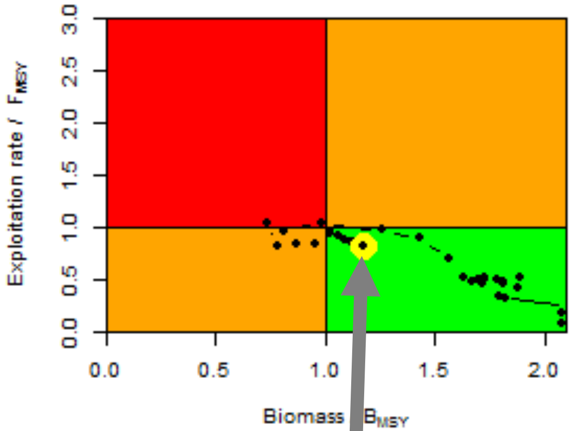
‘Tuna MSE’ – Stock assessment



‘Tuna MSE’ – Underlying Truth

We are not always lucky !



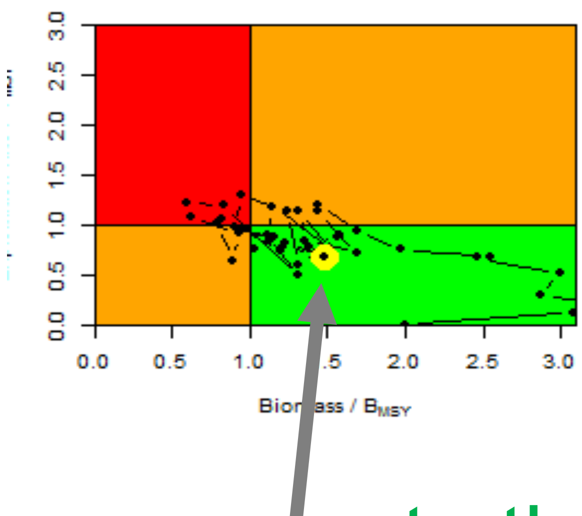


Assessment: the stock is in red

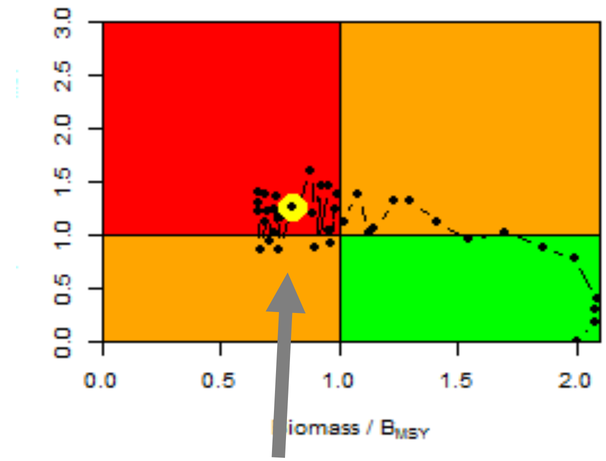
The truth: the stock is in green

‘Tuna MSE’– Underlying Reality

We are not always lucky !



Assessment : the stock is in green

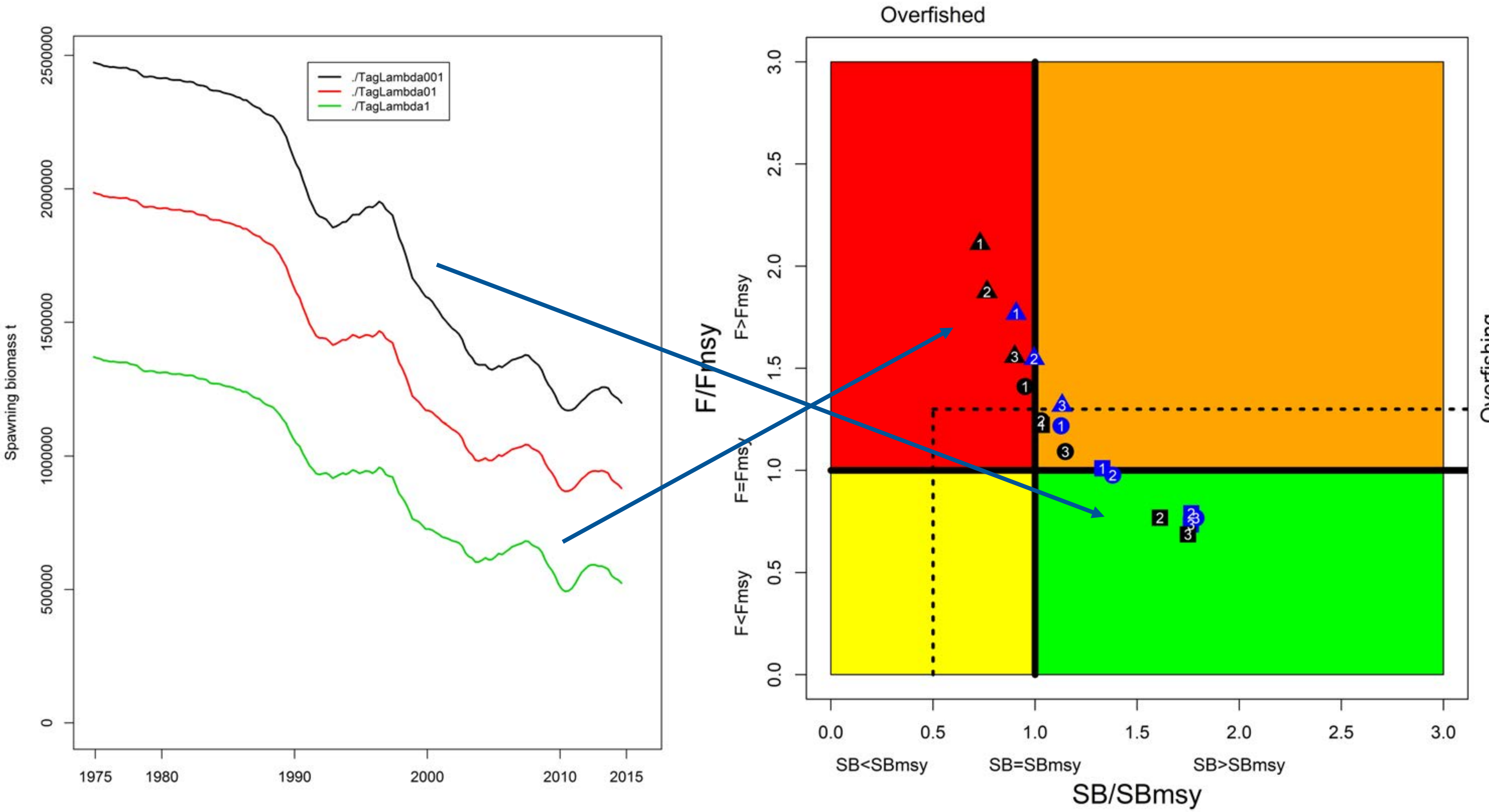


Reality: the stock is in red

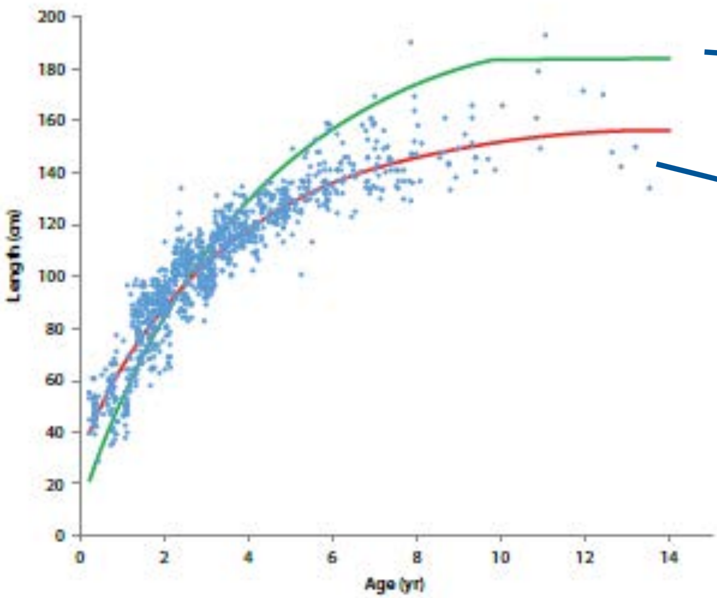
Stock assessment issues

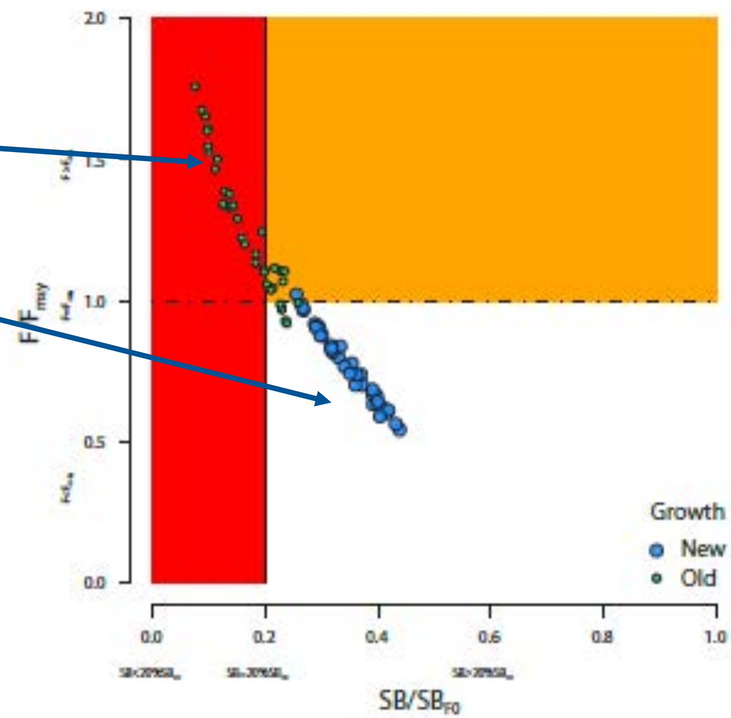
- Uncertainty in the status of the Stock
- Uncertainty in future levels of recruitment
- Uncertainty in the impact of future catches on the Stocks
- Overall uncertainty in state of stock and impacts of future catches makes consensus decision making difficult

IOTC bigeye tuna assessment



WCPFC bigeye tuna assessment



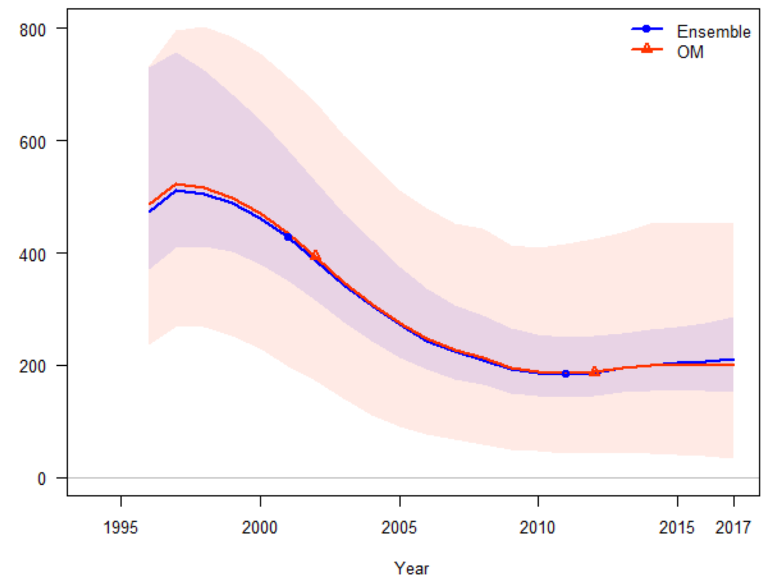


Disadvantages of stock assessment

- Results depended on quality of the data, and may be sensitive to method used
- Stock status is uncertain, and can easily change with new interpretation of data or change of models
- Often consider the most probable scenario, not covering a wide range of possibilities
- not characterize the full uncertainty in the long-term
- Not considering management response
- No rules about how quotas will be set and thus no transparency and understanding of what will happen

Advantages of Management Procedure

- Incorporates greater uncertainty than the assessment
- The goal is to develops a management procedure robust to uncertainty and variability in the long-term



Allan Hicks, IPHC (2018)

Advantages of Management Procedure

- Provides greater certainty for all stakeholders (agreed rules for decision making).
- Designed to achieve an agreed balance between competing management objectives.
- Provides a better chance of achieving management objectives (pre-testing to identify robust strategies).
- Designed to be robust to current scientific uncertainty.
- Demonstrates to the community that you are managing responsibly.

Challenges with Implementing a Management Procedure

- Technical challenges in developing and testing an MSE.
- Scientists and Commissioners are required to make a number of decisions and choices related to:
  - The management objective.
  - Choice of Harvest control rules
- Each decision involves trade-offs between catch and risk to the stock.

Introduction to Management Procedure approach, components and concepts

Furthering Capacity Building for Harvest Control Rules and Management Strategy Evaluation: Indian Ocean Tuna Management Workshop

Bangkok, Thailand, 21-22 January

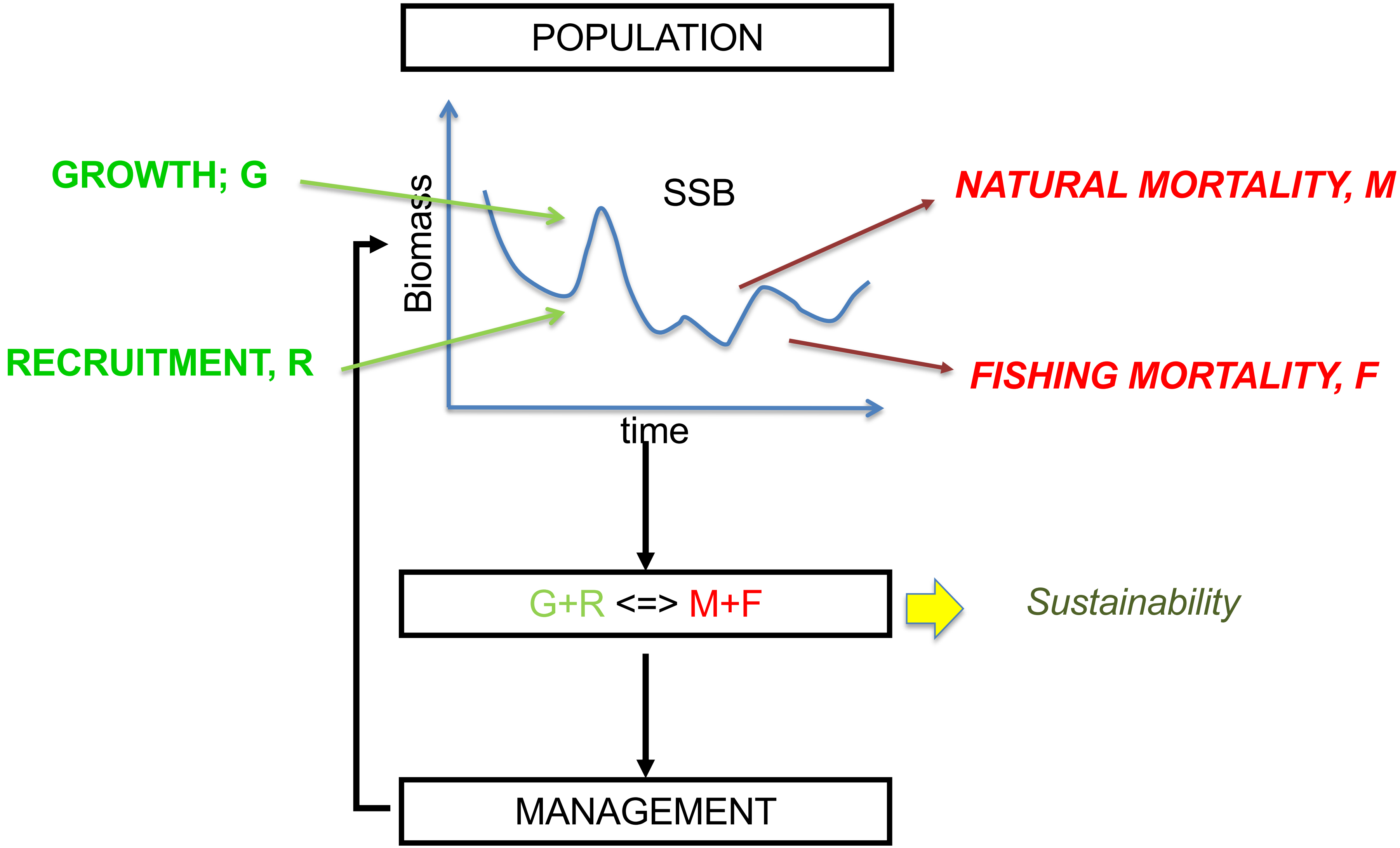
Dr. Hilario Murua (ISSF)
Dr. Dan fu & Dr. Toshihide Kitakado
(TUMSAT)

Outline

- Provision of Management Advice (***H. Murua***)
  - Target and Limit Reference Points,
  - Kobe Plot,
  - Decision framework.
- MP and MSE basic principles (***T. Kitakado***)
  - Objectives,
  - Timeframes & risk,
  - Trade-off between objectives,
  - MSE Process
  - Feedback from managers,
- Presentation of MSE Results (***T. Kitakado***)
  - Performance Indicators
- Roles and responsabilities and feedback mechanism

PROVISION OF MANAGEMENT ADVICE

Stock Assessment: Reconstruct population history



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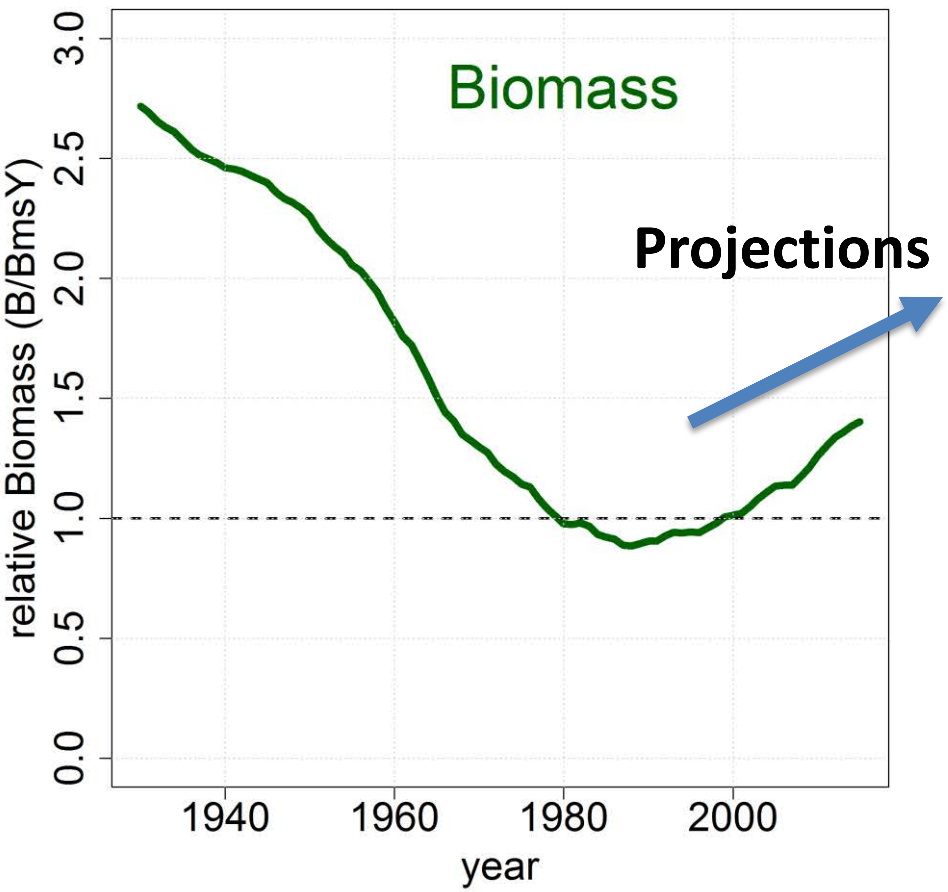
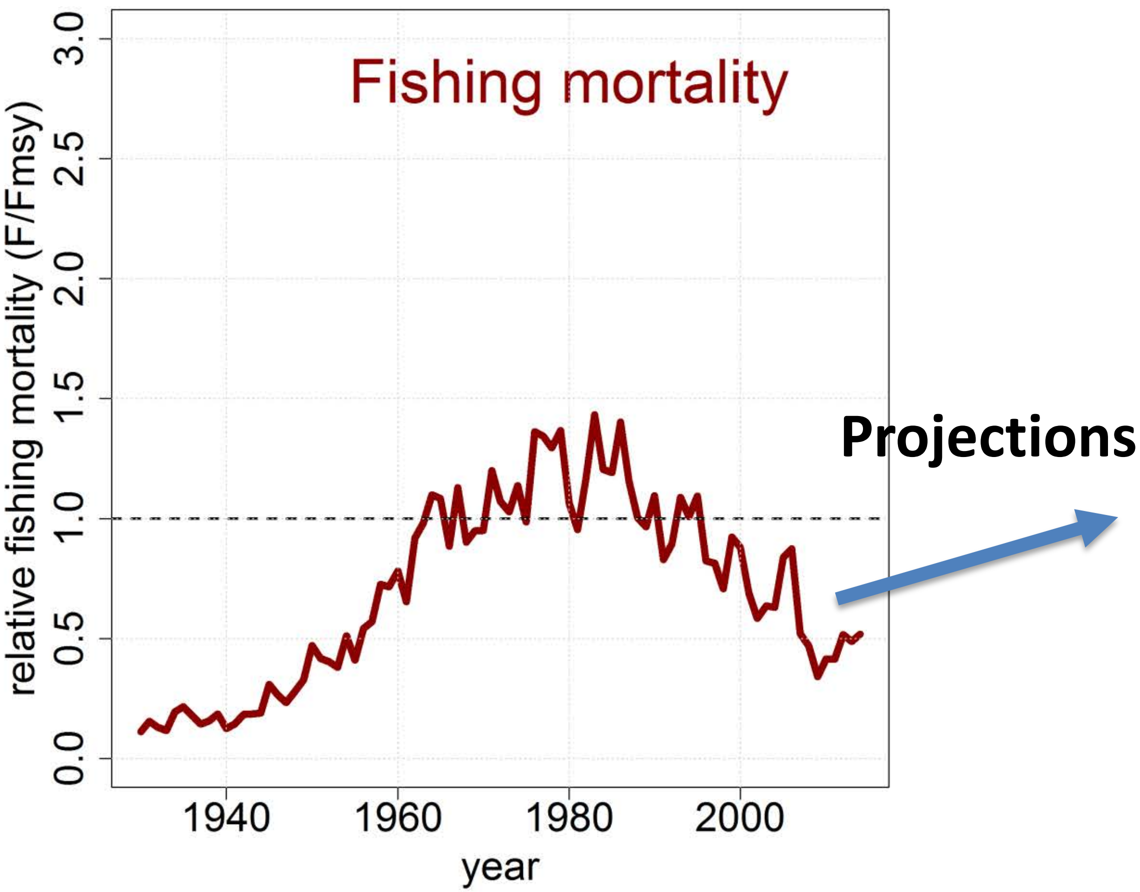
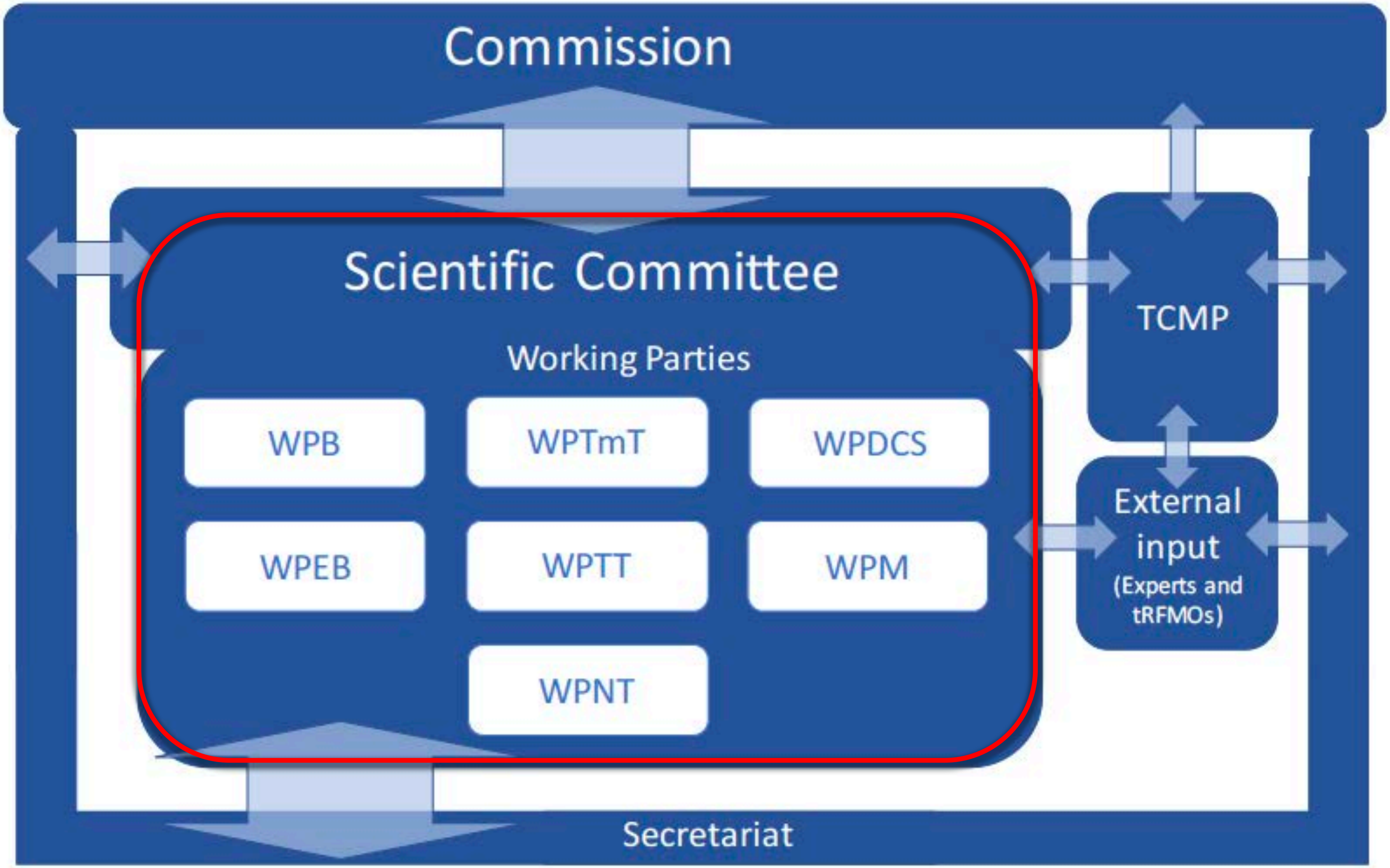




***Prediction is very difficult, especially if it's about the future** - Niels Bohr, Physicist*


Commission
Scientific Committee
Working Parties
WPB
WPTmT
WPDCS
WPEB
WPTT
WPM
WPNT
TCMP
External input
(Experts and tRFMOs)
Secretariat

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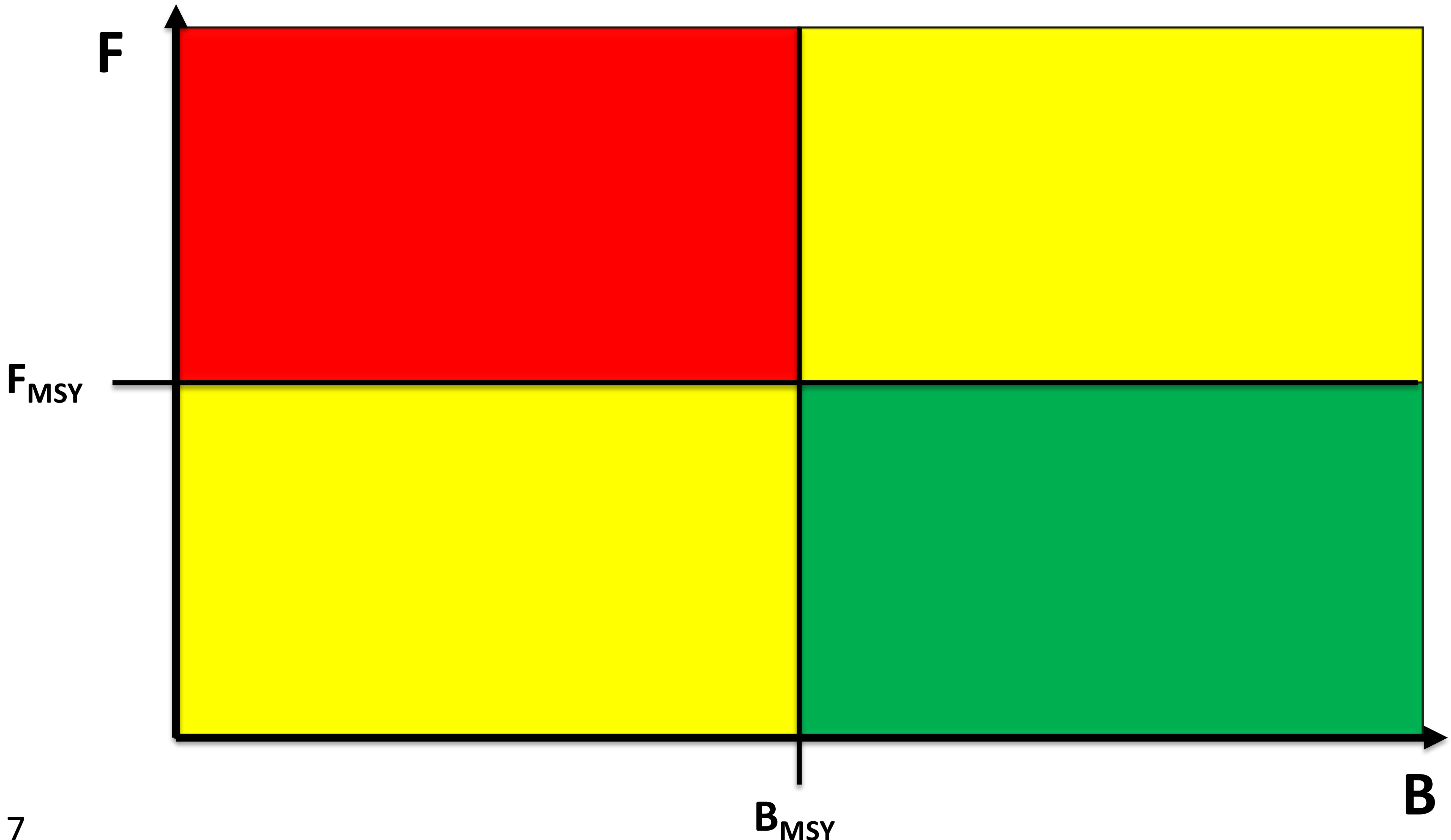

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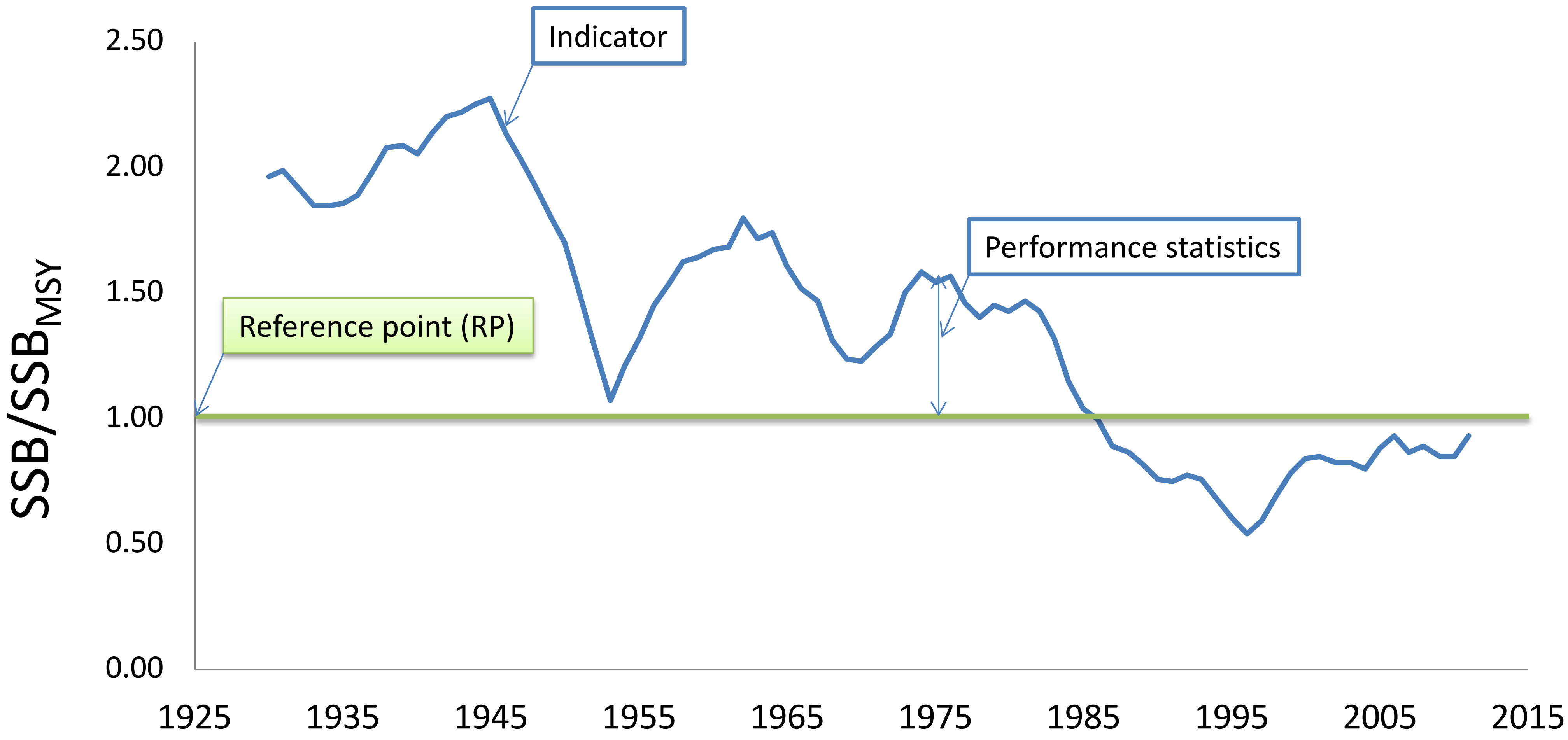
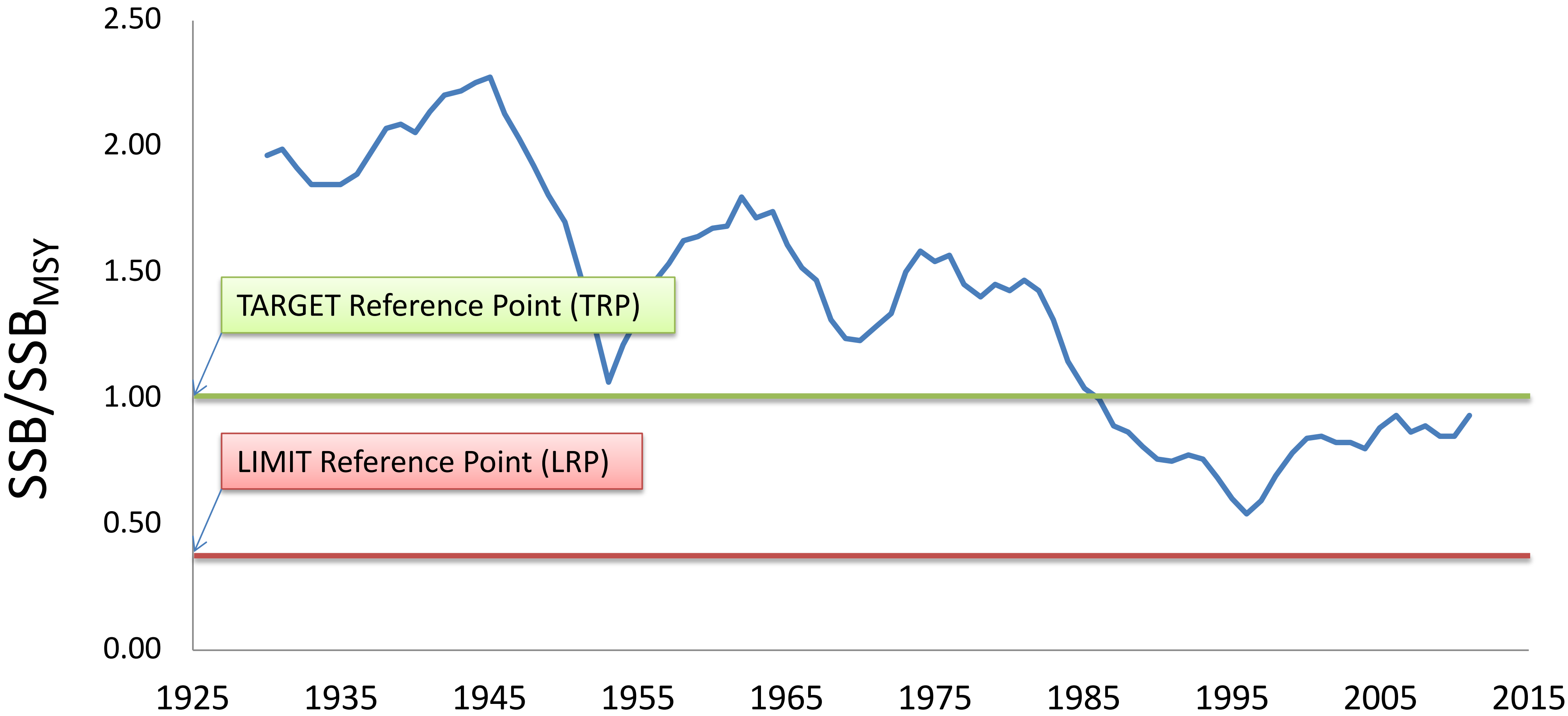


Reference Point is a **pre-determined** level of a given indicator that corresponds to a particular state of the stock

Resolution 15/10: Reference Points



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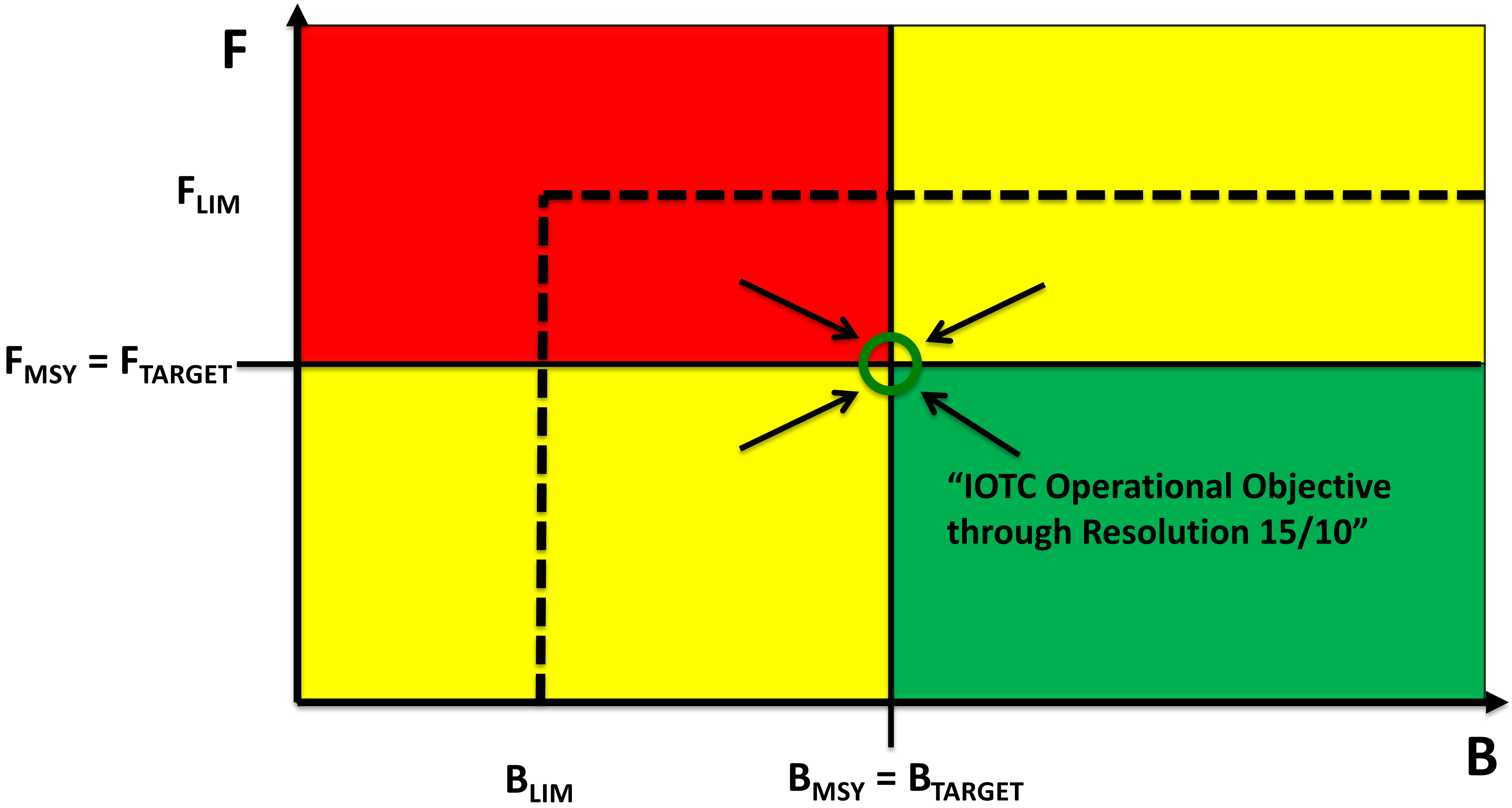
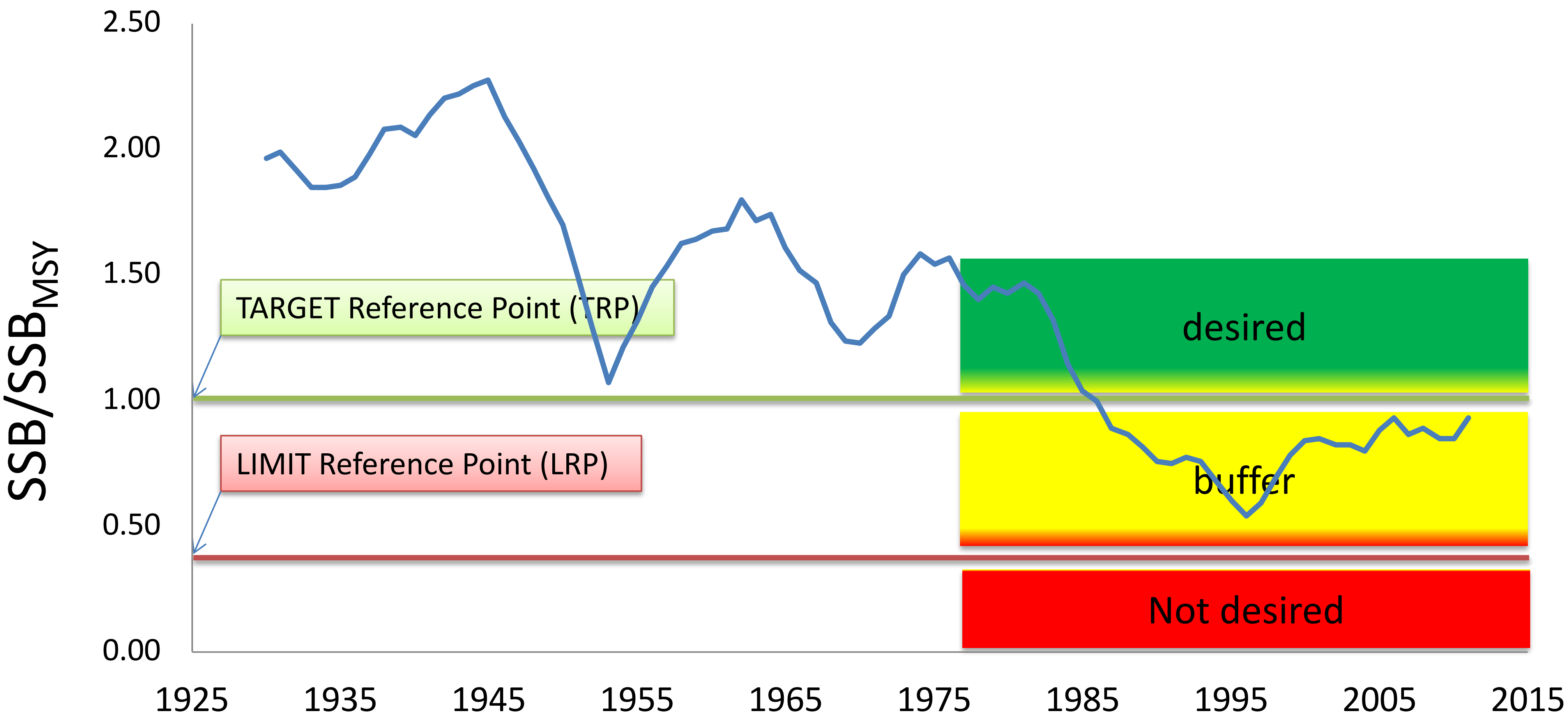
Provision of Management Advice



Resolution 15/10: Reference Points



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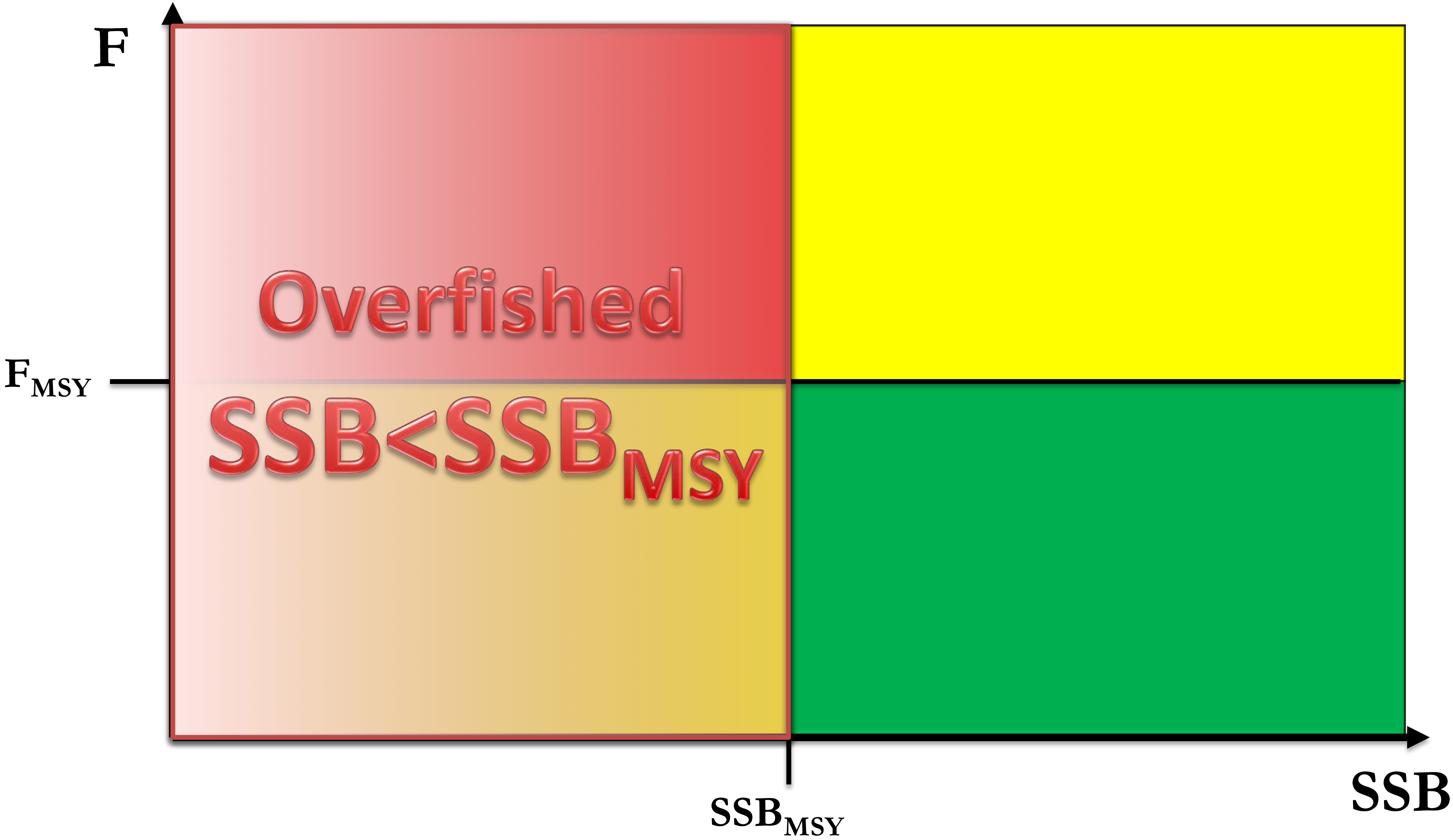
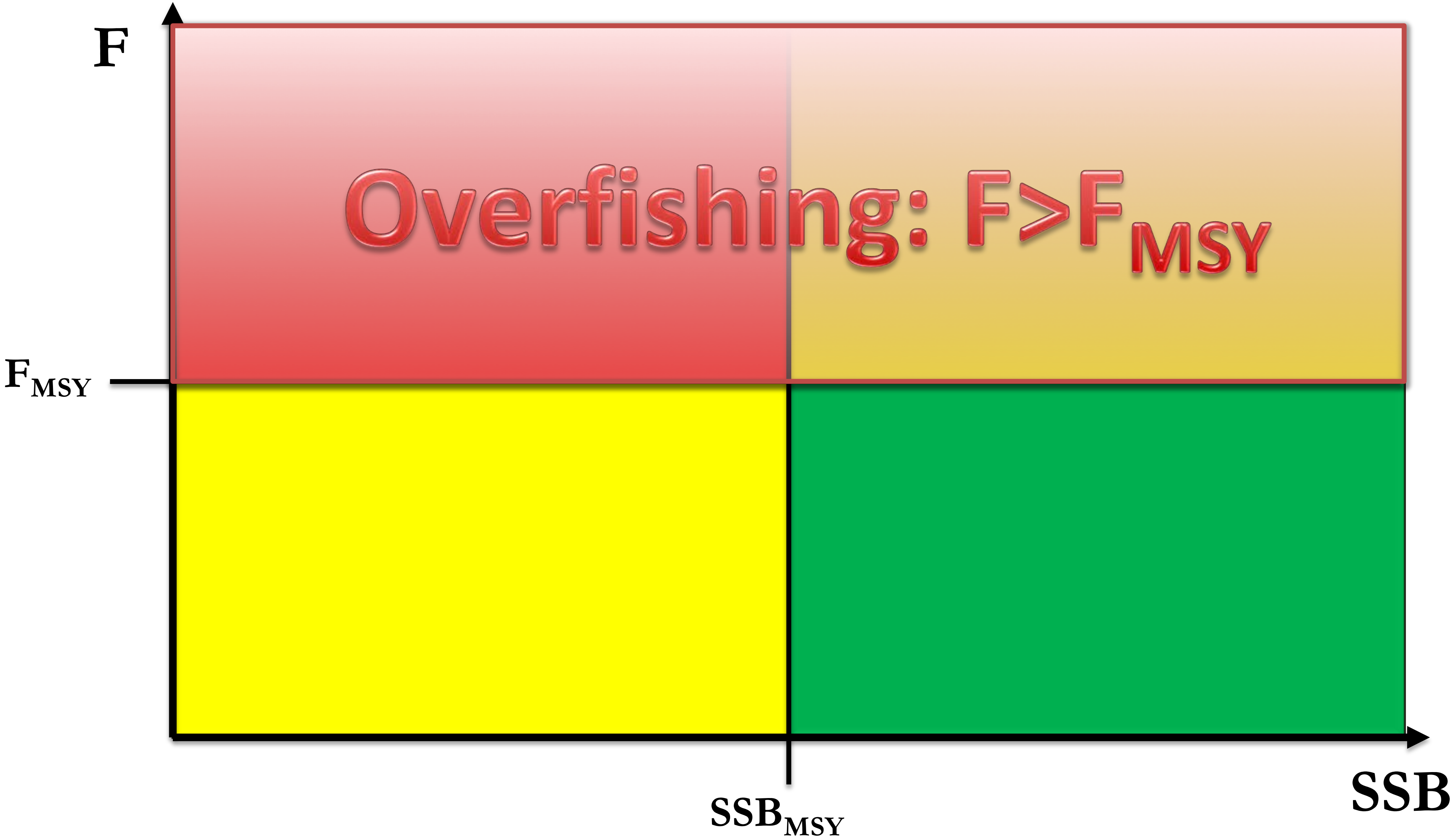
Providing scientific advice

"Kobe plot"

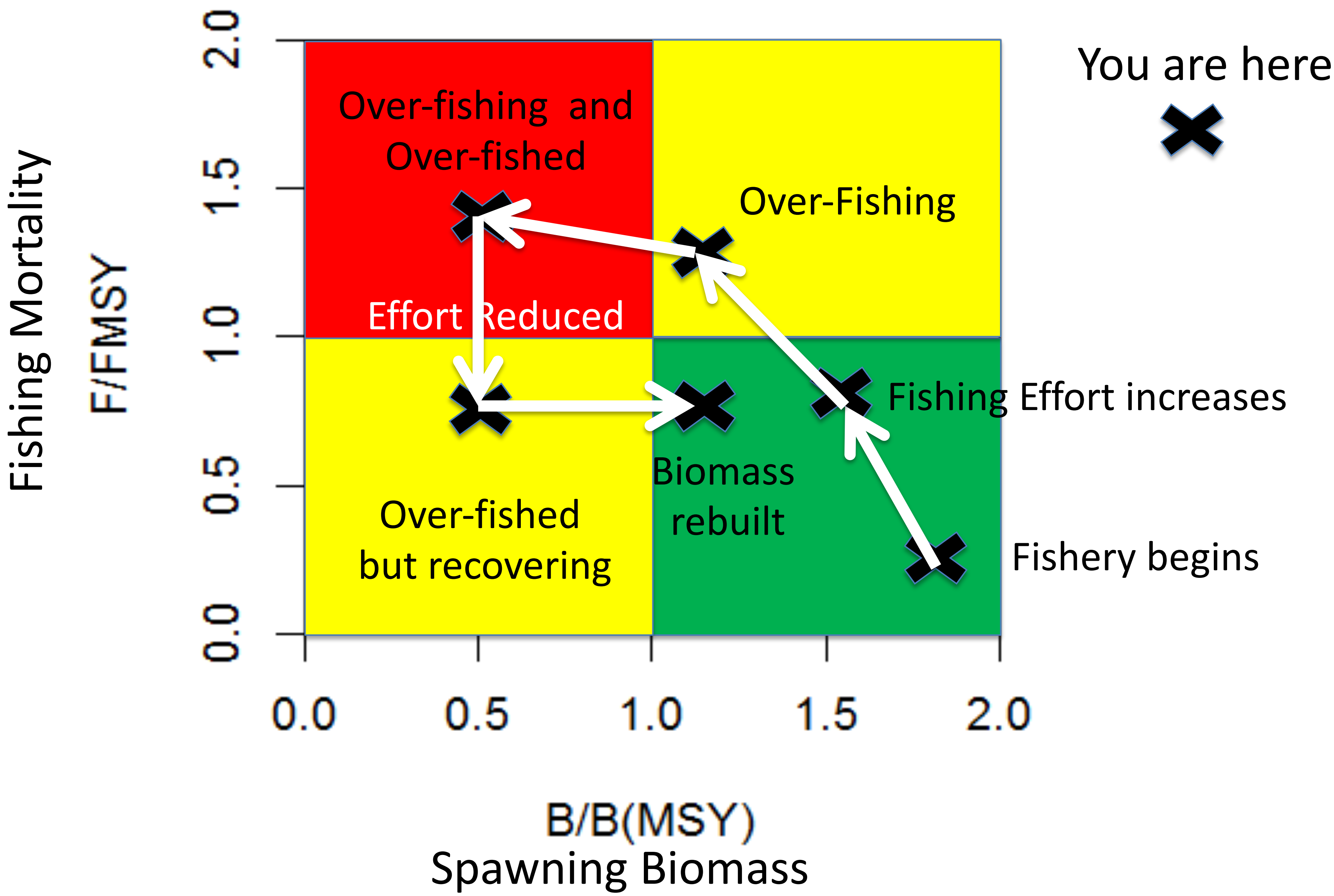


Providing scientific advice

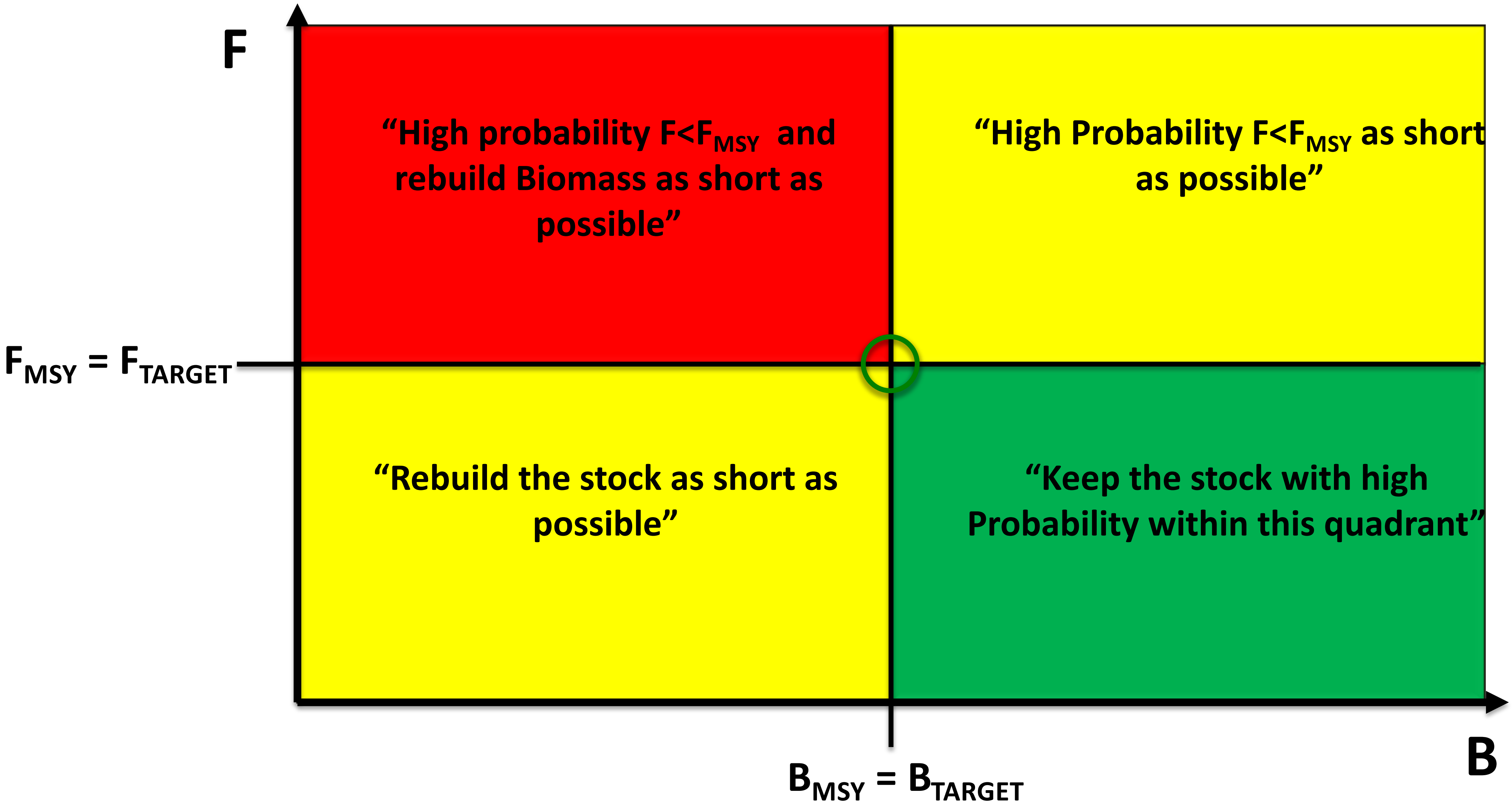
“Kobe plot”



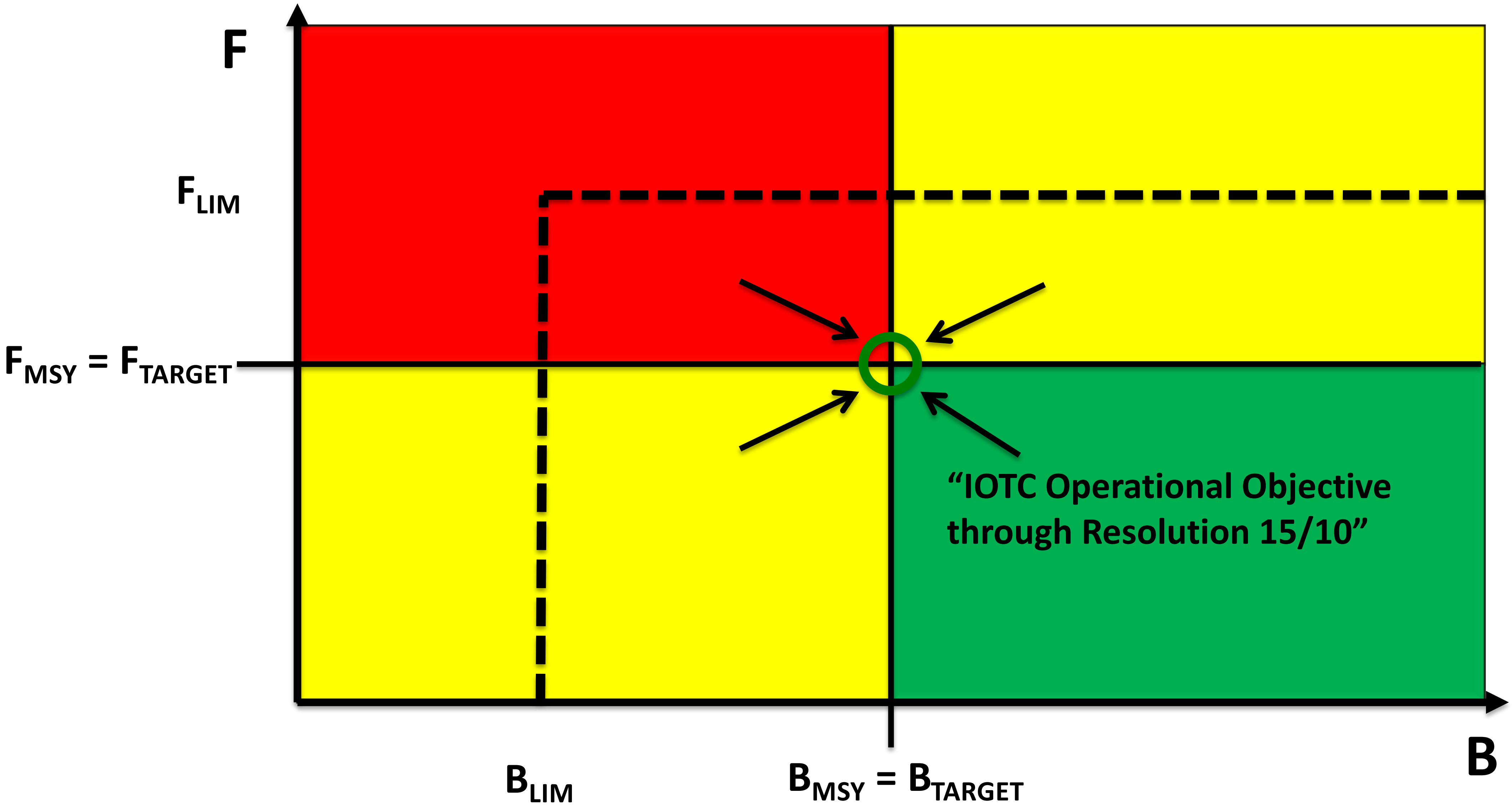
Providing scientific advice

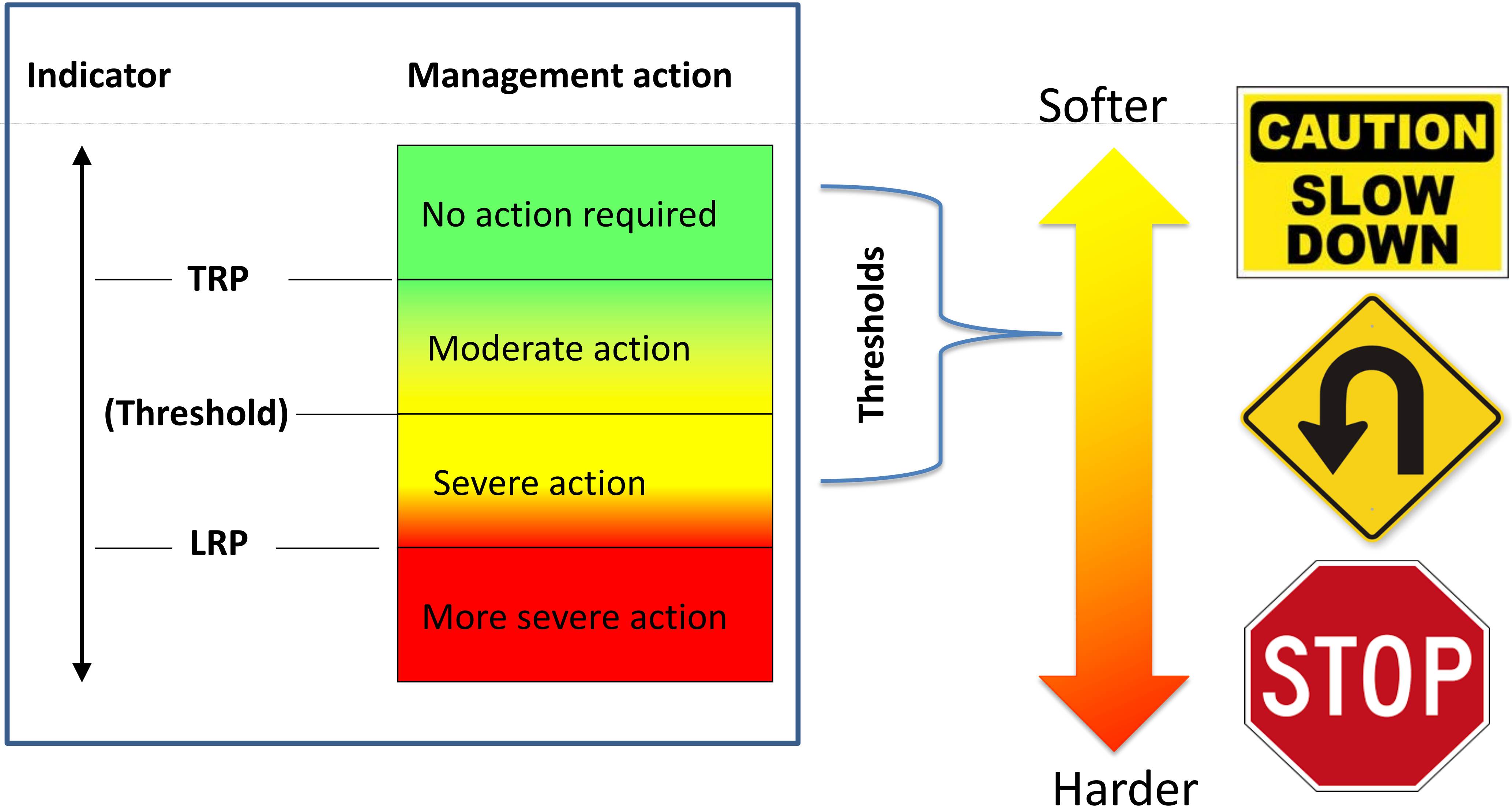


Resolution 15/10: Reference Points (Operational Objectives)



Provision of Management Advice

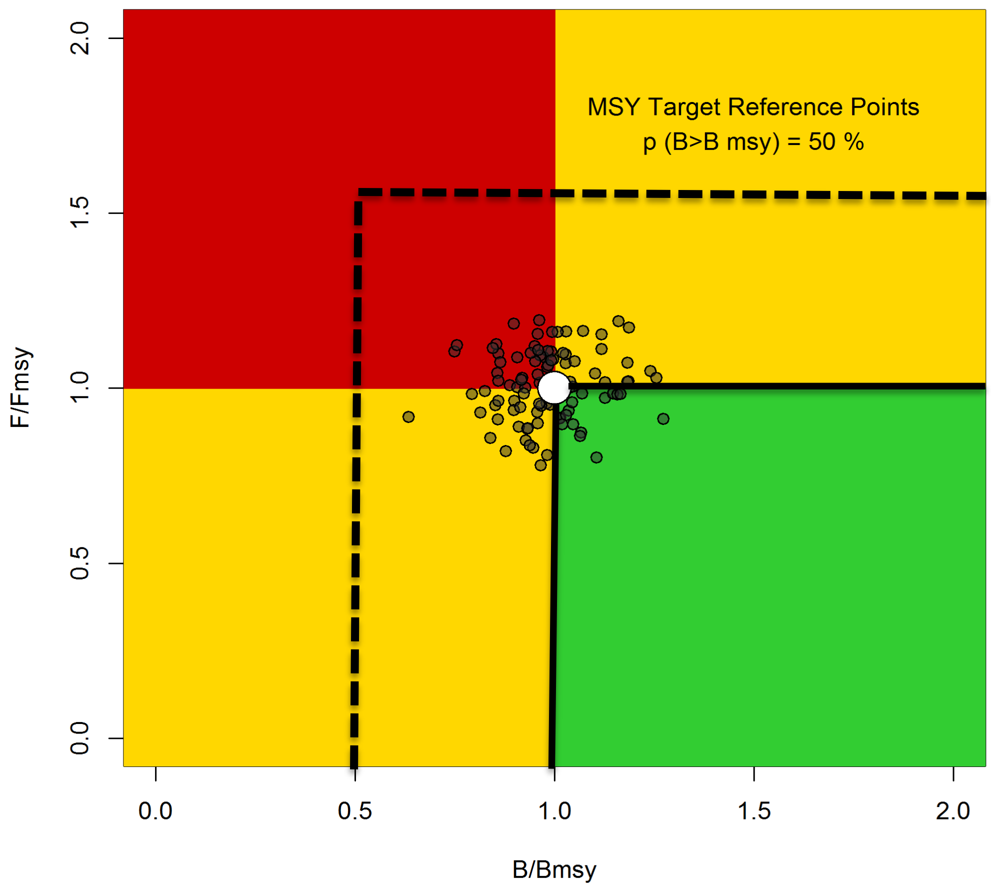




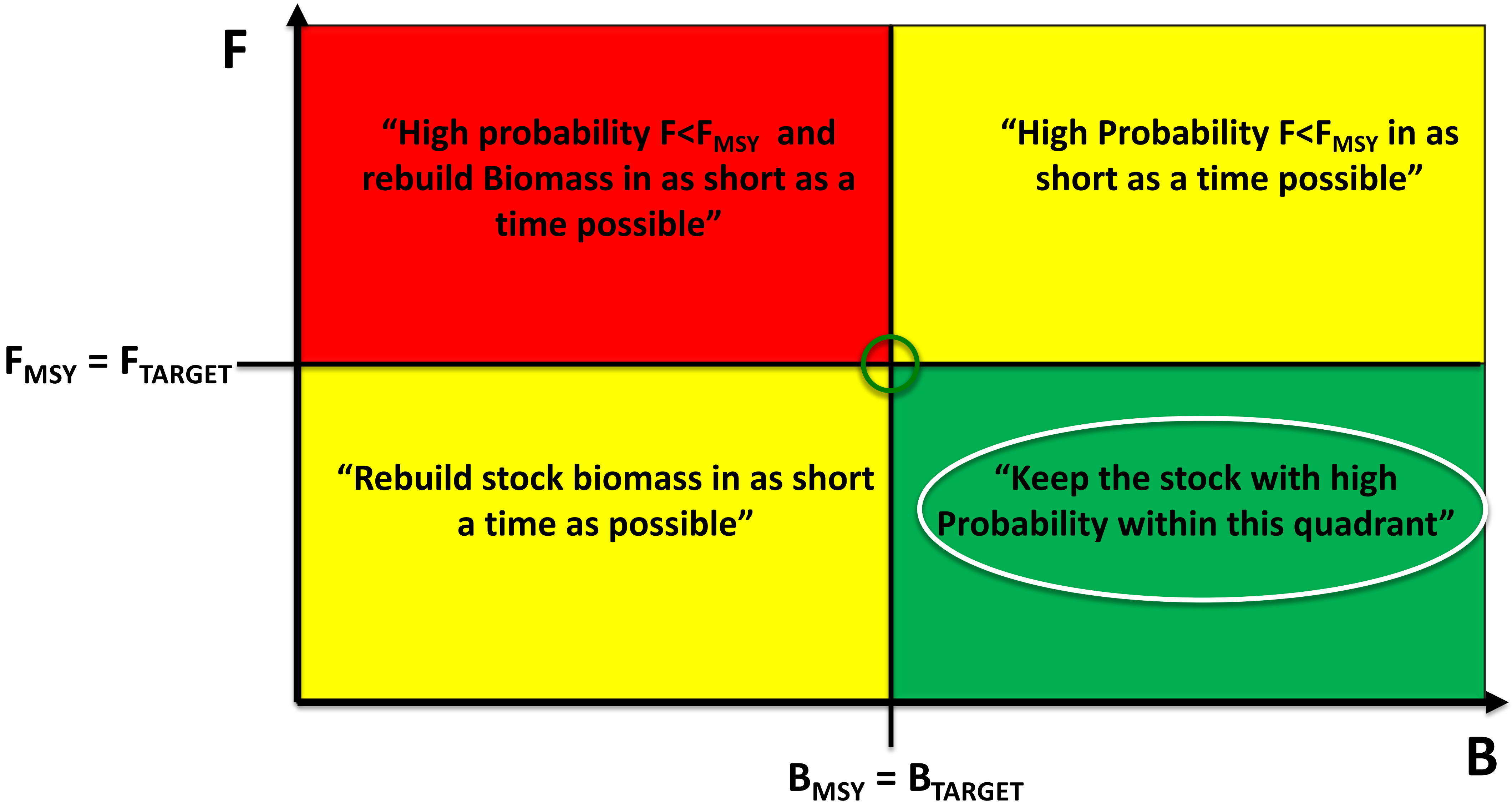
- **Target Reference Points** (TRPs): values for stock size and/or fishing mortality rate that a manager aims to **achieve and maintain**.
- **Limit Reference Points** (LRPs), which describe an undesirable state of the indicator that should be **avoided** with high probability.
- **Thresholds** defining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

Provision of Management Advice

Where does IOTC want the fishery to be? If the objective is to be at or above BMSY and fishing at FMSY, there can be a ≈50 % chance of being overfished in the Kobe classification due to natural fluctuations.



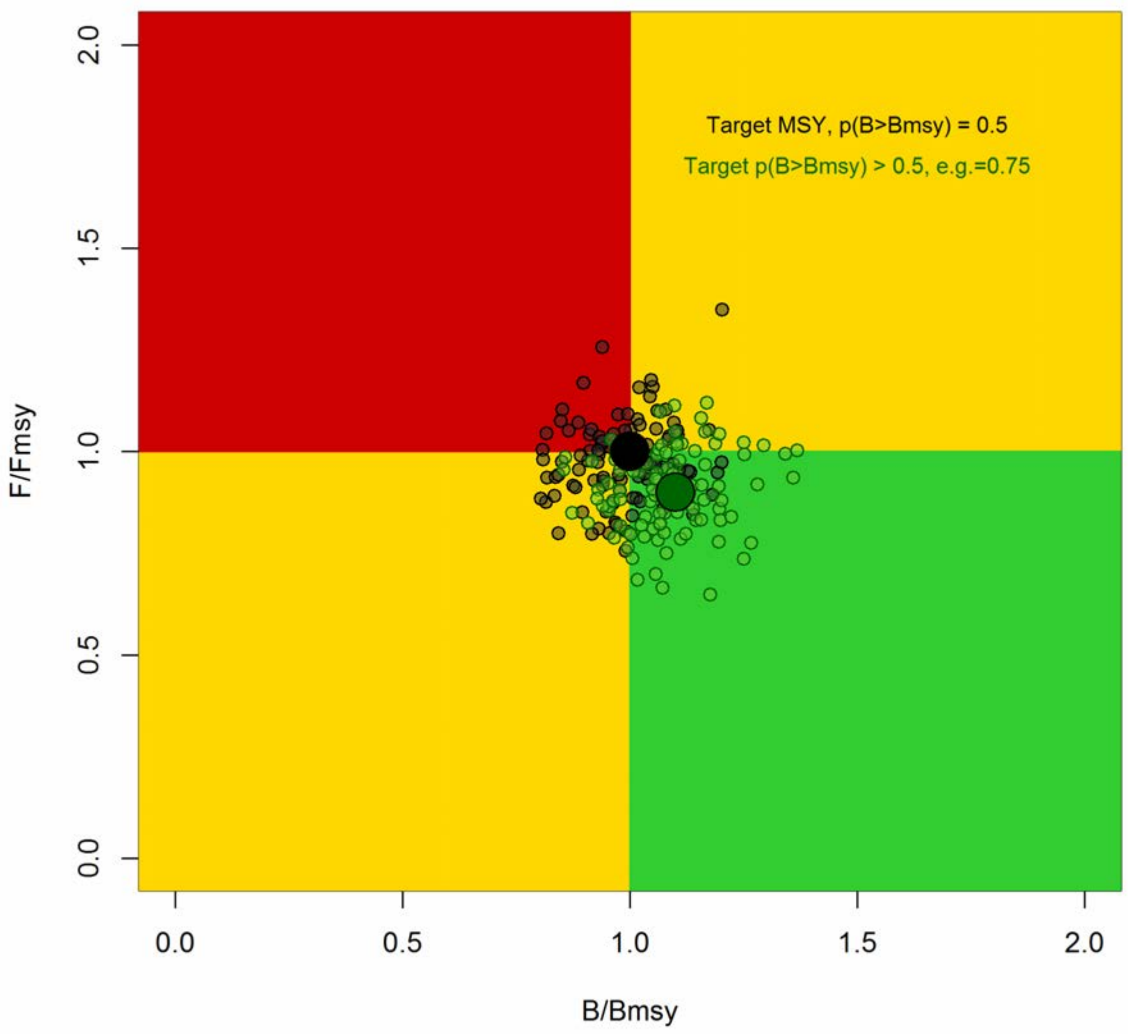
Resolution 15/10: Reference Points (Operational Objectives)



- … but what are the timeframes and probabilities?

Objectives

Where do we want the fishery to be, considering Decision Framework in Res 15/10?



OBJECTIVEs:

"Maintain the biomass at or above levels required to produce MSY or its proxy and maintain the fishing mortality rate at or below F_{MSY} or its proxy;" and

"Avoid the biomass being below B_{LIM} and the fishing mortality rate being above F_{LIM}"

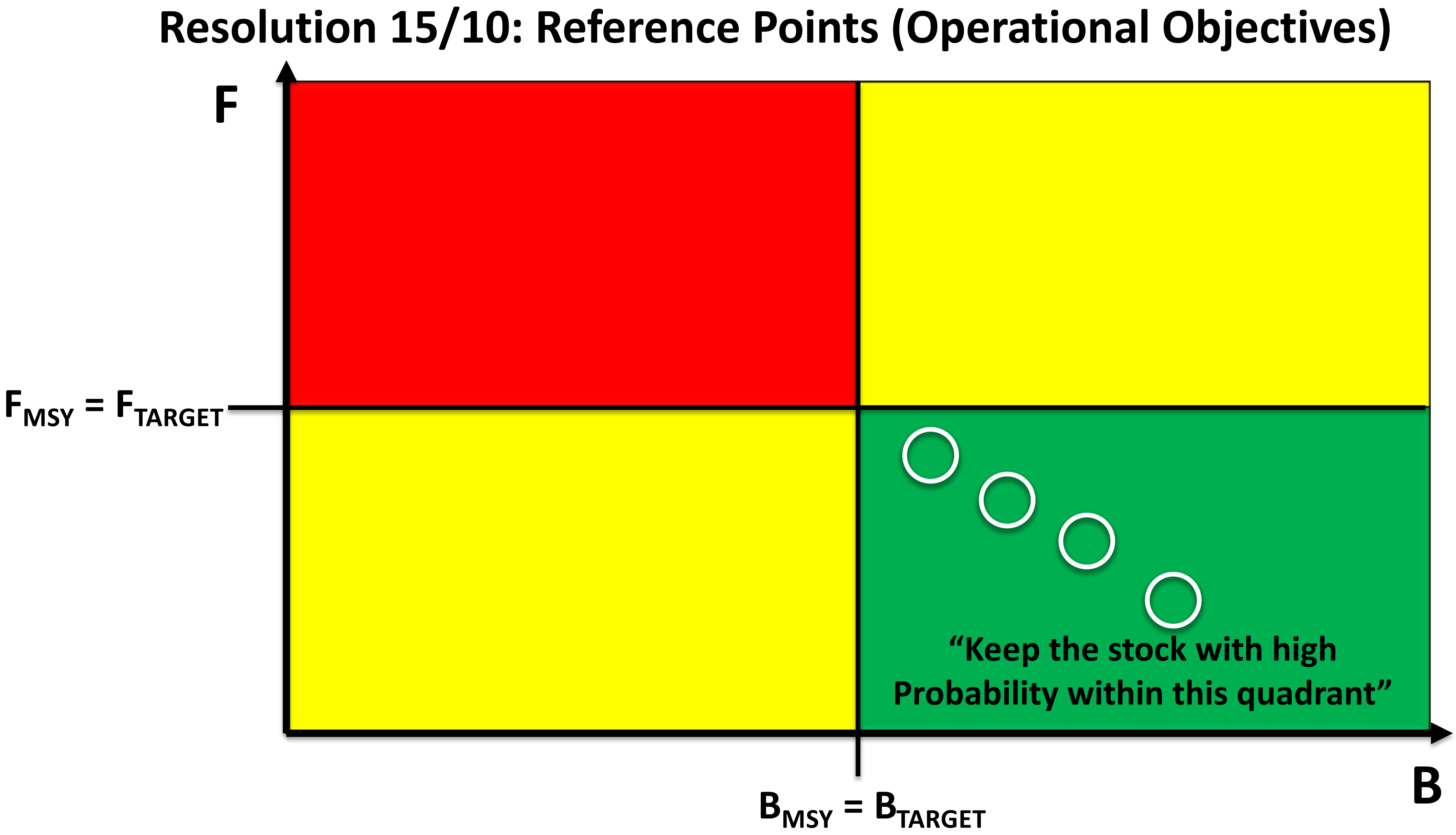
Management Procedures: Objectives

OBJECTIVE
TO MAINTAIN IN GREEN

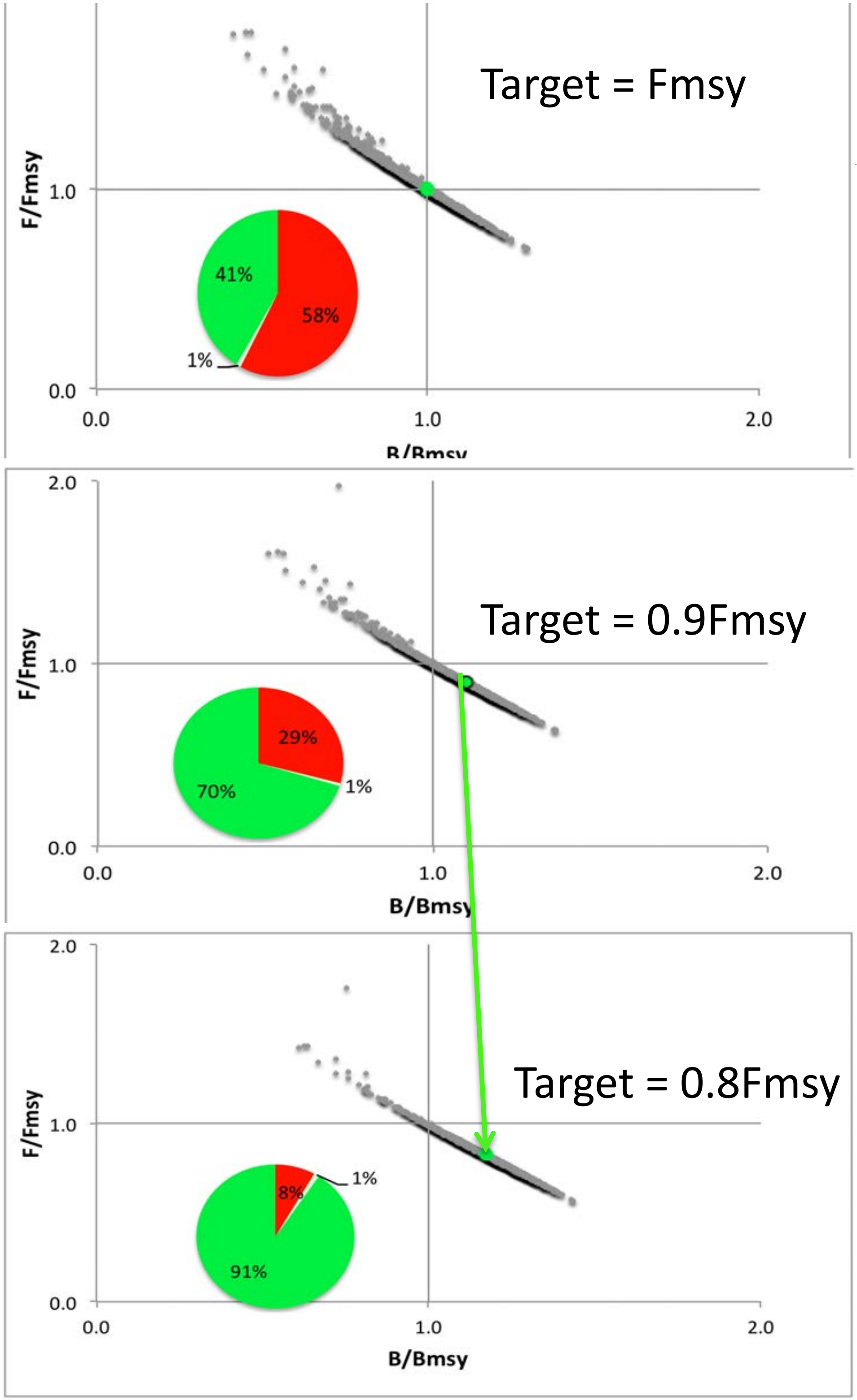
BUT, WHAT GREEN?

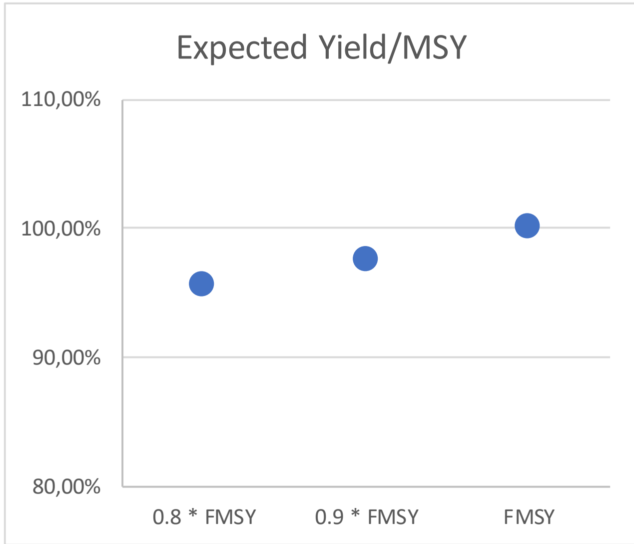
OR AT PROBABILITY?

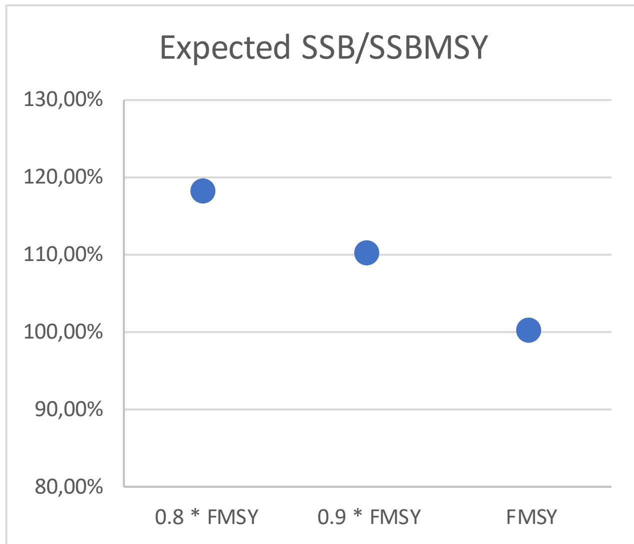
Management Procedures: Objectives



Uncertainty impacts on targeting





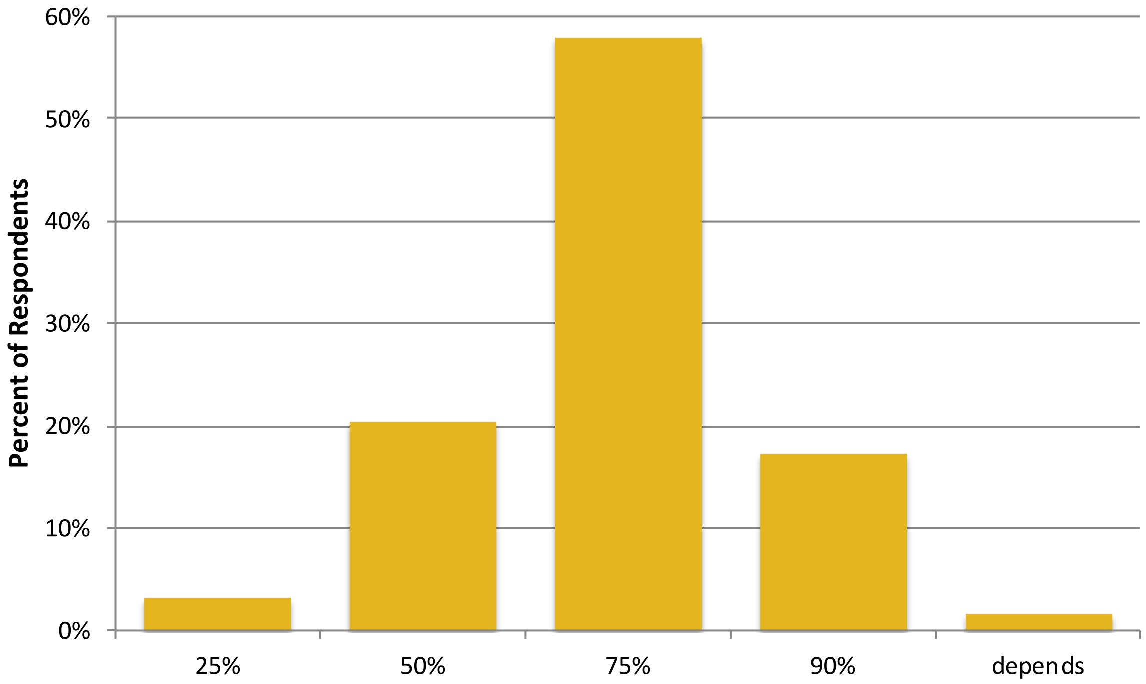


Relatively small, <5%, loss in Yield

Substantial gain in SSB with gain in P("Green")

What is High Probability of Achieving a Target?

Survey Says.....



From 2015 Surveys at IOTC's MPD02 and ICCAT's SWGSM (64 respondents). In keeping with other organizations, the majority view by participants was that ~75% (or 3 chances out of 4) is a high probability for achieving a target.

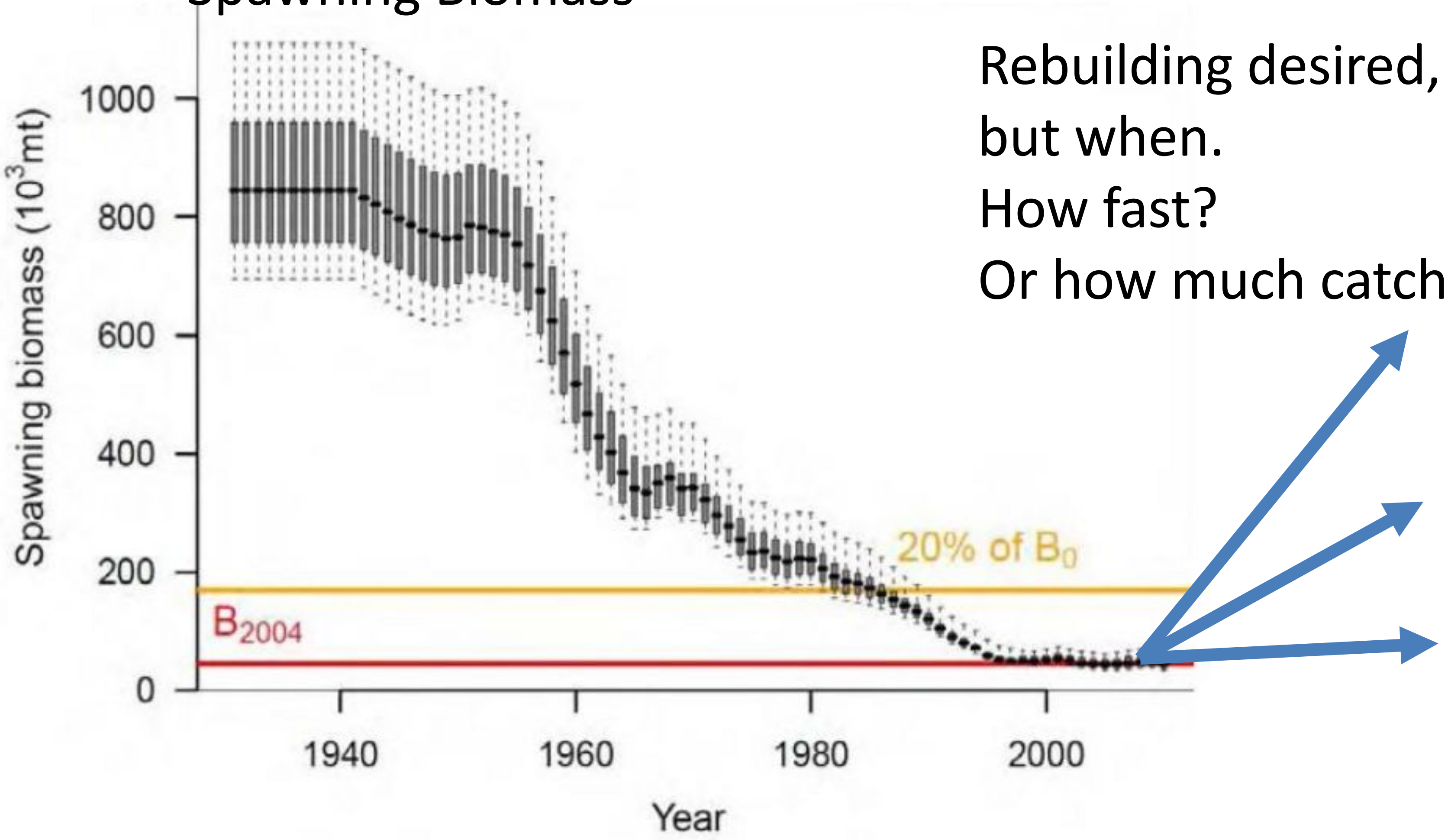
Harvest Control Rules: Timeline

Where and when do we want the fishery to be?

Harvest Control Rules (with Reference Points): Timelines

Where and when do we want the fishery to be?

Spawning Biomass



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

?

Objectives

- Green Zone with **high probability**
- In case of not green zone, come back as quick as possible with high probability.

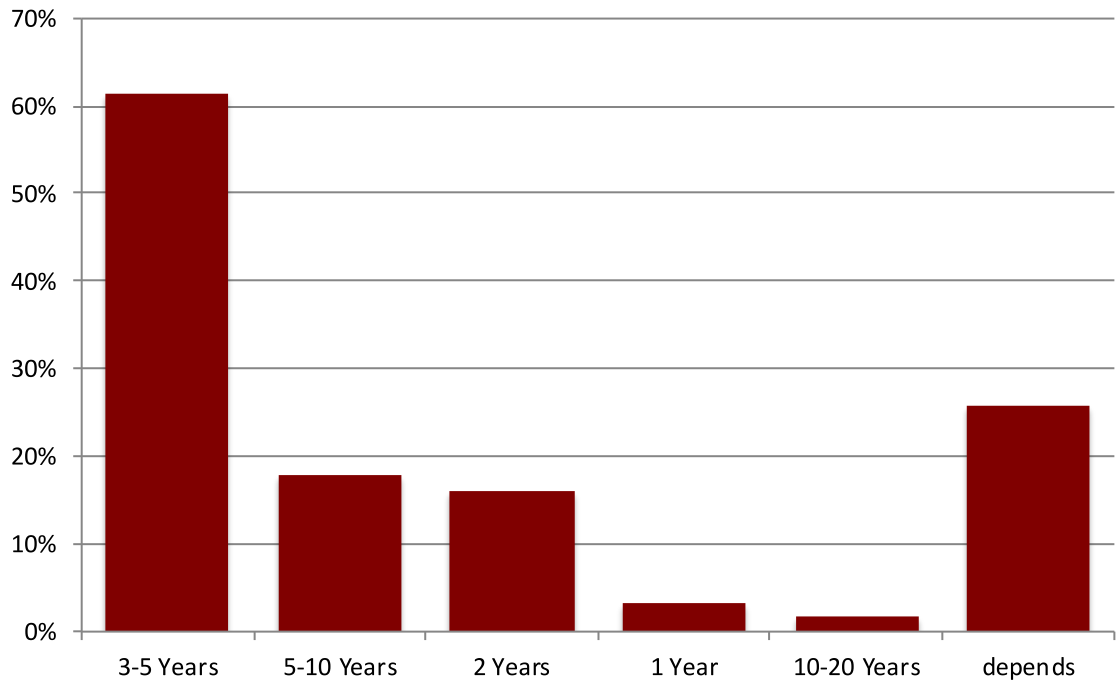
Other Priorities (Social)

- Employment/stability of catch
- Maximum Economic Yield Vs Maximum Sustainable Yield.
- Expanding Fleet Capacity/ Opportunity (Industry)
- Conserving stocks for Intrinsic Benefits (Enviros)

Inherently what you need to decide

- Balance long-term yield to long-term stock biomass.
- In case of adverse conditions, evaluate how long it may take to recover.
- Take a lot of pain now for benefits later or less now for longer rebuilding time

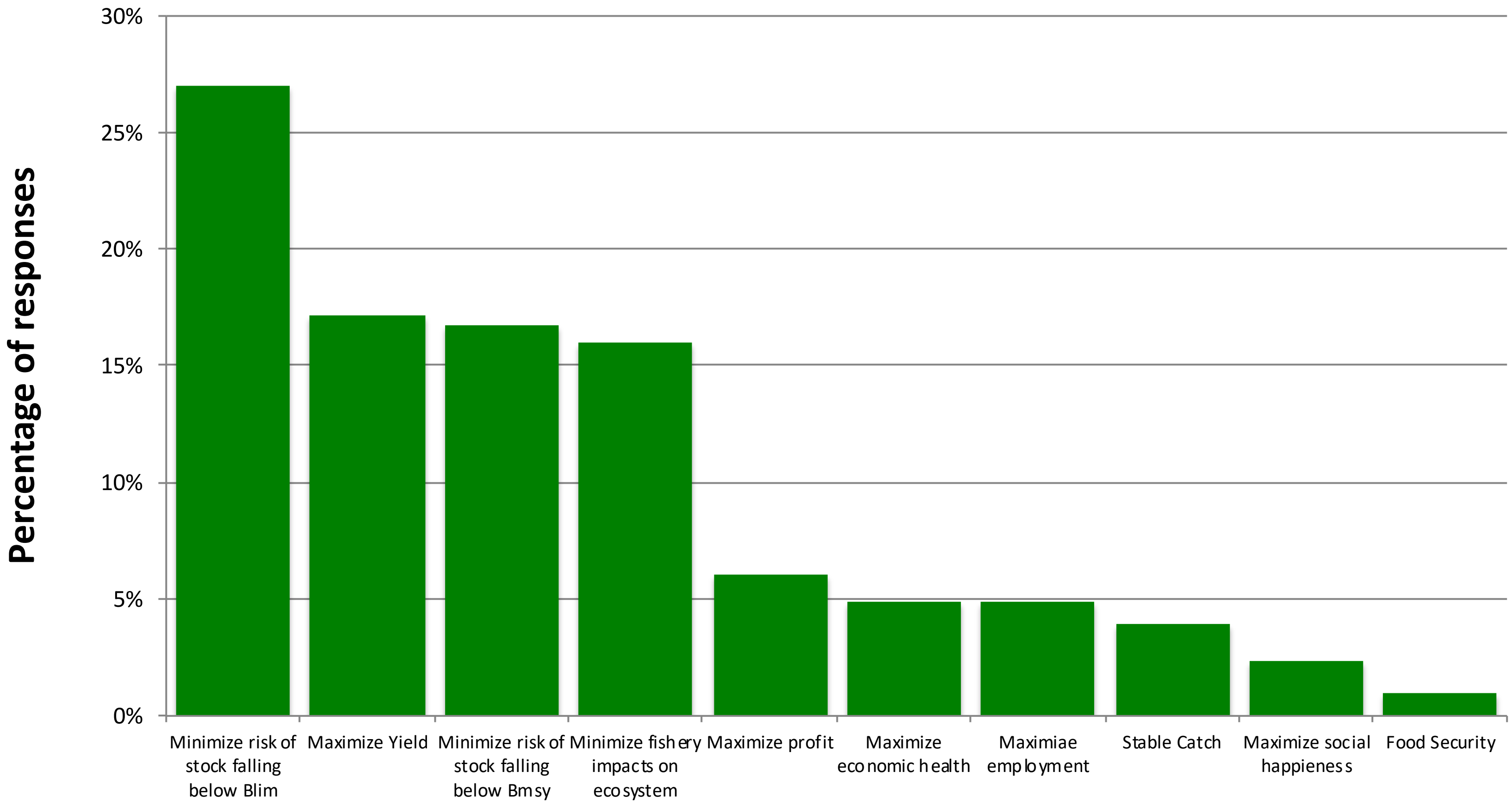
What should be `as short a time as possible' for recovery? Survey says …



- From 2015 Surveys at IOTC's MPD02 & ICCAT's SWGSM (76 respondents). Most participants viewed a time frame of 3-5 years in this context, although a high proportion of respondents indicated it depends on the stock of concern. Others indicated that time frames for managing fishing intensity (F) should be more immediate than for rebuilding biomass to desired levels.

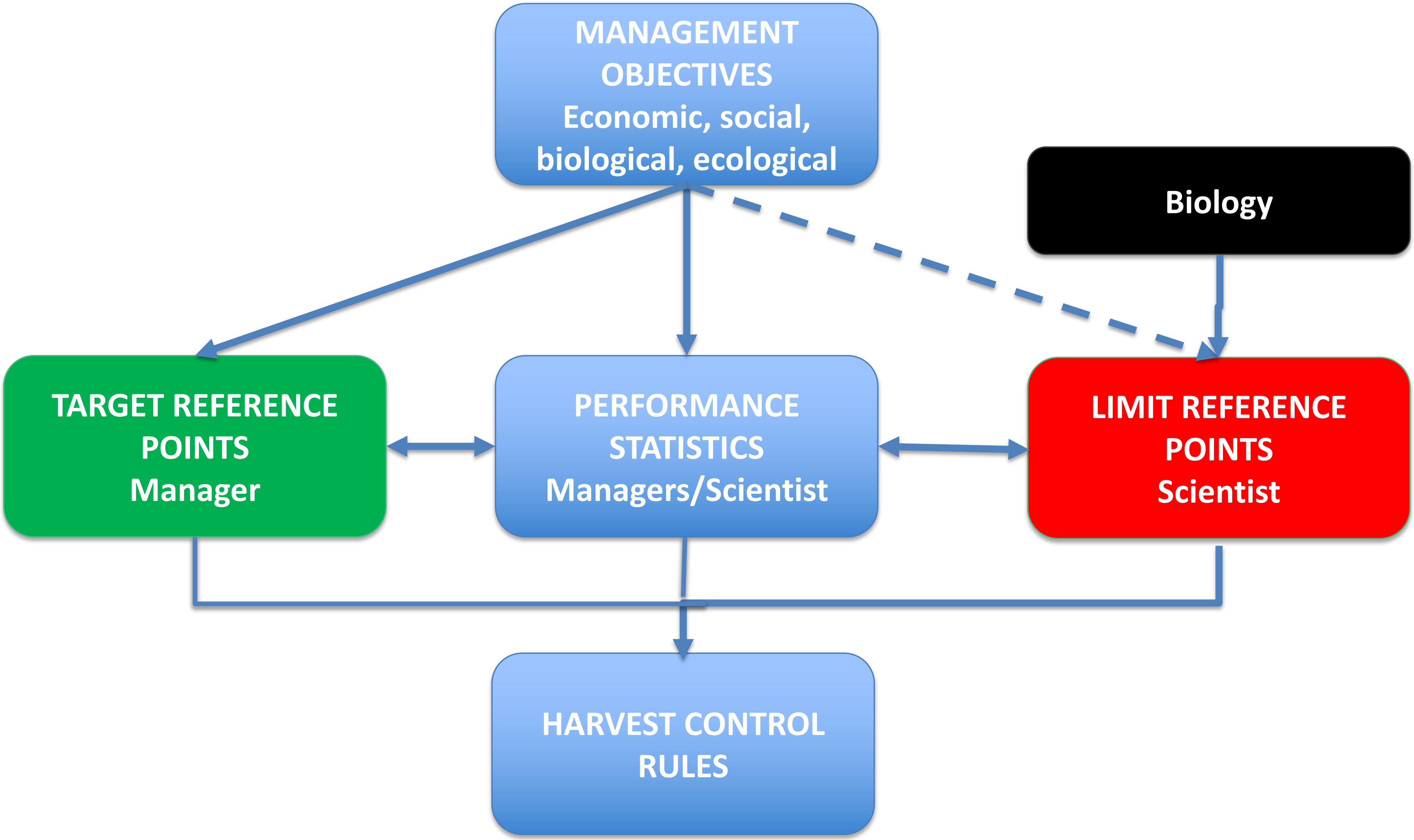
Harvest Control Rules: Trade-offs

Different Management Objectives ➔Trade offs

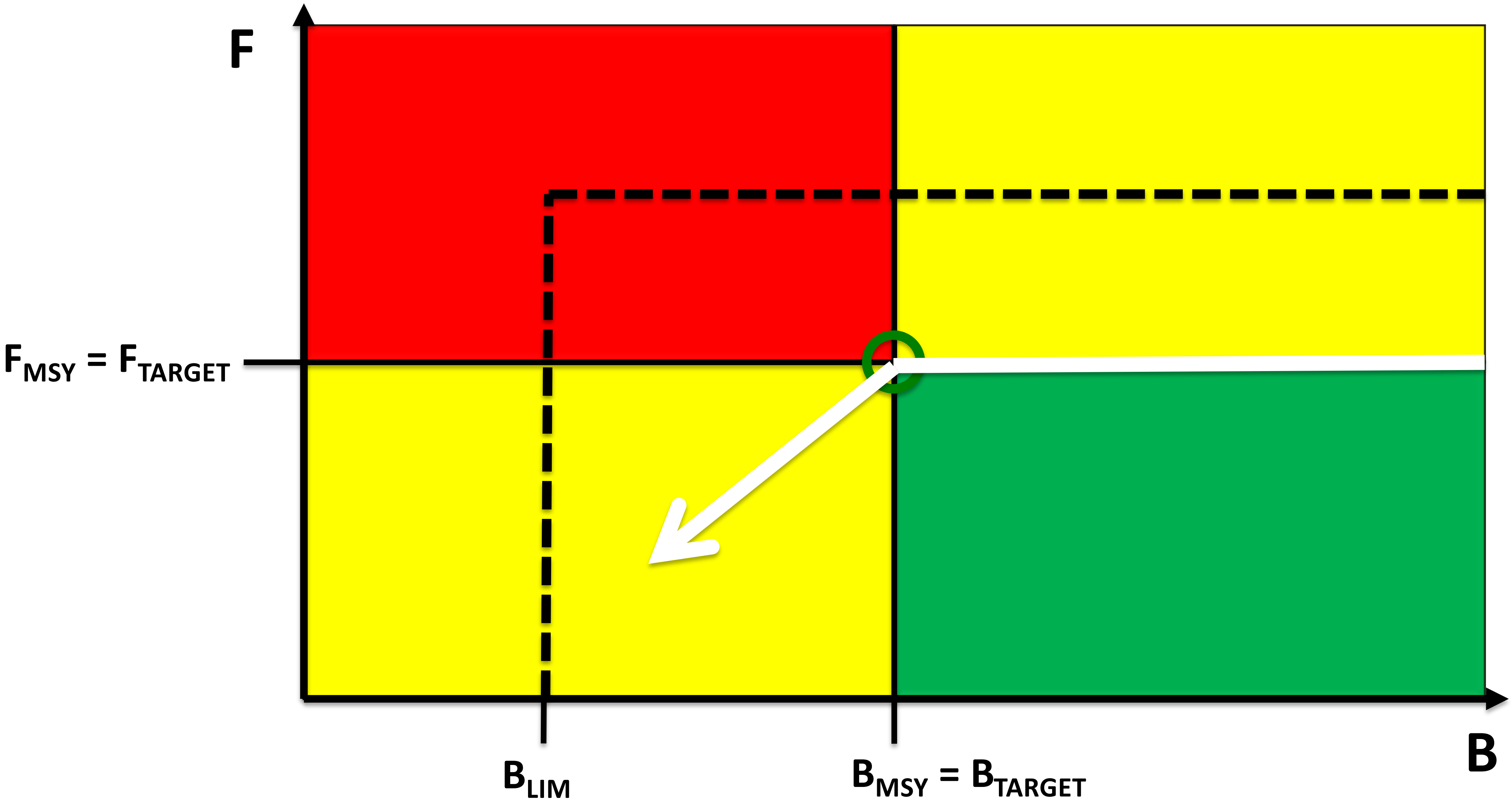


- From 2015 Survey at ICCAT's SWGSM. Considering priority given to the management objectives noted by Particiants, those related to 'Safety', 'Yield', and P(green) aka 'Sustainability' ranked highest followed by minimizing ecosystem impacts.

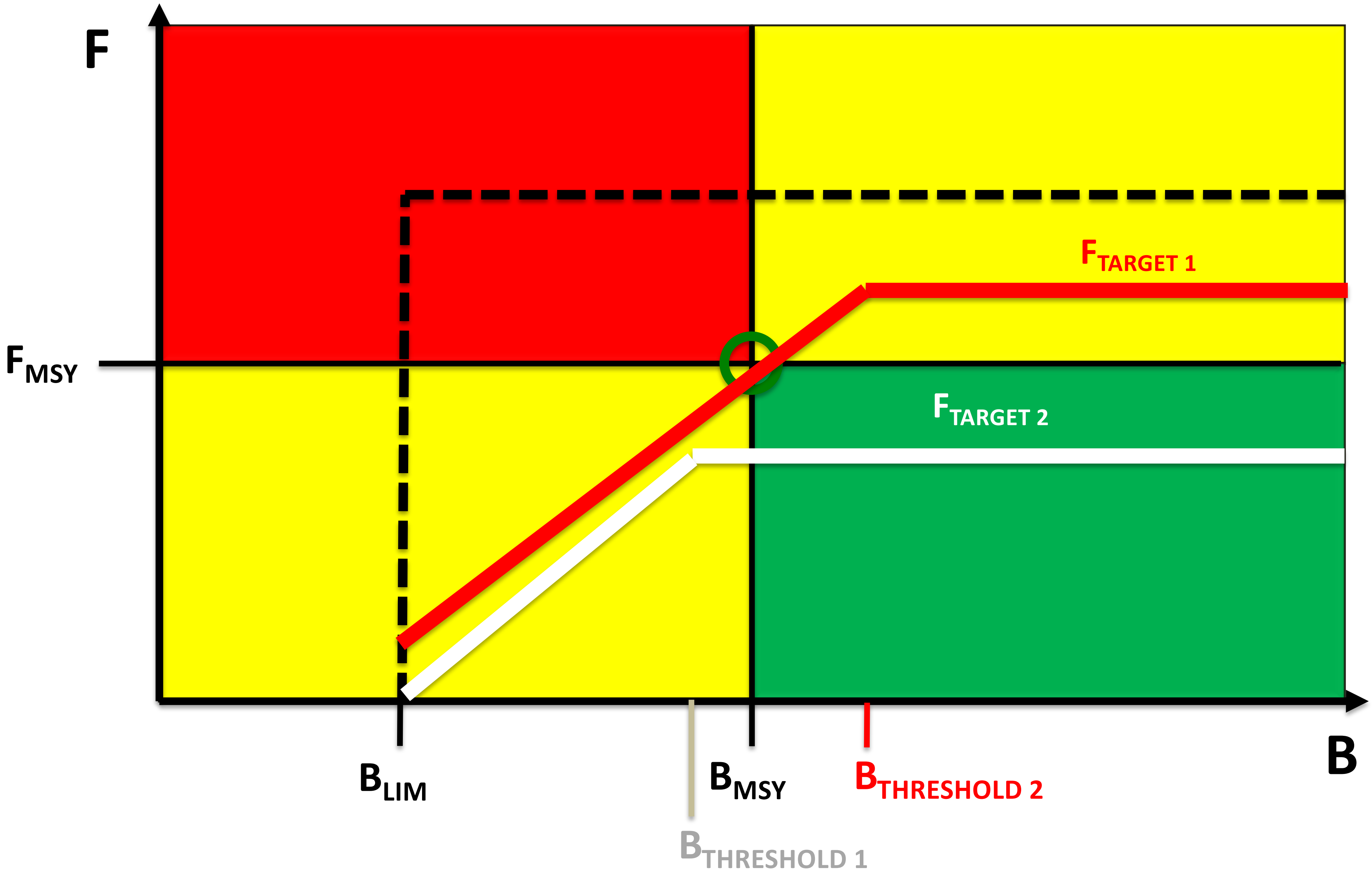
Harvest Control Rules



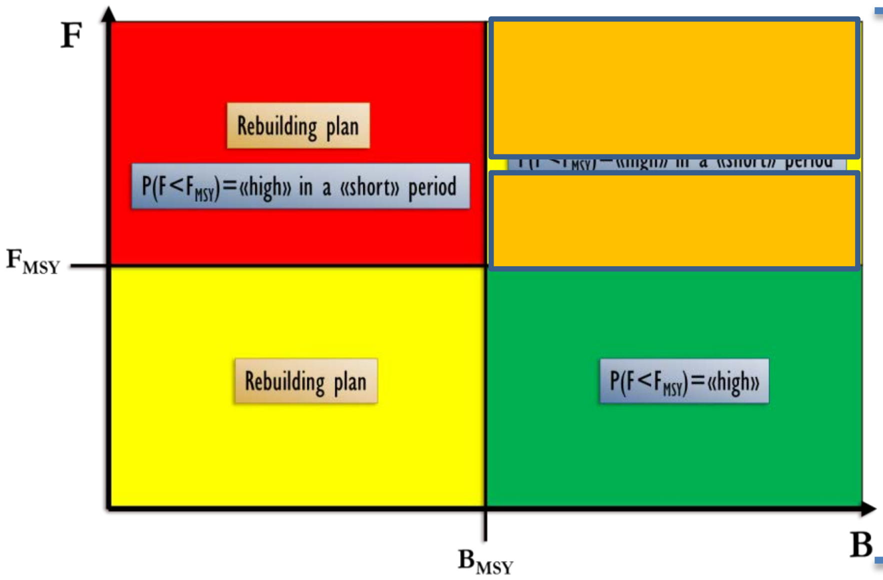
Harvest Control Rules



Harvest Control Rules



Harvest Control Rules (HCR)

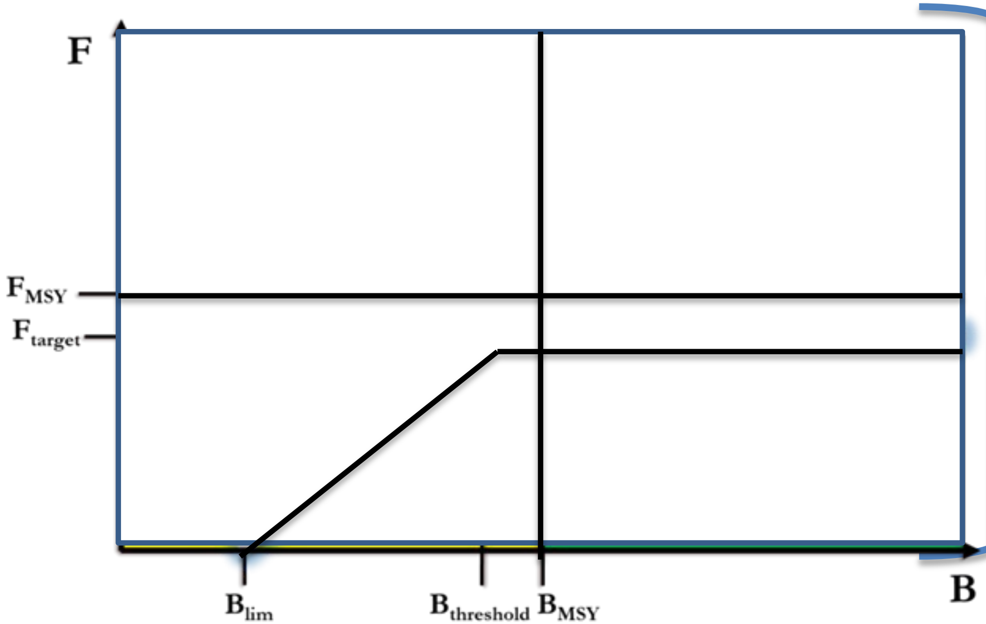


HIGH probability

IPCC: 80%
Canada: 75%
MSC: 70%-80%

SHORT period

USA: 10 years or 1.5 generations
Australia: 10 years + 1 generation
MSC: 2 generations



F target

[0.7, 0.75, 0.8, 0.85, 0.9 and 1] x F_{MSY}

B threshold

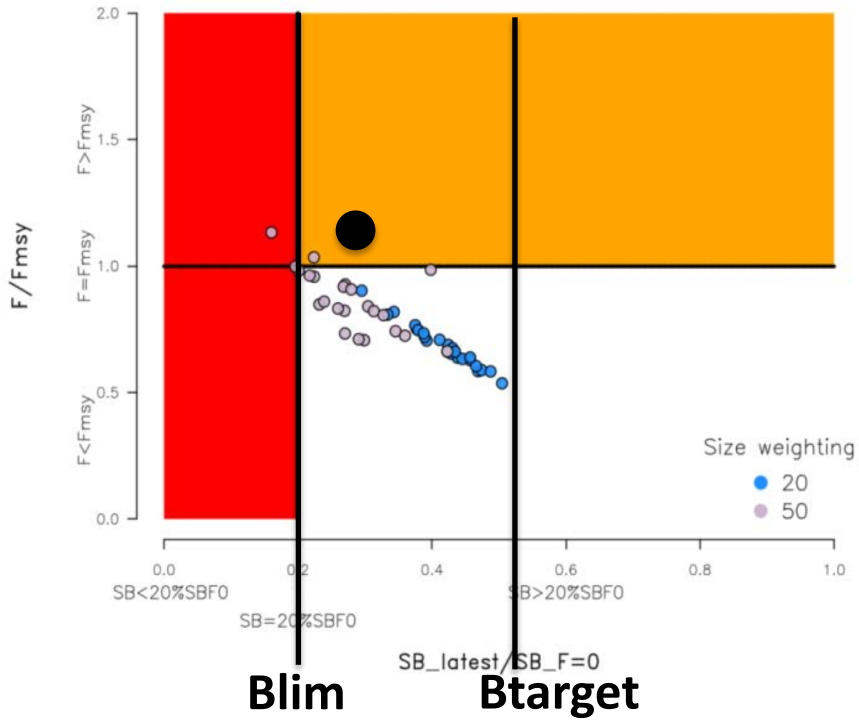
[0.6, 0.8 and 1] x B_{MSY}

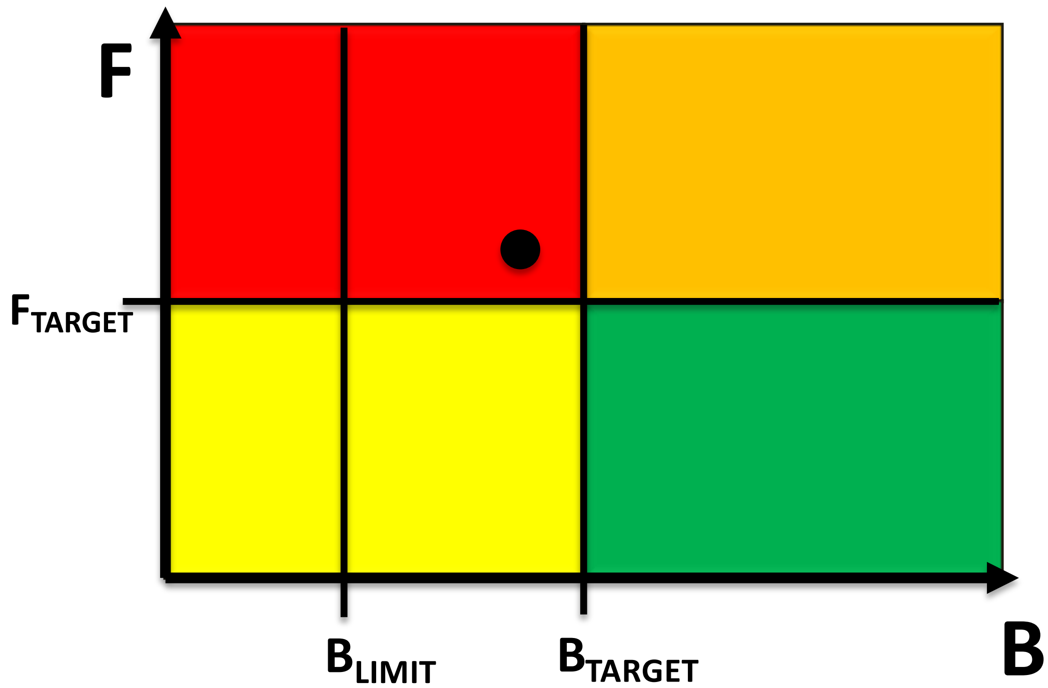
B lim

$0.4B_{MSY}$

Courtesy: ICCAT

Provision of Management Advice





MSE BASIC PRINCIPLES

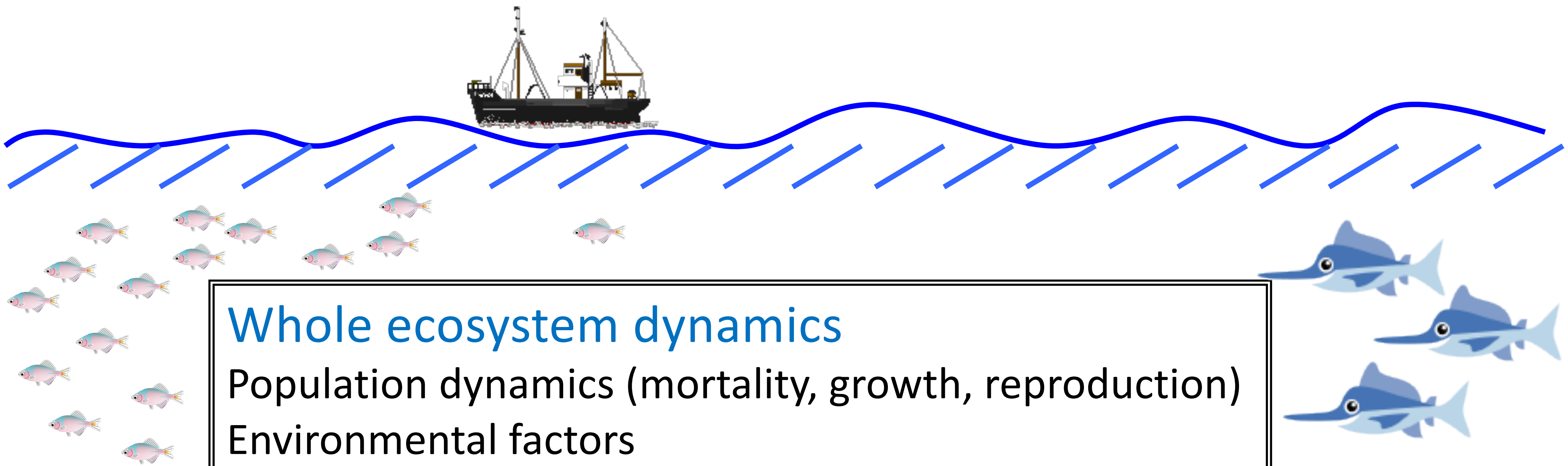
Food and Agriculture Organization of the United Nations

COMMON OCEANS

iotc ctoi

ISSF INTERNATIONAL SEAFOOD SUSTAINABILITY FOUNDATION

Fishery management



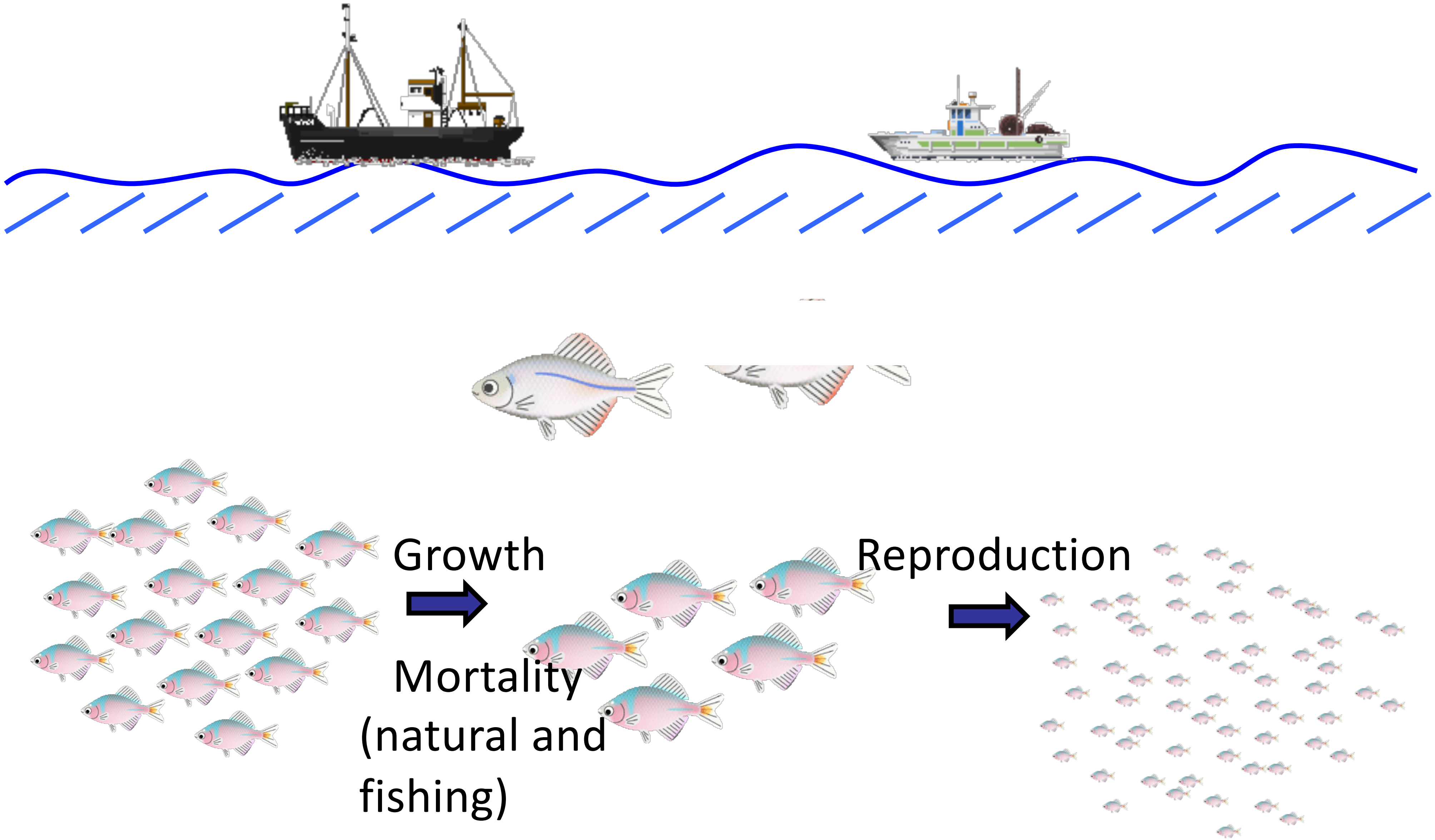
Whole ecosystem dynamics

Population dynamics (mortality, growth, reproduction)

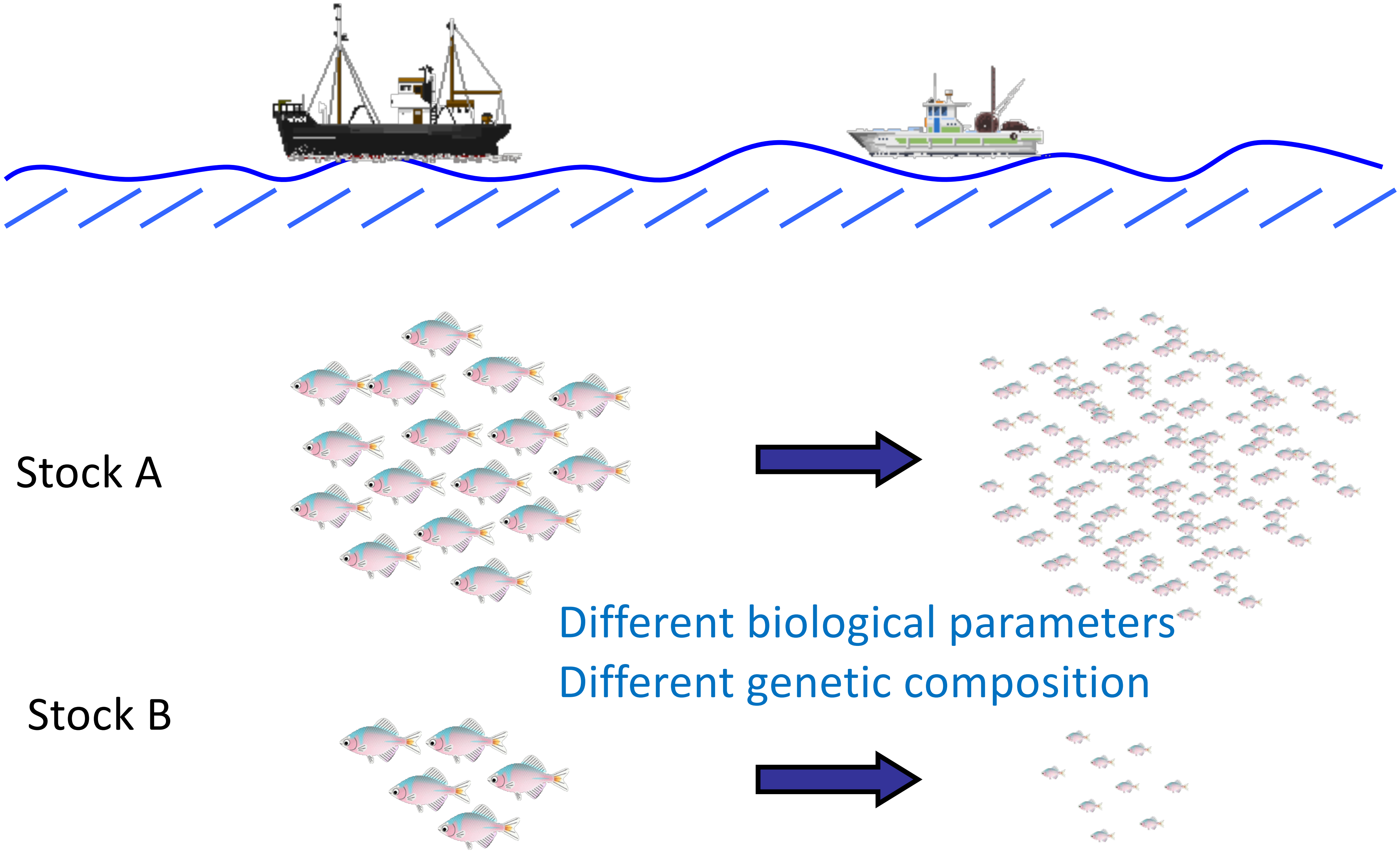
Environmental factors

Food web, genetic stock structure

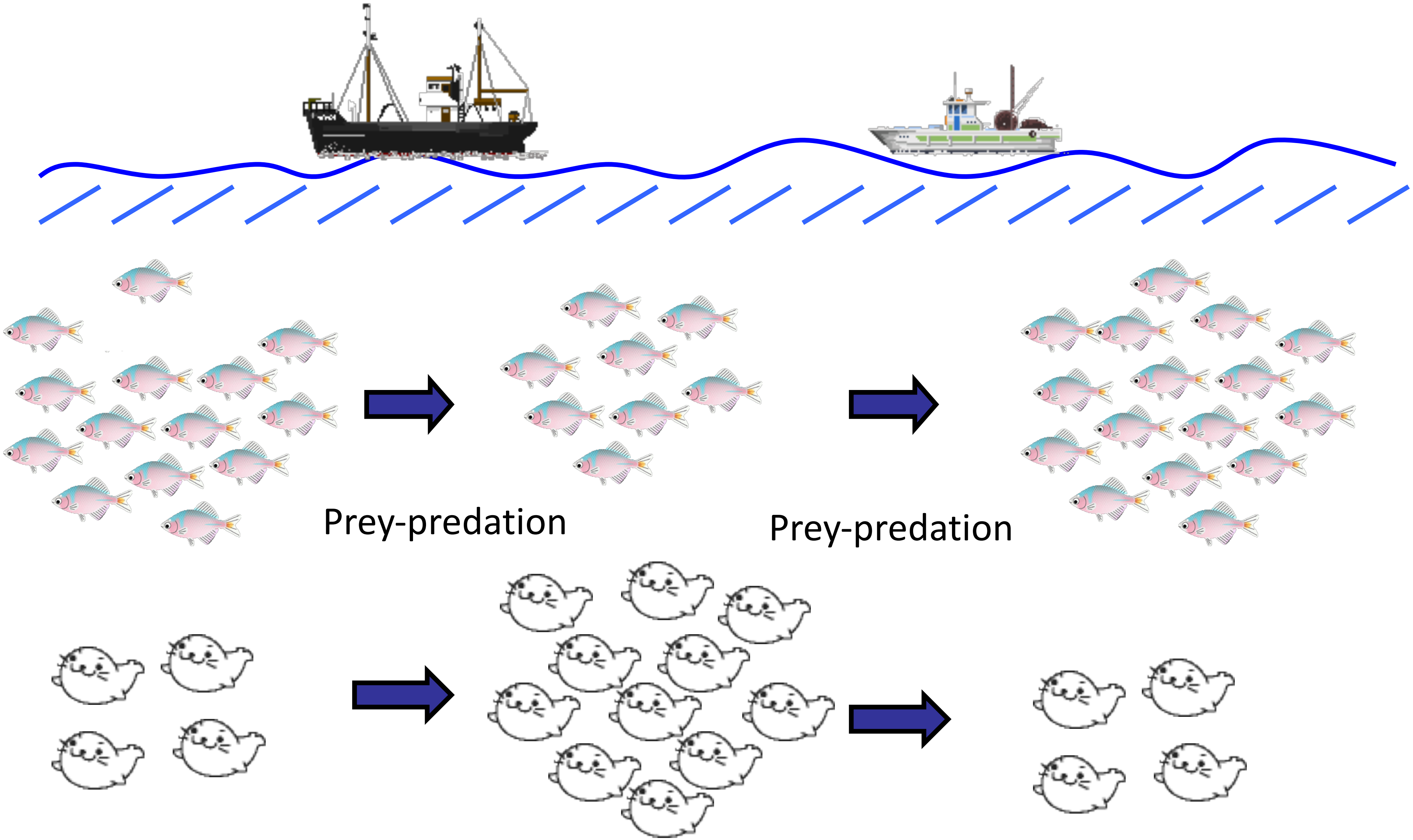
Fishery management



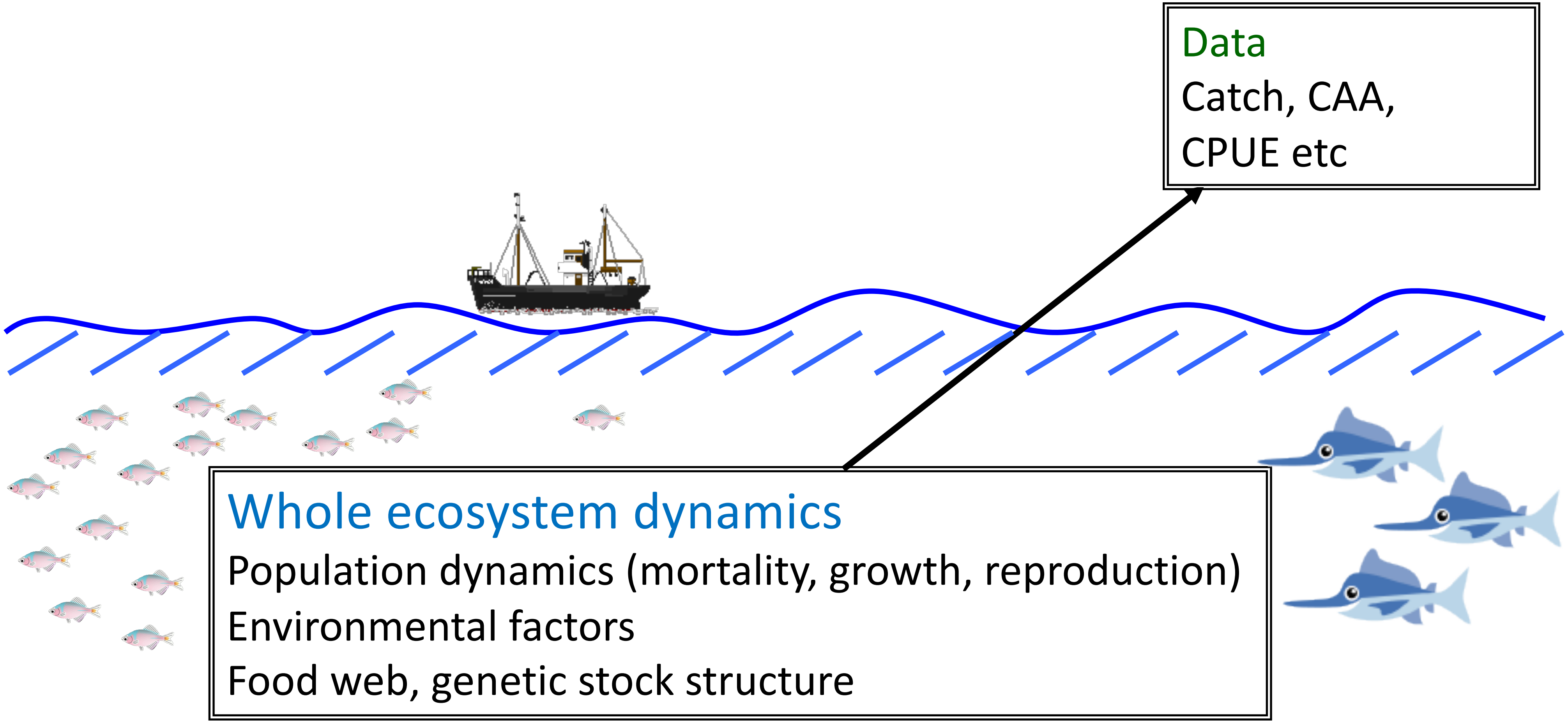
Fishery management



Fishery management



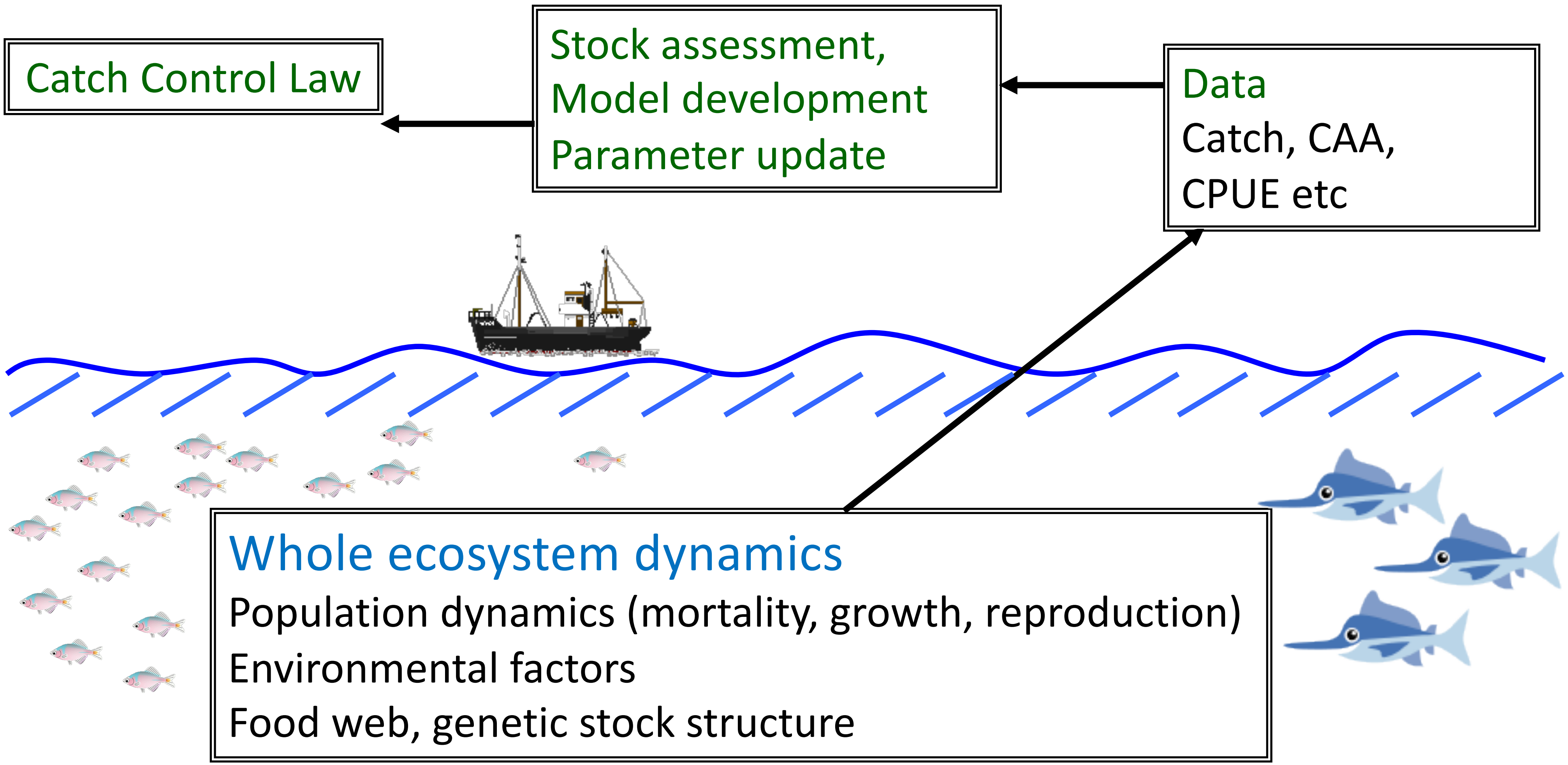
Fishery management



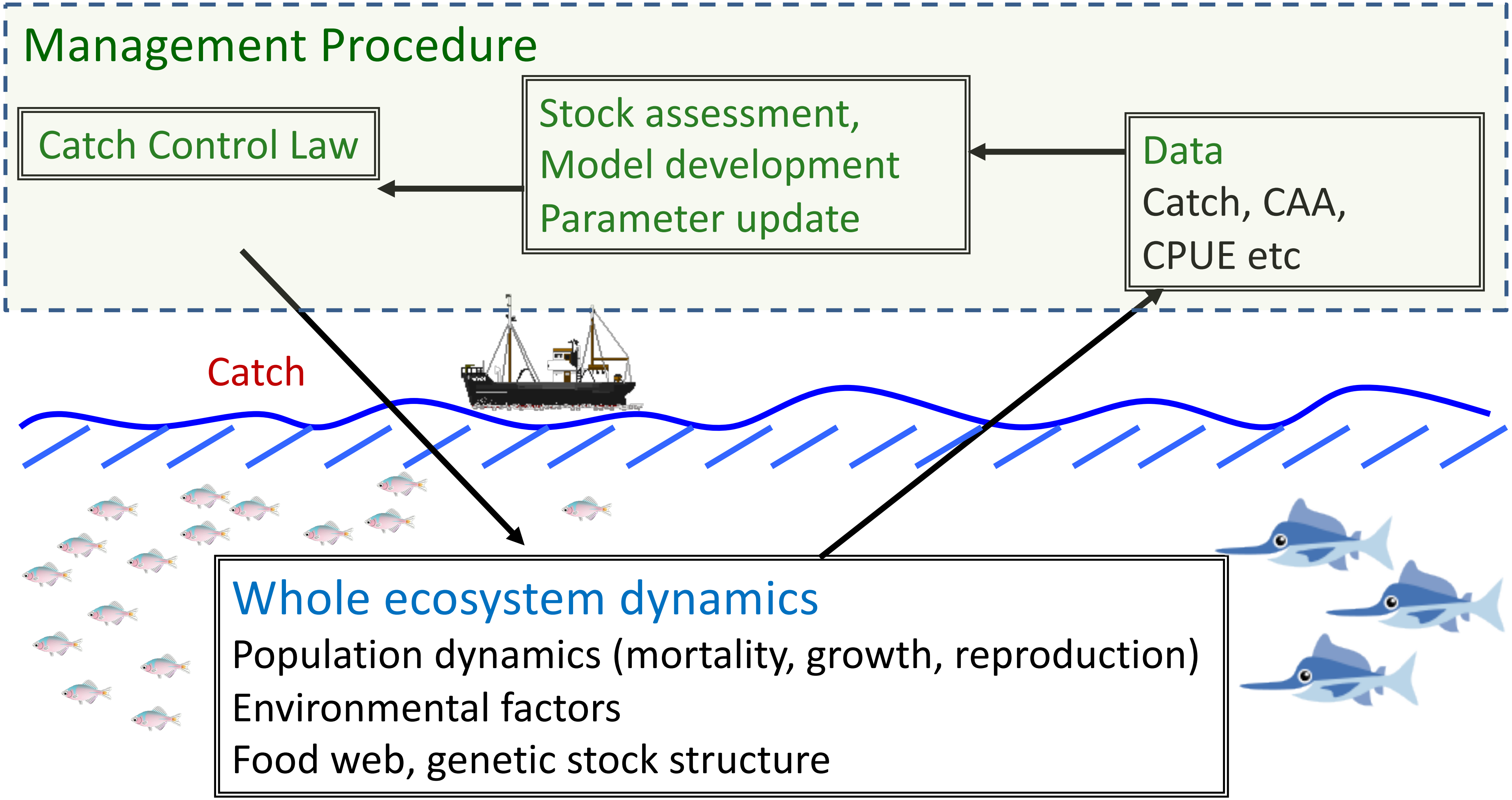
Fishery management

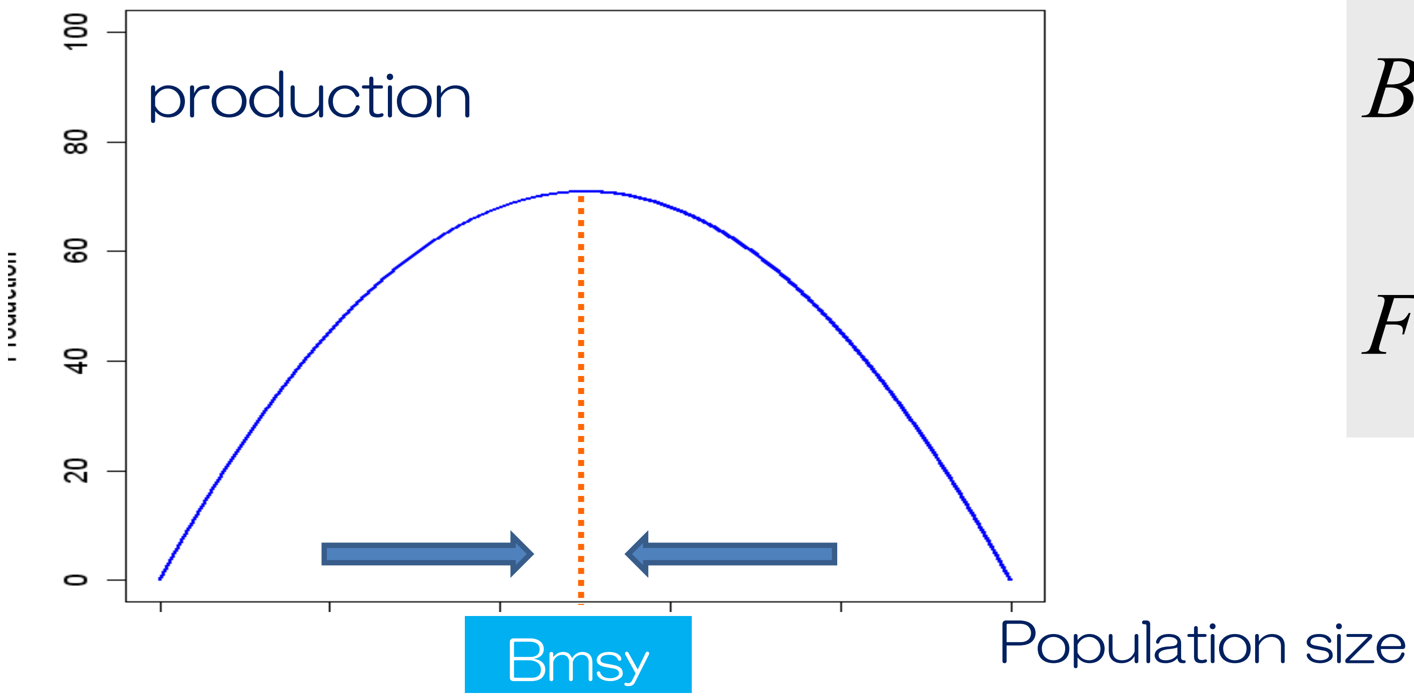
Total Allowable Catch (TAC)

Allowable Biological Catch (ABC)



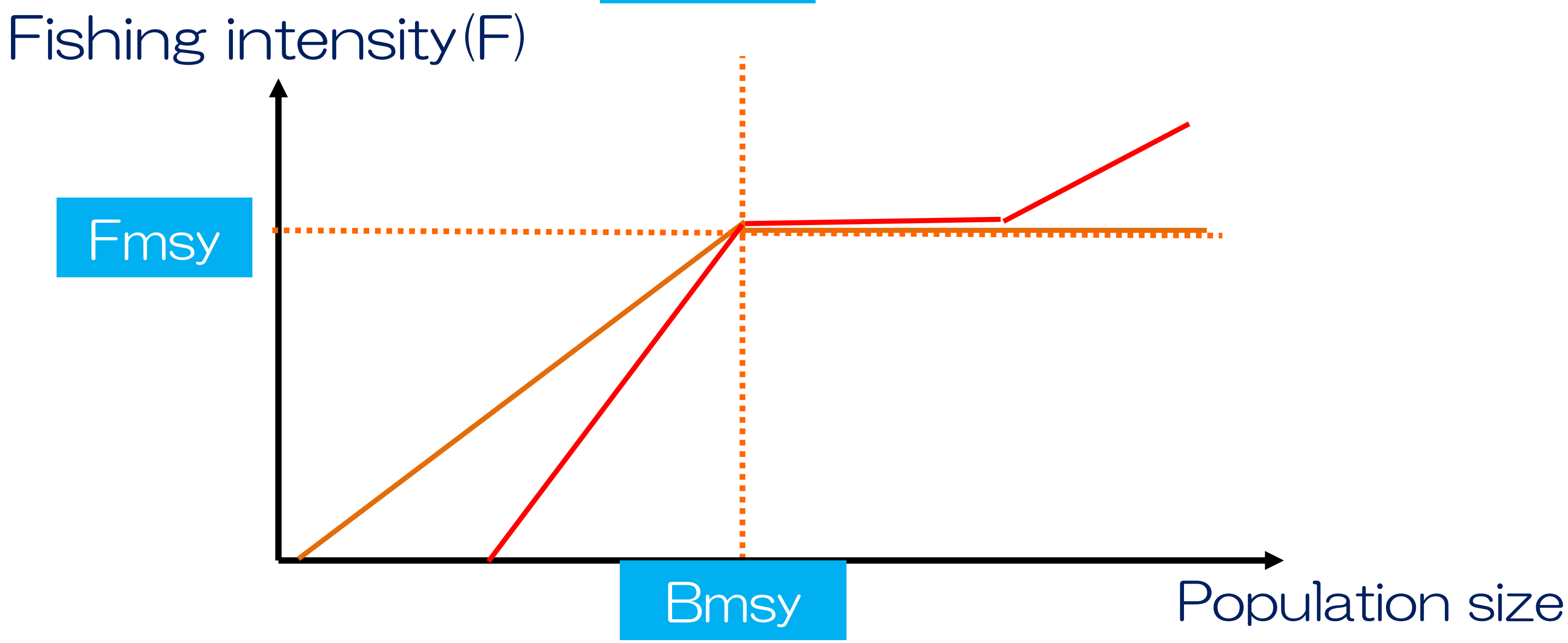
Fishery management



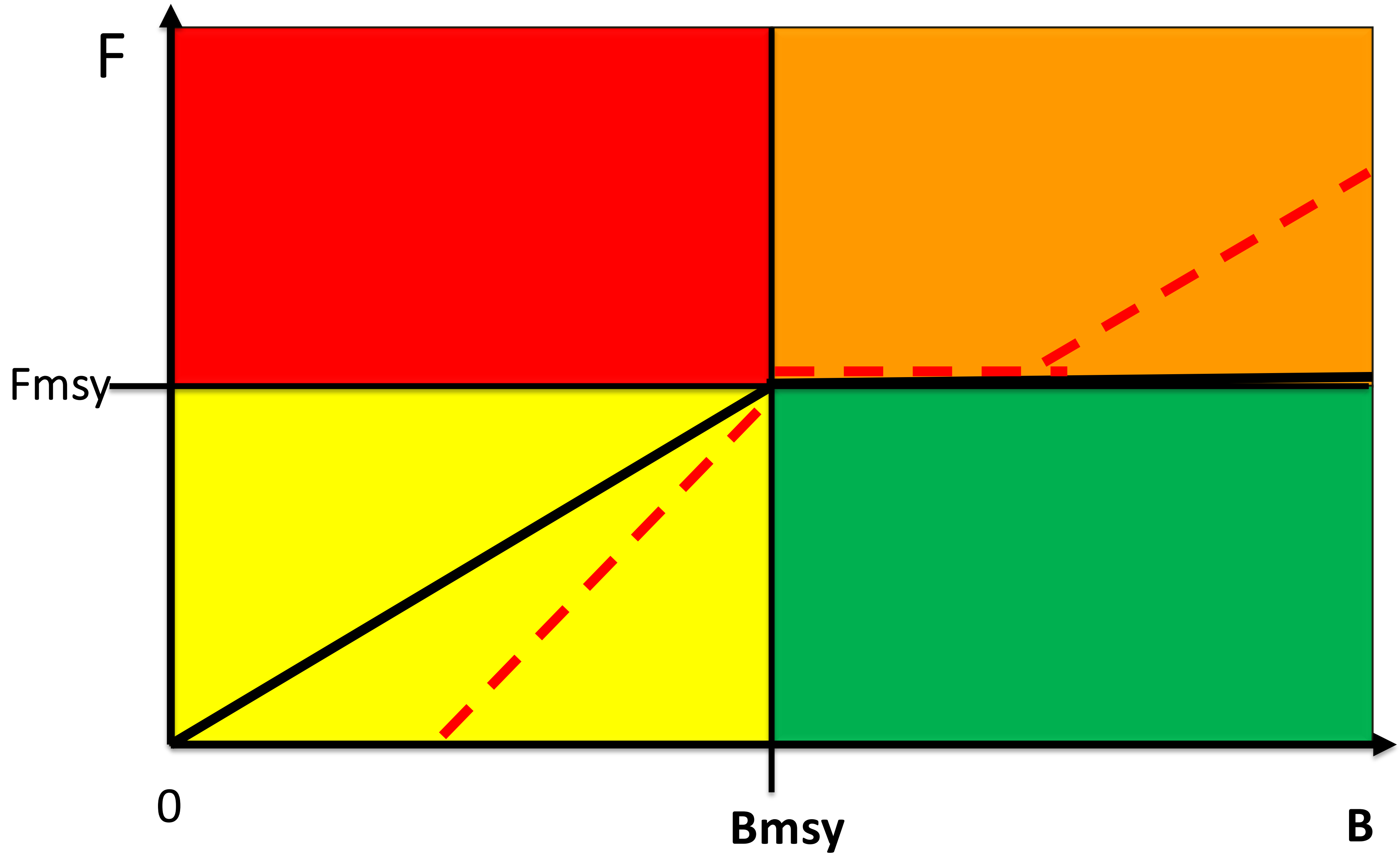


$$Bmsy = \frac{K}{2}$$

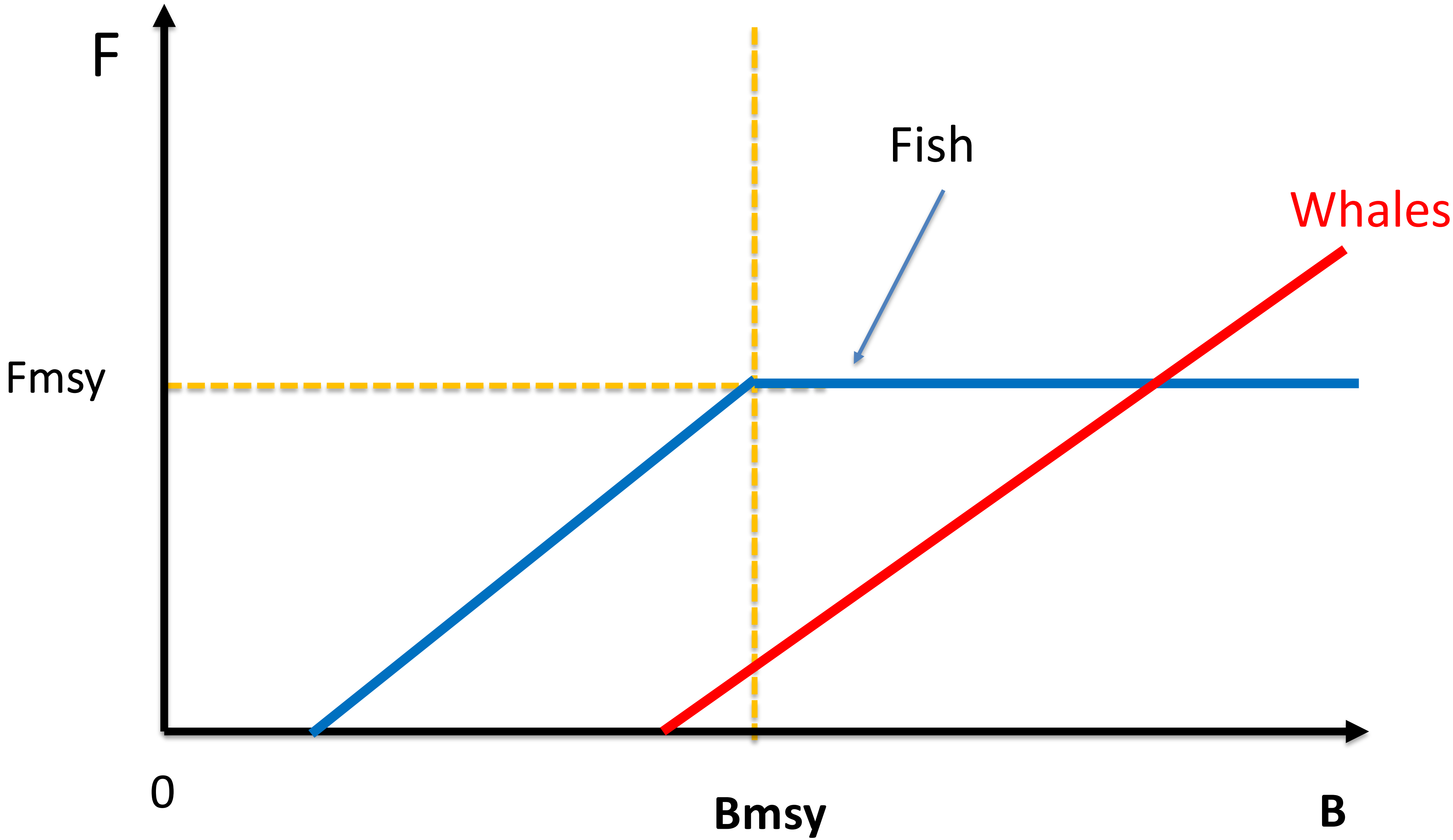
$$Fmsy = \frac{r}{2}$$



Kobe plot上に管理方式を上書きすると

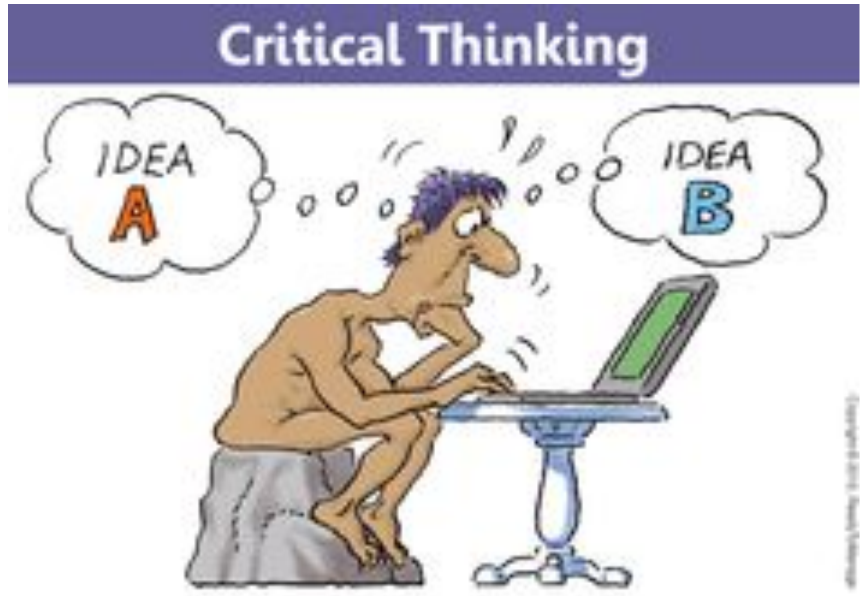


Catch Limit Algorithm (CLA) for management of whales



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



Why MSE ?

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

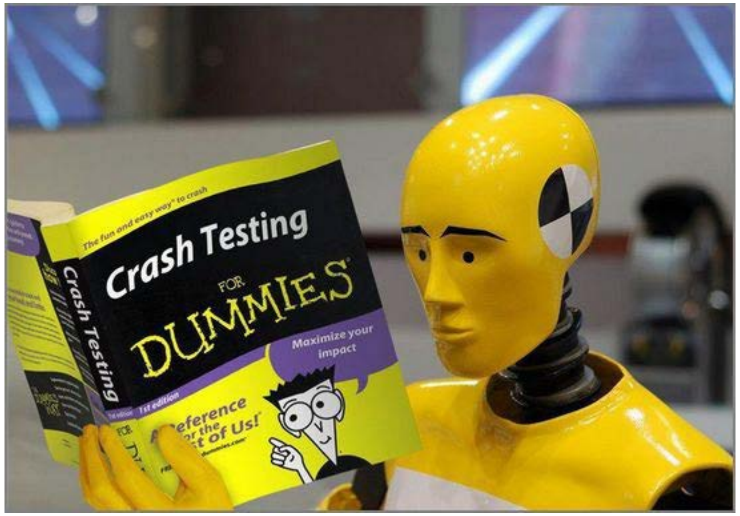
→ **you need predetermined goals/objectives**

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!

What is MSE ?

- A simulation framework for assessing the performance of management procedures
- 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)
- 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
- Should be practical as much as possible
- Anytime interim, should be reviewed regularly

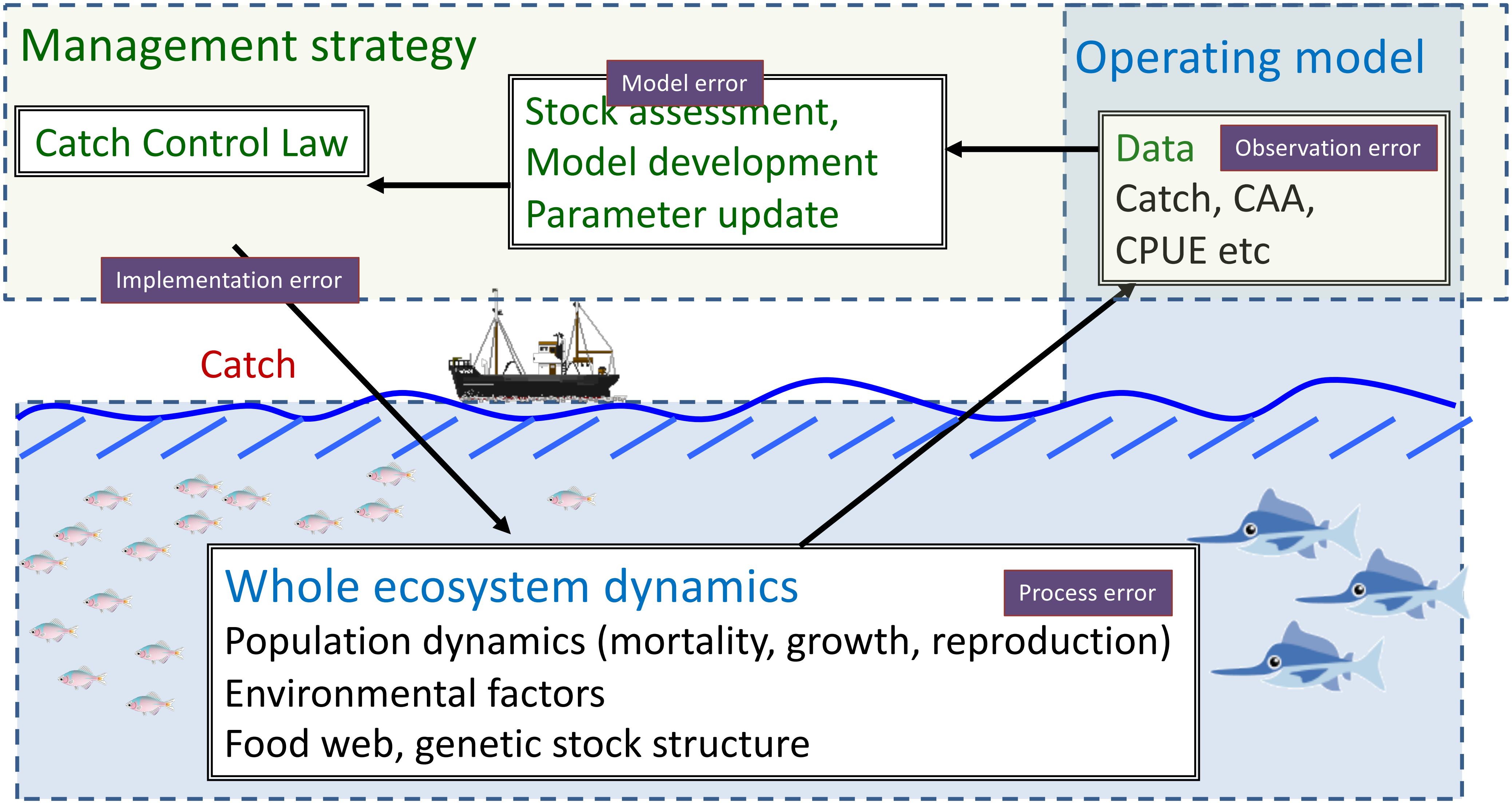
What is MSE ?

- 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 test adaptive management procedures
- 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

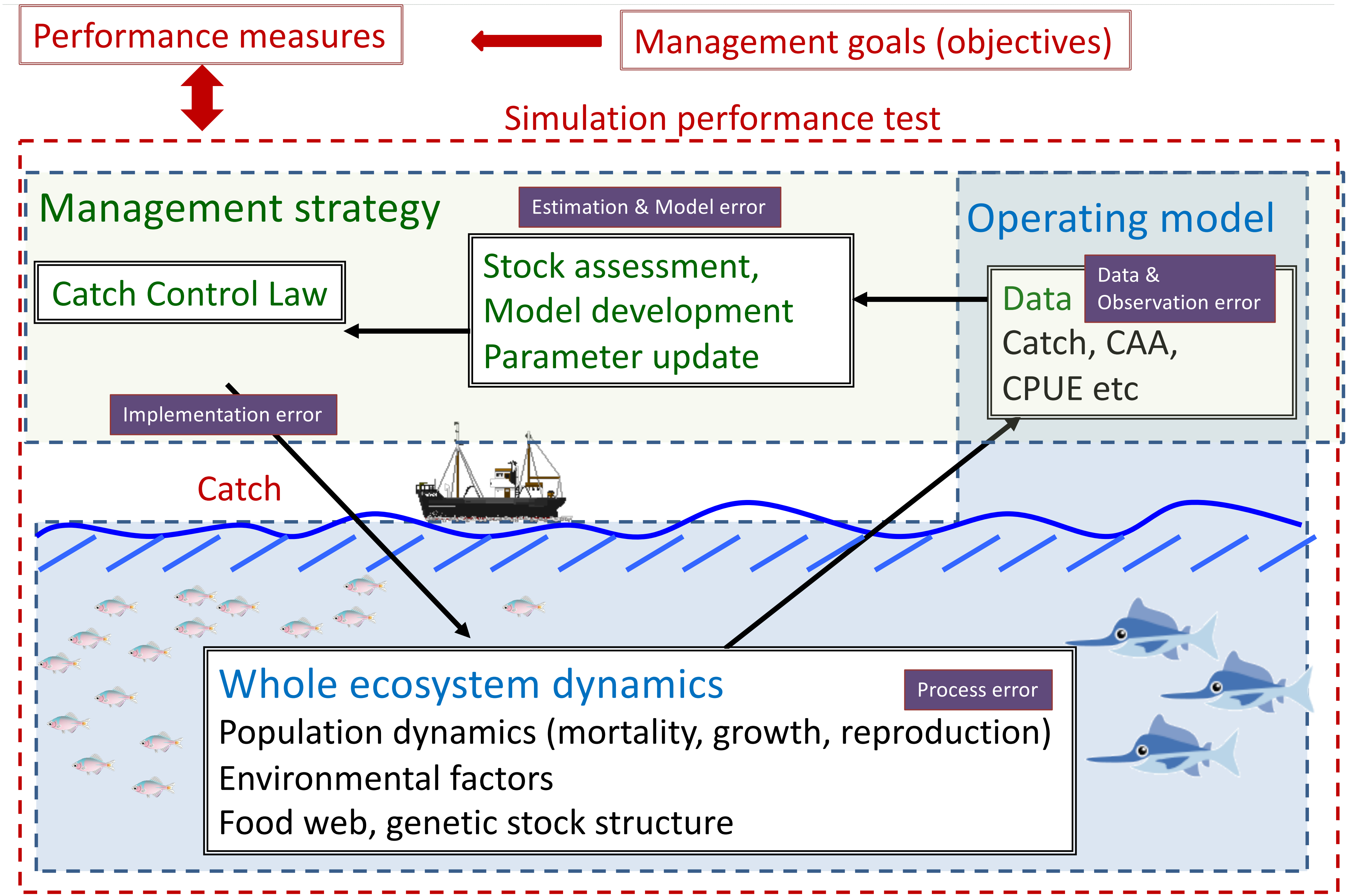
Fishery management

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.



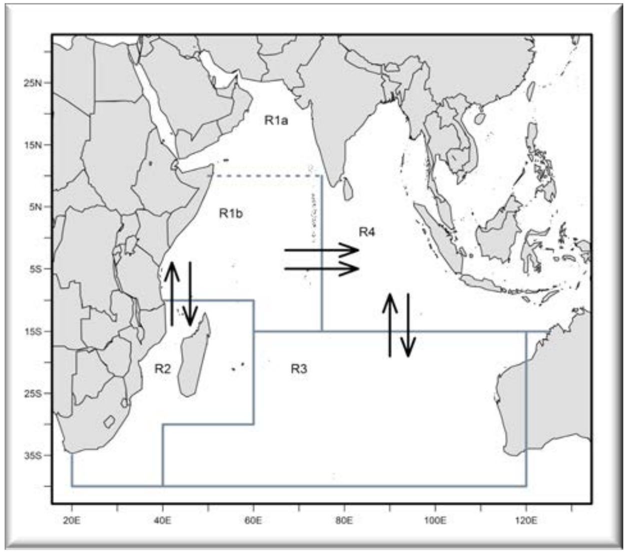
Management Strategy Evaluation (MSE)



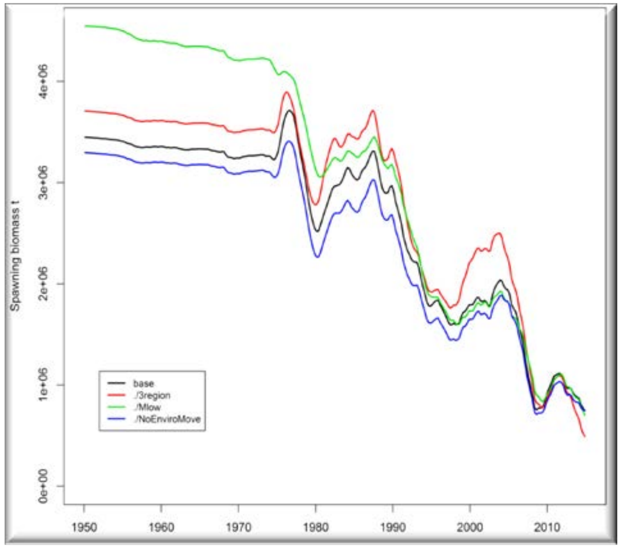
Operating Models (OMs)

Usually based on existing stock-assessment with

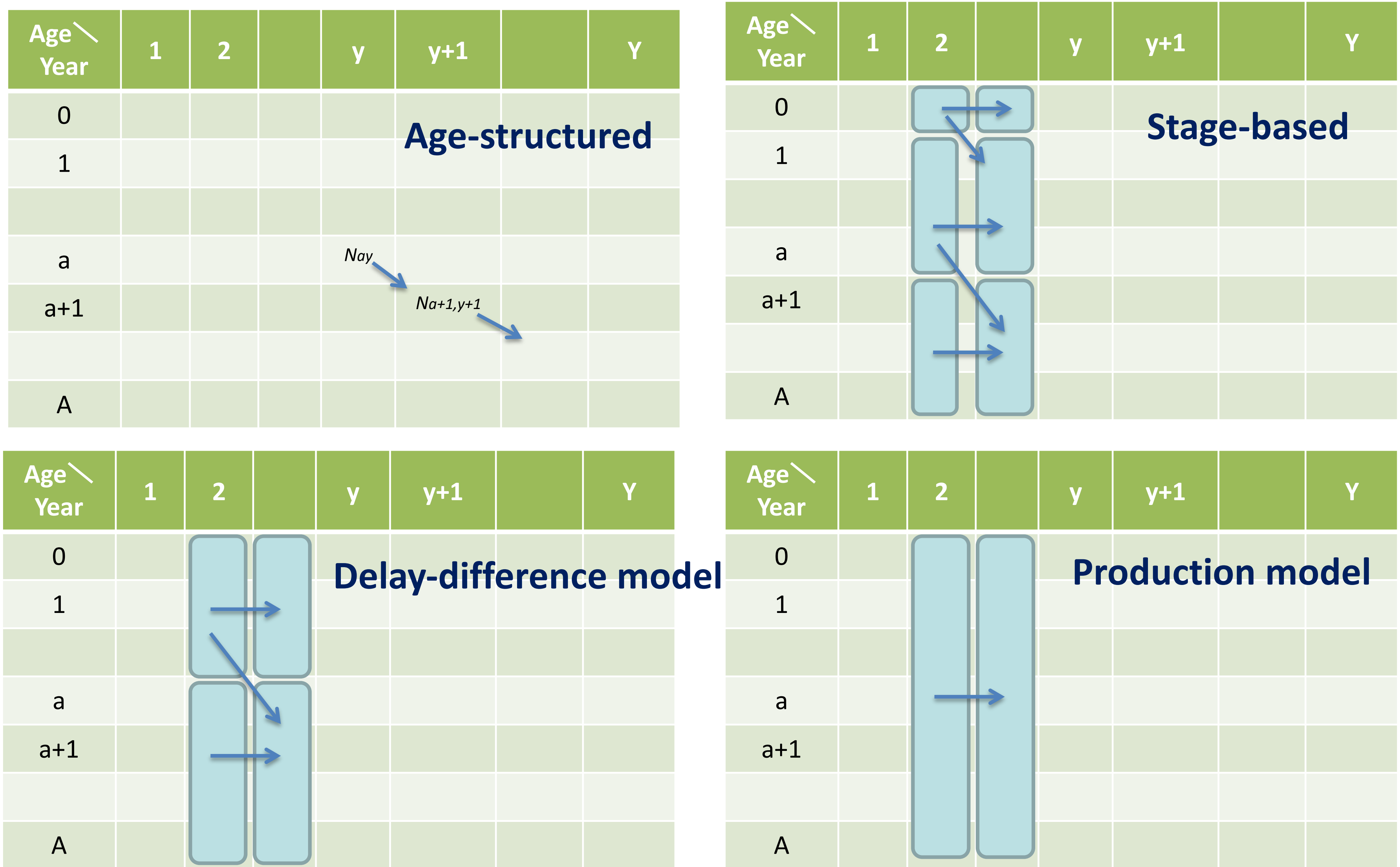
- Best-available information
- Plausible range of biological ecological parameters



- As virtual reality
- Uncertainty with respect to
  - data
  - parameters
  - models
  - estimation
  - stochastic process in population
  - implementation



Possible range of stock assessment models



Management Procedures (MPs)

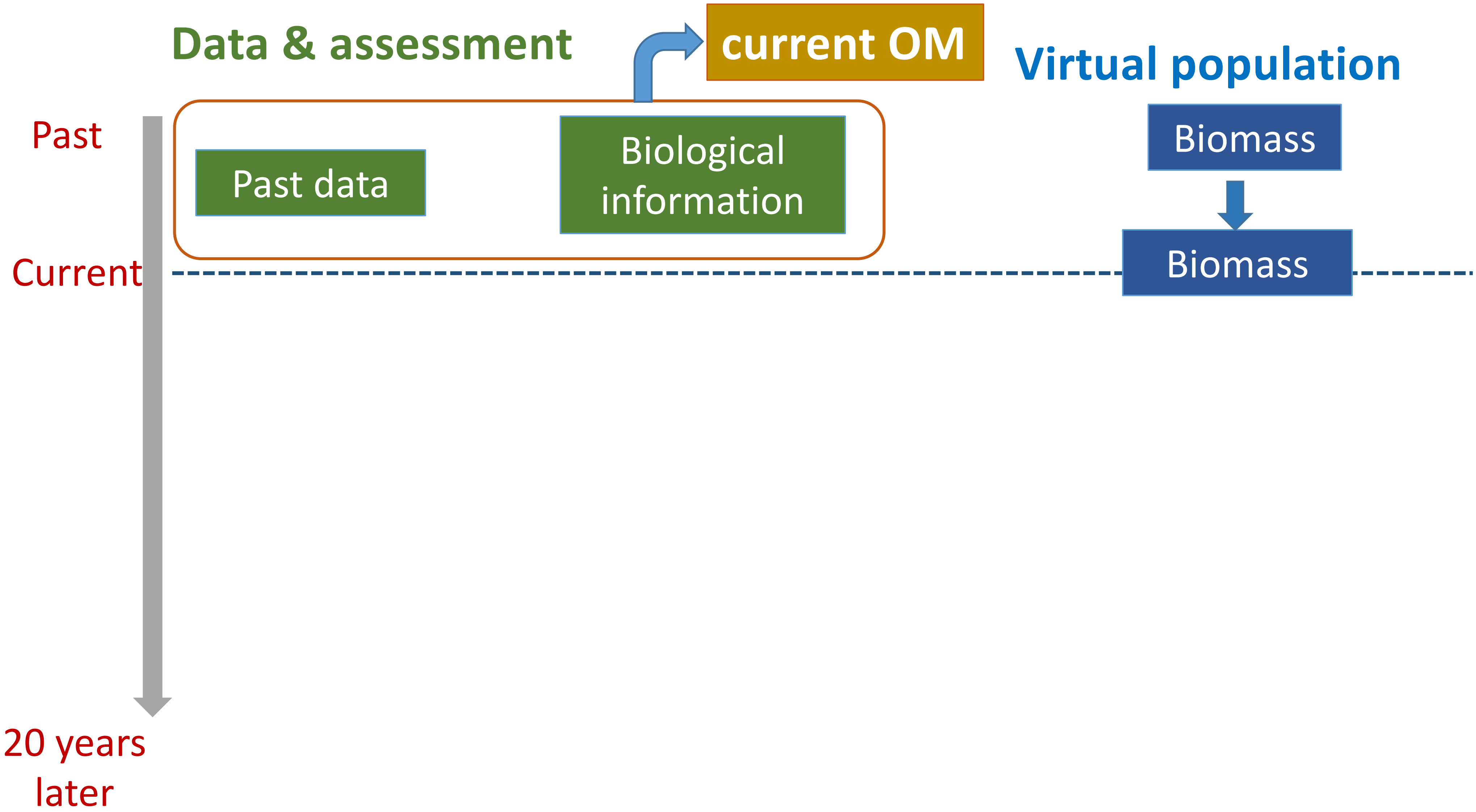
MPs including HCRs

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

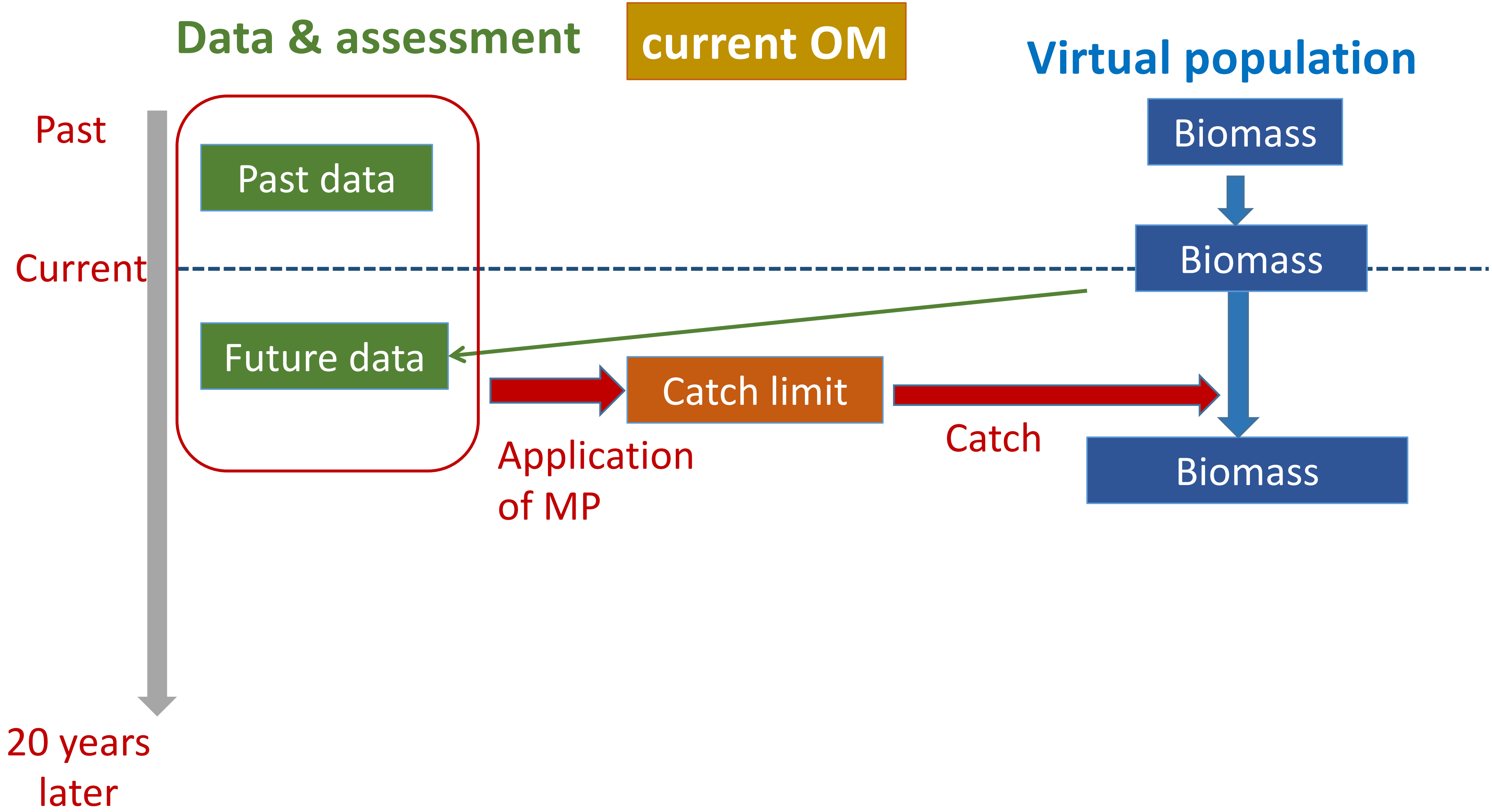
Note: Any MPs do not know the reality of OMs !!

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

Update of MPs



Update of MPs

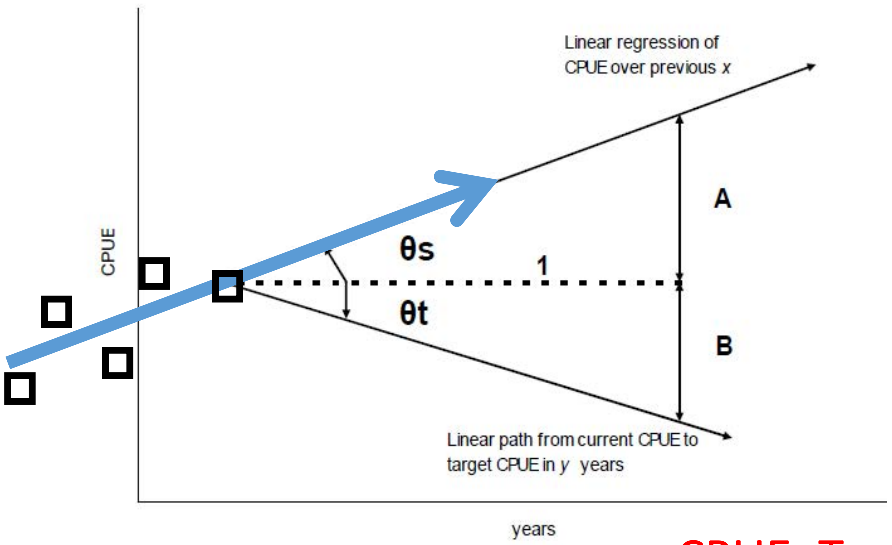


Currently two types of MPs

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

1) Empirical MP:

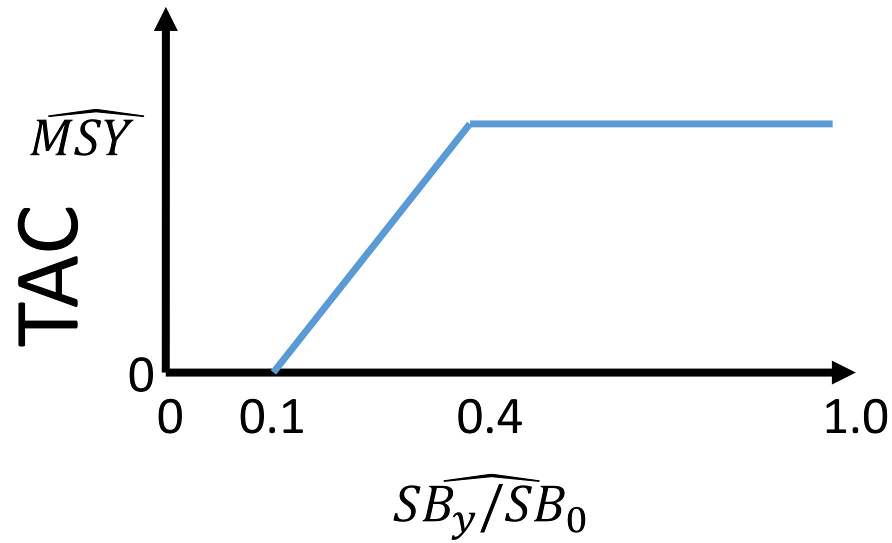
Aims to keep the stock near a target CPUE



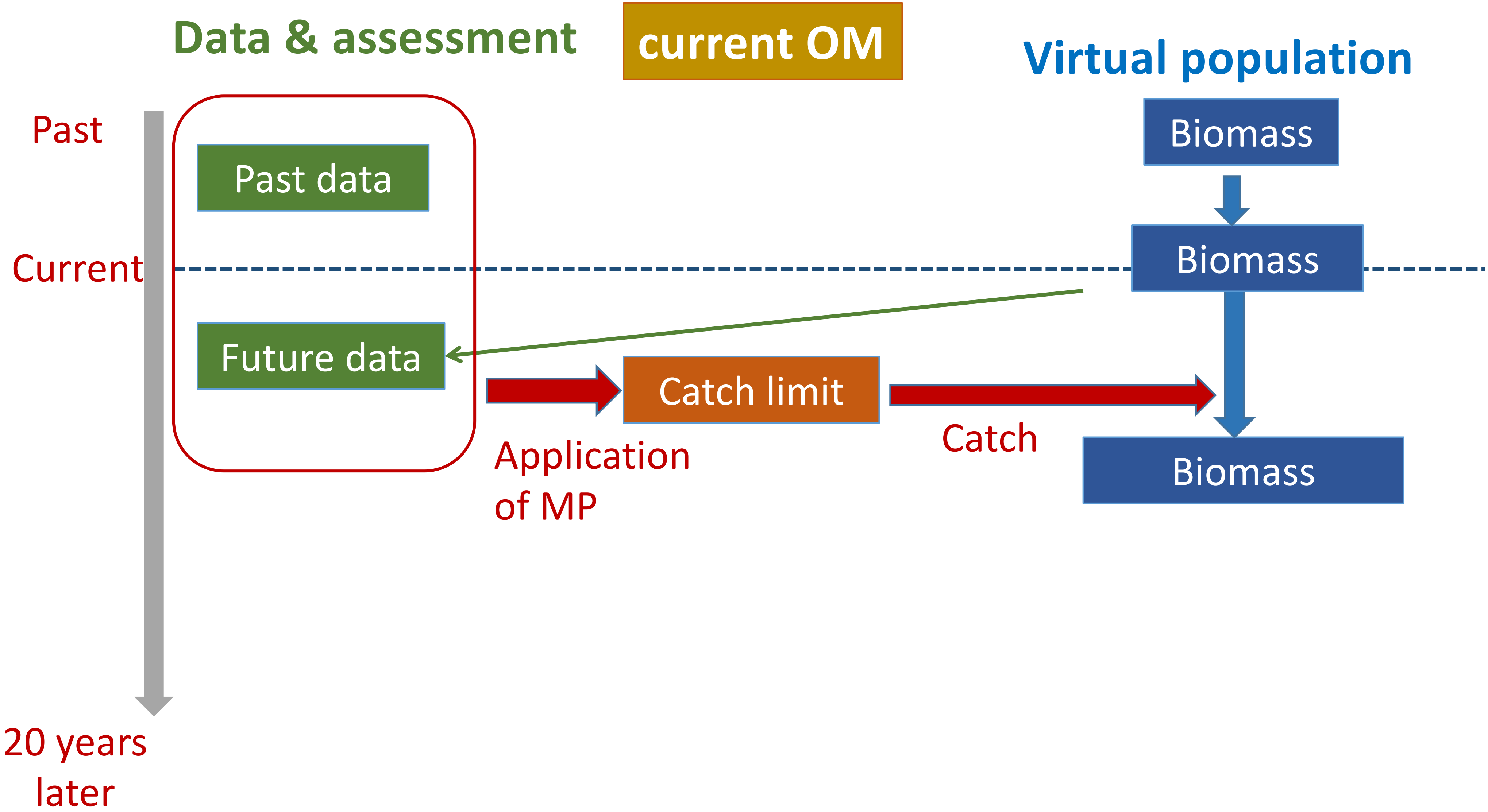
CPUE<Target
TAC decrease

2) Model-based MP:

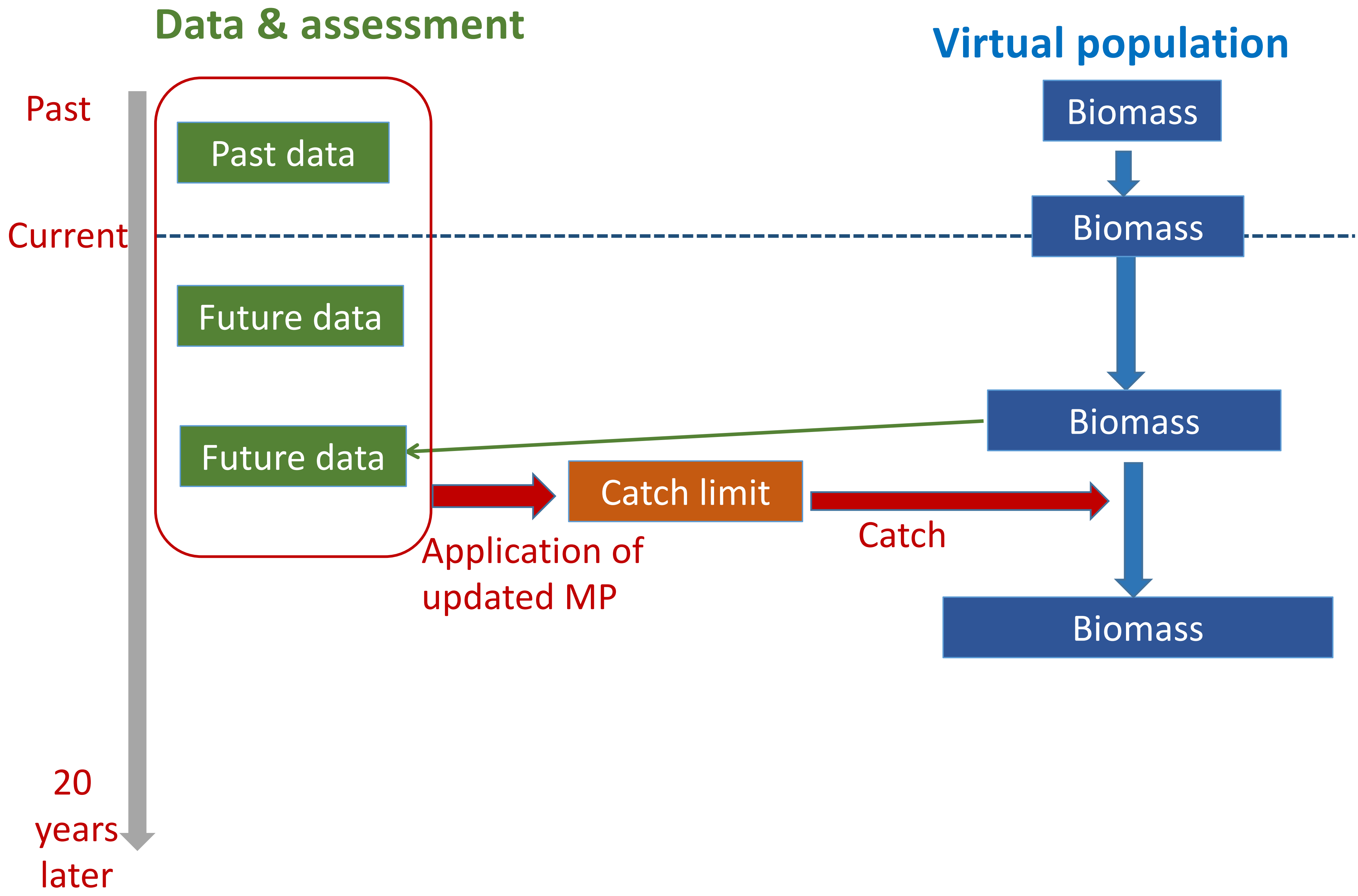
- Fits a Pella-Tomlinson surplus production model,
- Set the TAC using a 40:10-type HCR



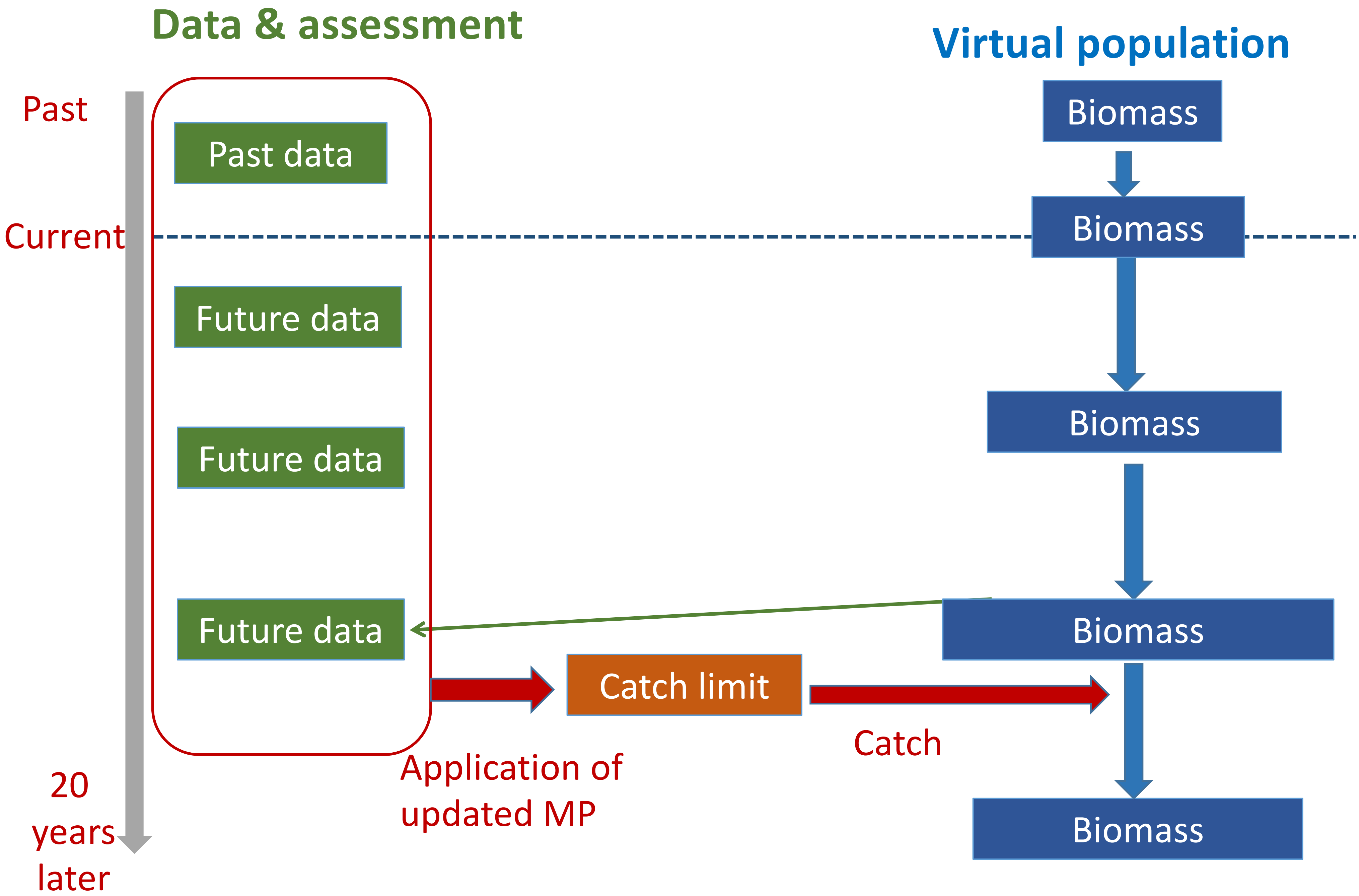
Update of MPs

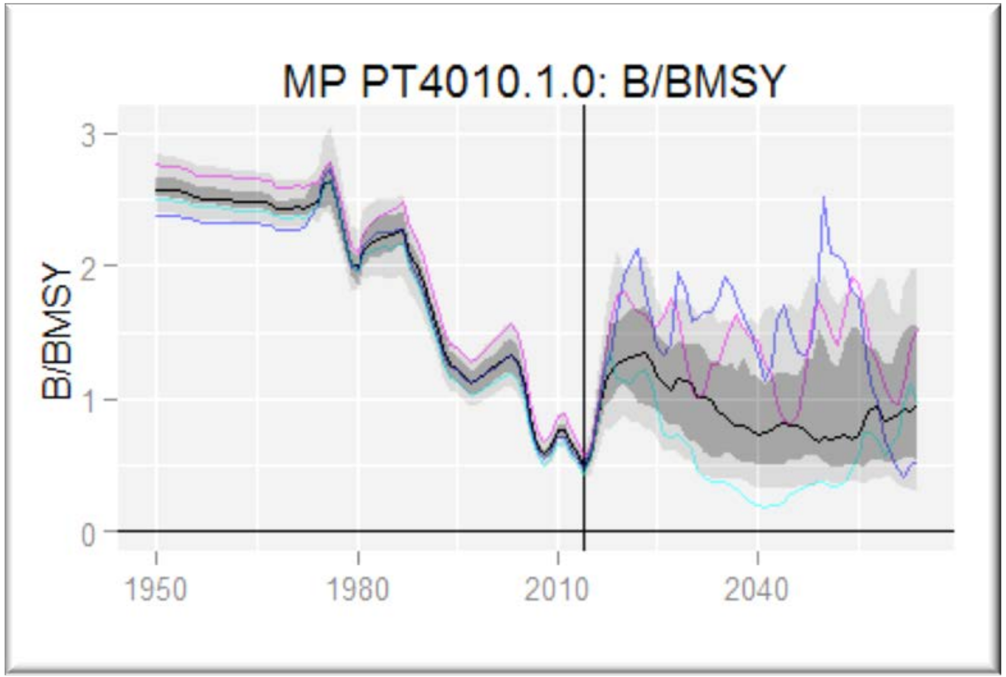


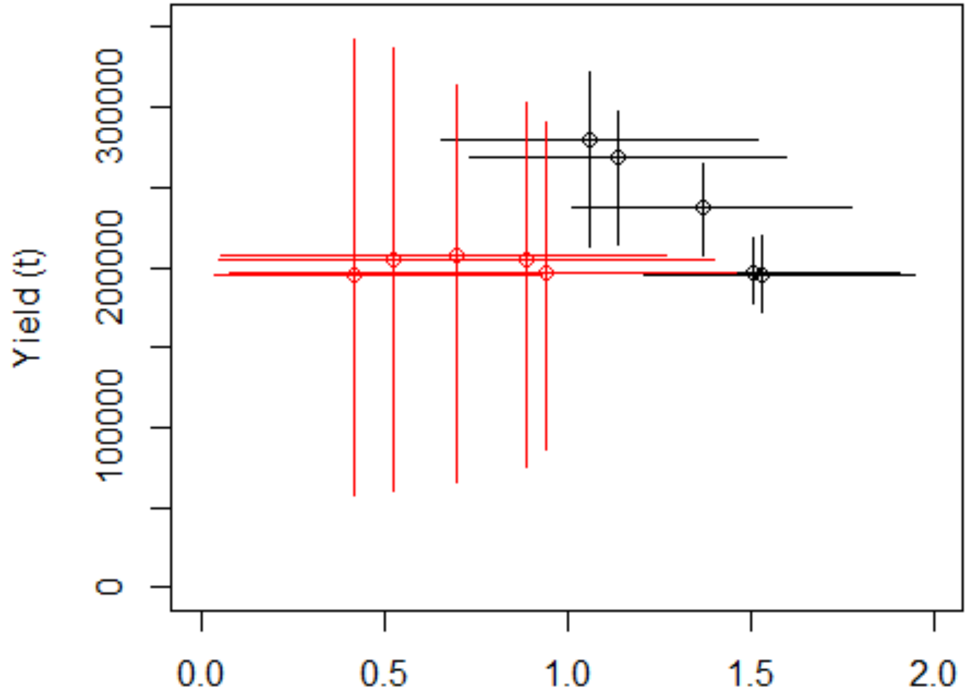
Update of MPs

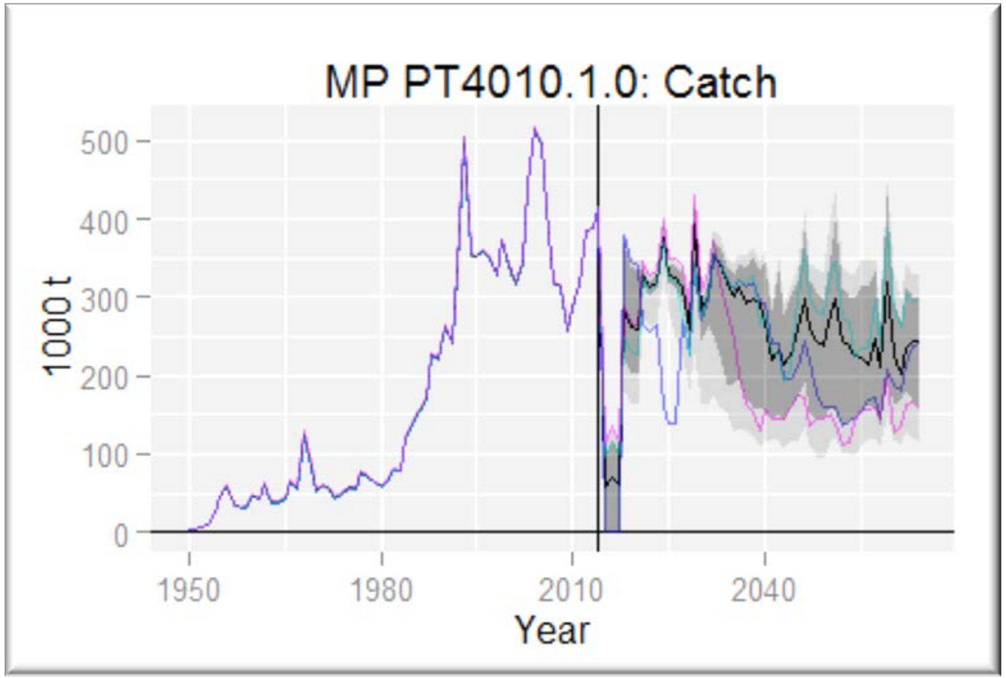


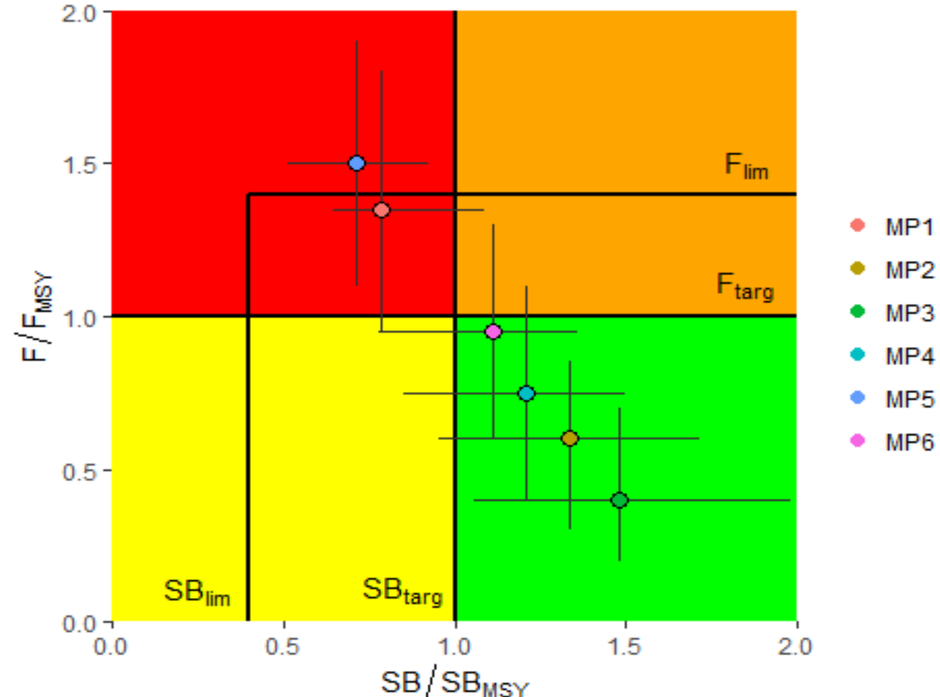
Update of MPs




MP PT4010.1.0: B/BMSY
B/BMSY
3
2
1
0
1950
1980
2010
2040


Yield (t)
300000
200000
100000
0
0.0
0.5
1.0
1.5
2.0


MP PT4010.1.0: Catch
1000 t
500
400
300
200
100
0
1950
1980
2010
2040
Year


F/F_{MSY}
2.0
1.5
1.0
0.5
0.0
F_{lim}
F_{targ}
SB_{lim}
SB_{targ}
0.0
0.5
1.0
1.5
2.0
SB/SB_{MSY}
MP1
MP2
MP3
MP4
MP5
MP6

Management Strategy Evaluation

Simulation testing to

- *Develop management procedure strategy for a particular fishery*
- *Evaluate generic management procedure*
- *Identify management procedures that will not work and should therefore be eliminated from further consideration*
- *Evaluate benefits of additional data collection.*

Key Note: The aim is to find **management procedure** through Simulation Testing that are **robust to major uncertainty** (rather than strategies that are optimal if a particular scenario is true)

Management Procedure: the combination of pre-defined data, together with an algorithm to which such data are input to provide a value for a set of implementable management measures.

Management Strategy Evaluation

- MSE …. what are we ***evaluating***?

"Simulated reality"
Operating Model

Management Strategy Evaluation

- MSE …. what are we *evaluating*?

“Simulated reality”
Operating Model

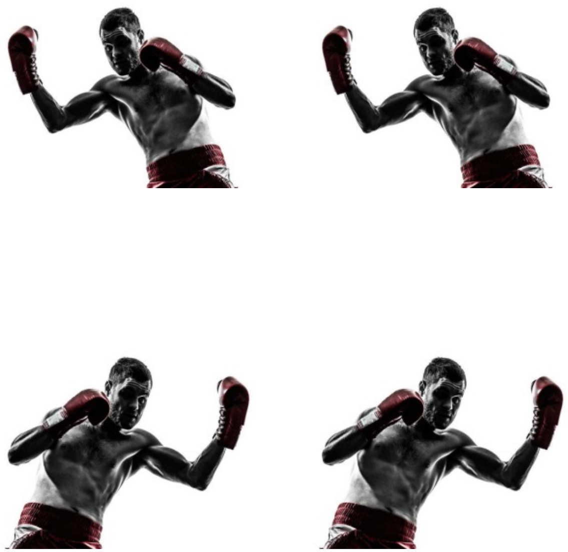
Management Procedure

- MSE …. what are we *evaluating*?

But WHAT IF?

"Simulated reality"
Operating Model

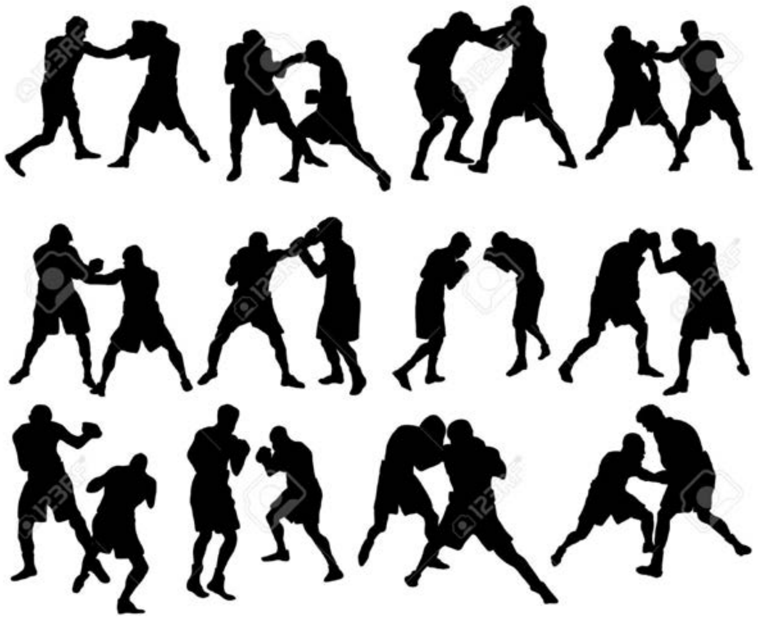
- MSE …. what are we *evaluating*?



"Simulated reality"
Operating Model

But WHAT IF?

- MSE …. what are we *evaluating*?



But WHAT IF?

"Simulated reality"
Operating Model

Management Strategy Evaluation

- MSE …. what are we ***evaluating***?

"Simulated reality"
Operating Model

Management Procedure

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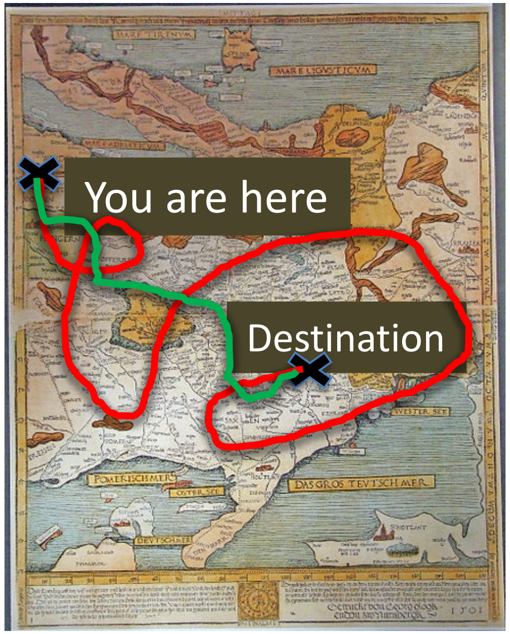
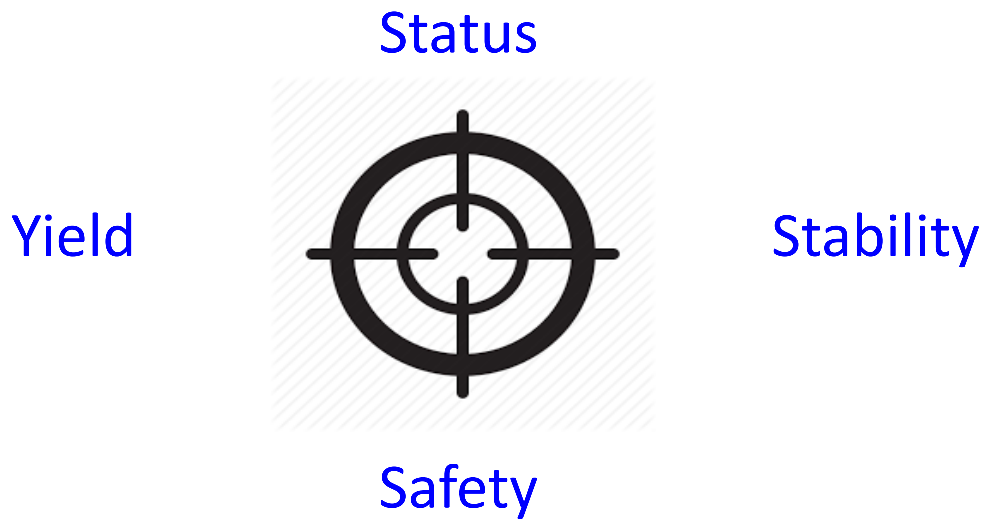
Management Procedure: the combination of pre-defined data, together with an algorithm to which such data are input to provide a value for a set of **<u>implementable management measures</u>**.

"Agreeing the rules of the game before it is played"

Doug Butterworth

Management Procedure

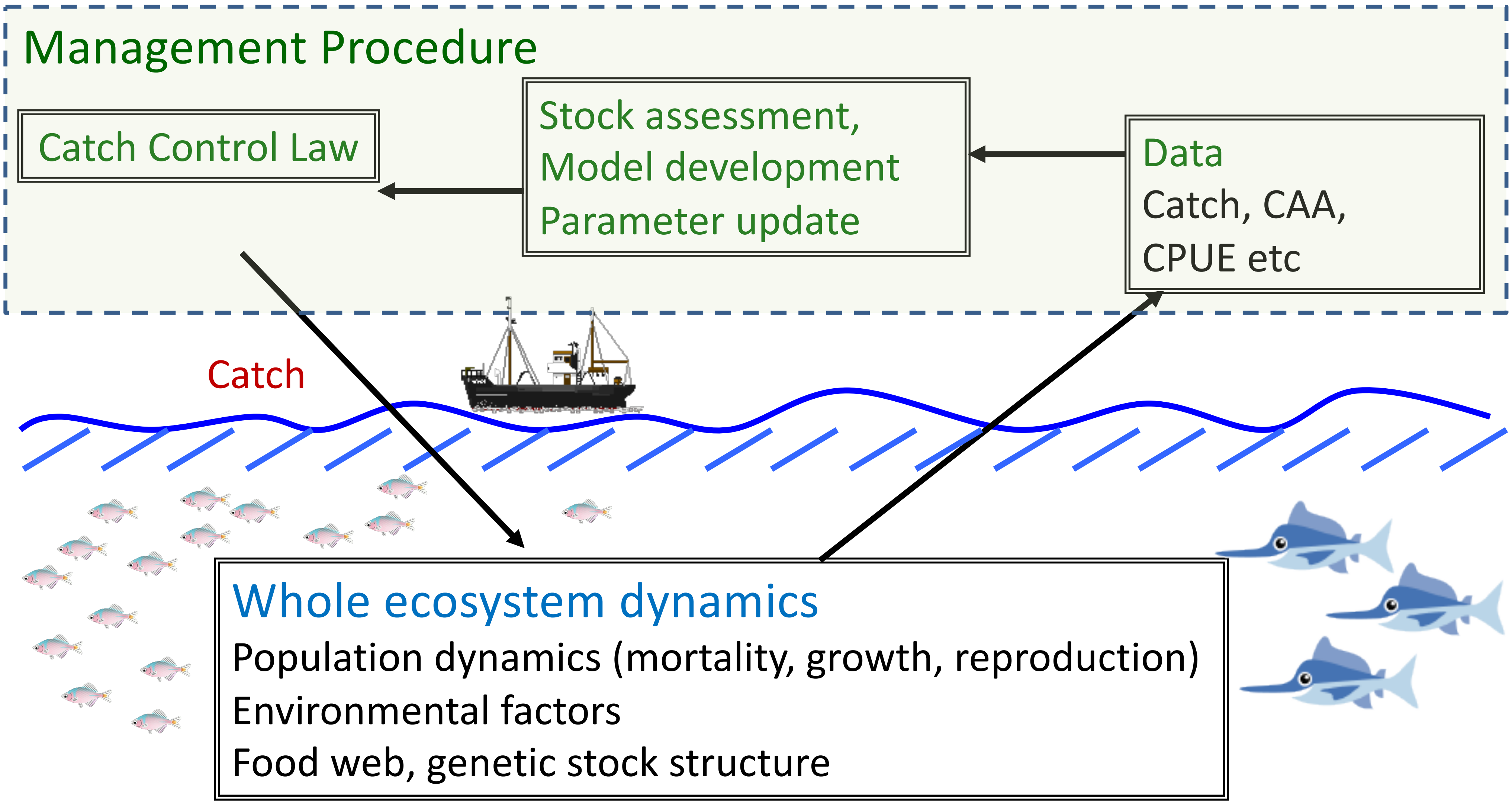




- Stock assessment – where we were and are now
- Management procedure – How/When to get to the target
- MSE – What's "*the best*" way to the target (eg a MP meeting the target and provided most appropriate trade-off results between desired management objectives)

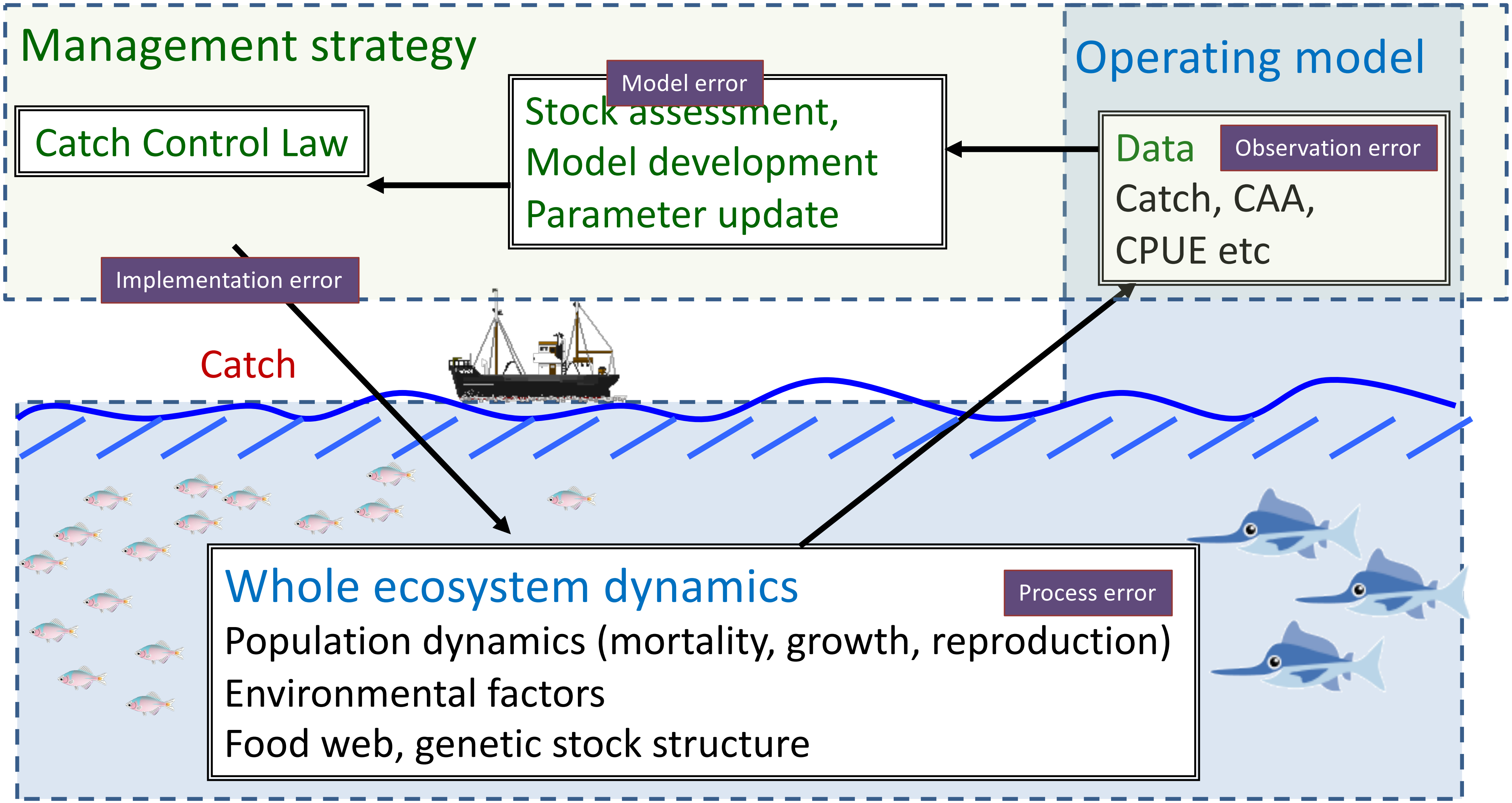
Management Strategy Evaluation
PROCESS

Fishery management

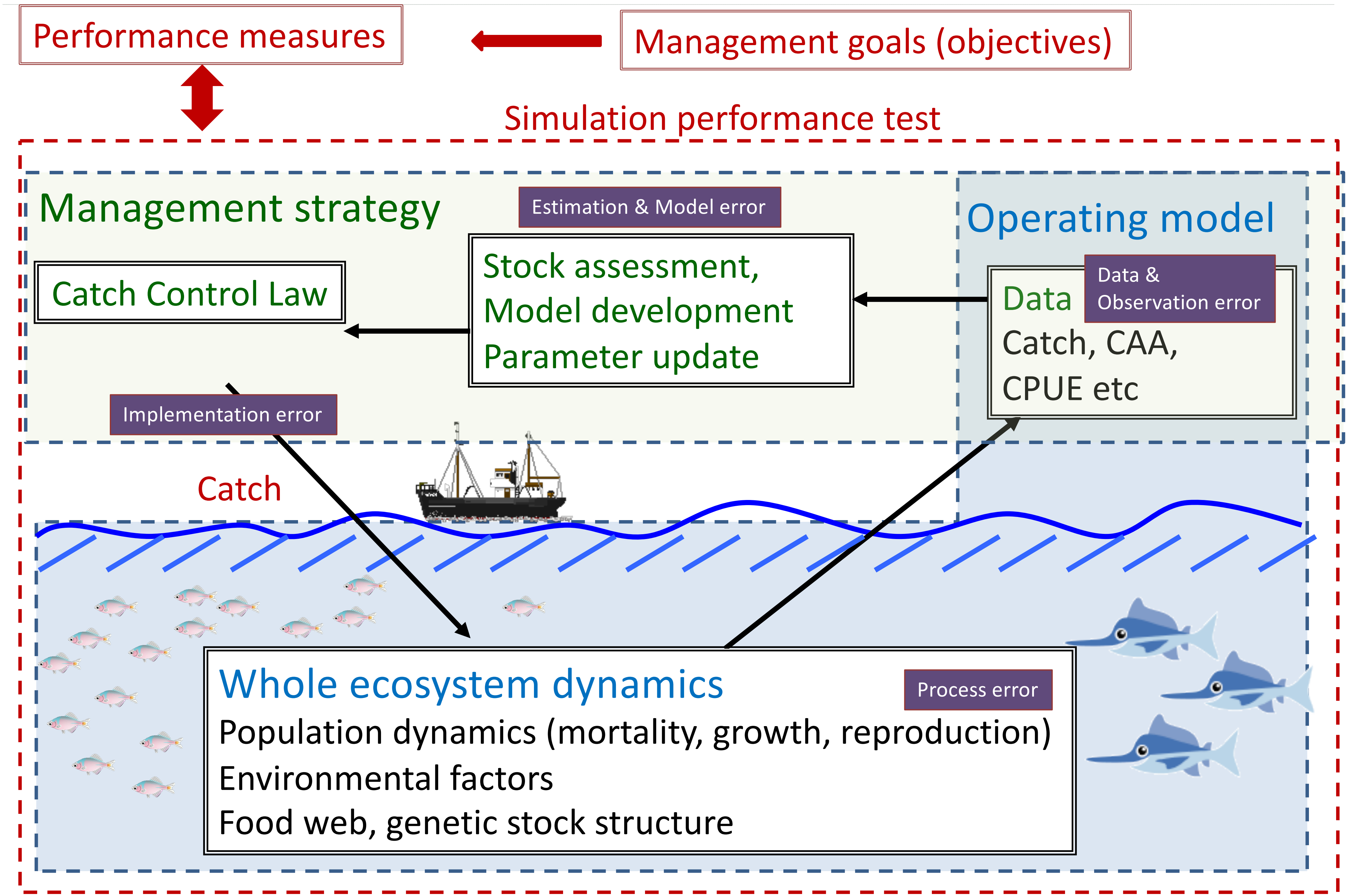


Fishery management

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.



Management Strategy Evaluation (MSE)



MSE Process

1. Identification of management objectives and quantifiable performance measures
2. Development of a range of Operating Models (OMs) to represent the uncertainty in the fishery
3. Development of candidate Management Procedures (MPs)
4. Simulation testing of candidate MPs with the OMs
5. Selection of an MP on the basis of the simulated performance
6. Implementation of the MP.

Skipjack Harvest Control Rule (HCR)

Simulation Testing:

- Assume “consensus stock assessment” will be available with known statistical properties

- Simulate fishery

- Simulate stock assessment result

- Use HCR to set quota

Management Procedure (BET, ALB, YFT, SWO)

Simulation Testing:

- Predefine data collection, analysis and HCR

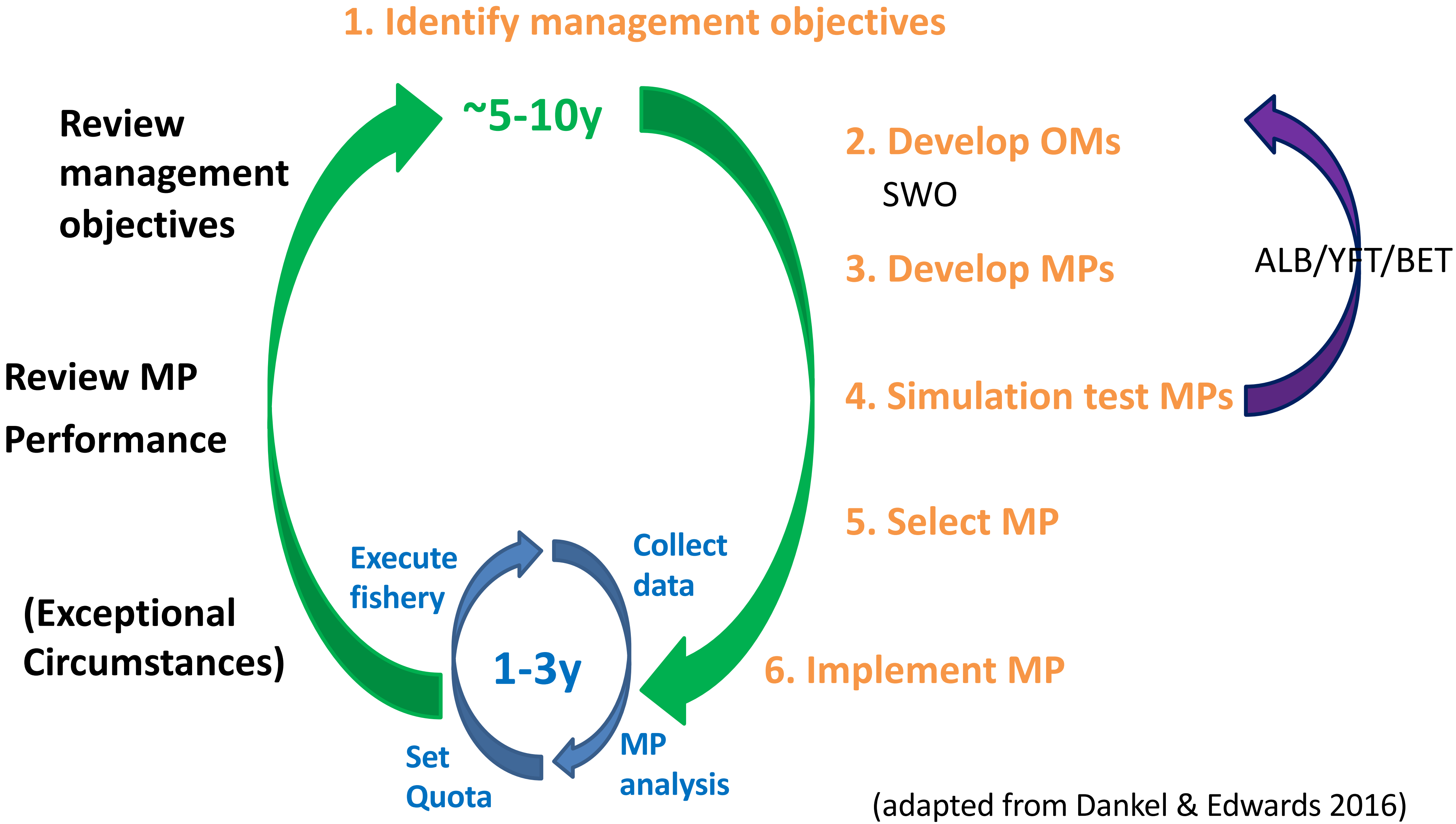
- Simulate fishery

- Simulate Data collection and estimate “indicators”

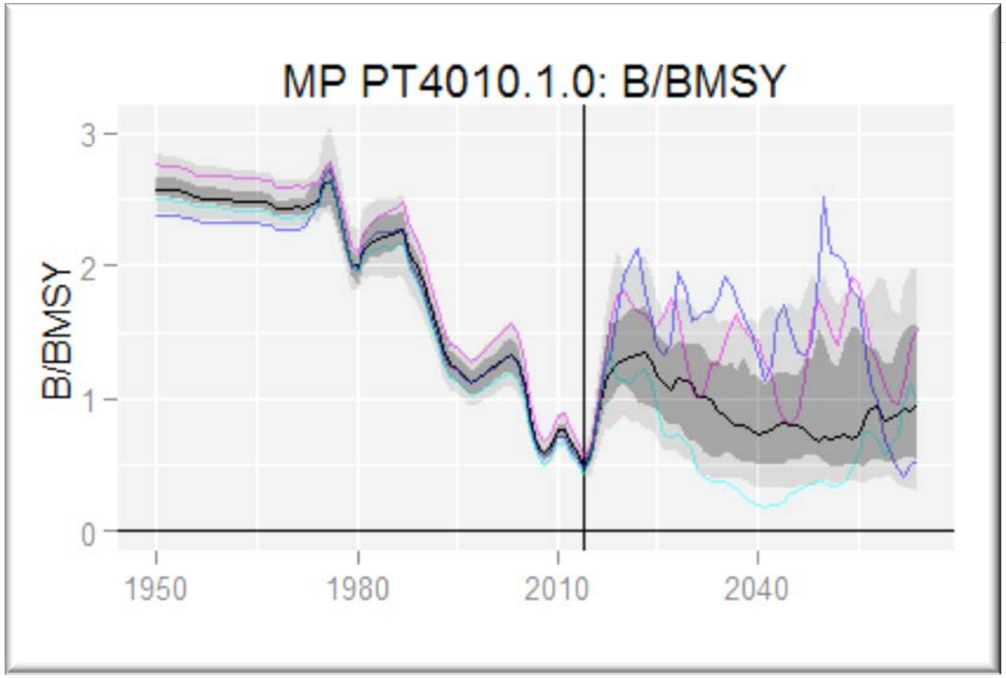
- Use MP to set quota

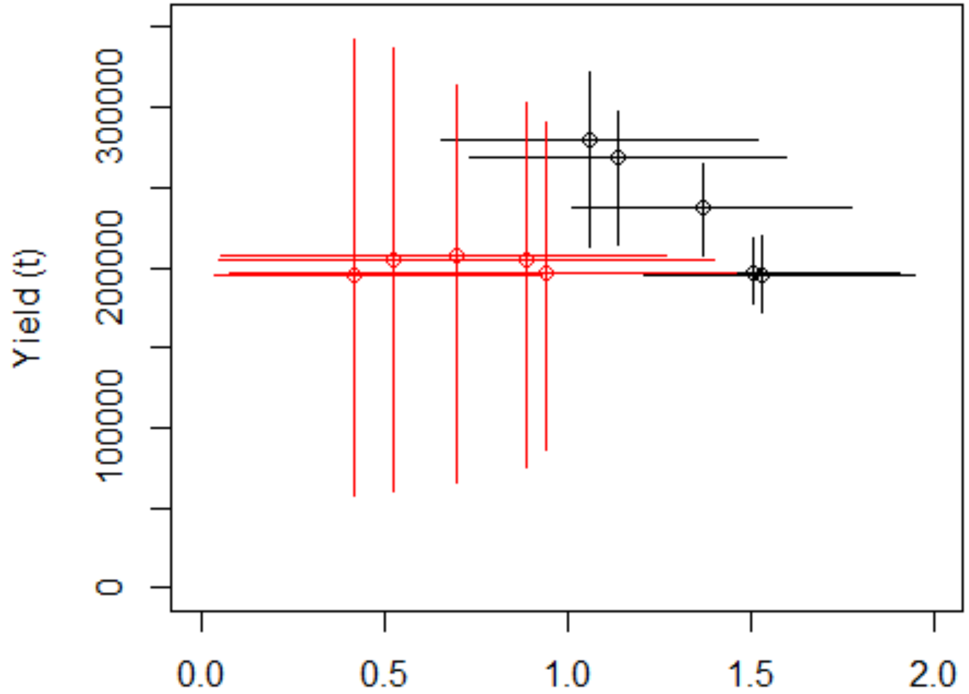
i.e. “consensus stock assessment” is not a problem – it is already agreed and tested as part of the MP

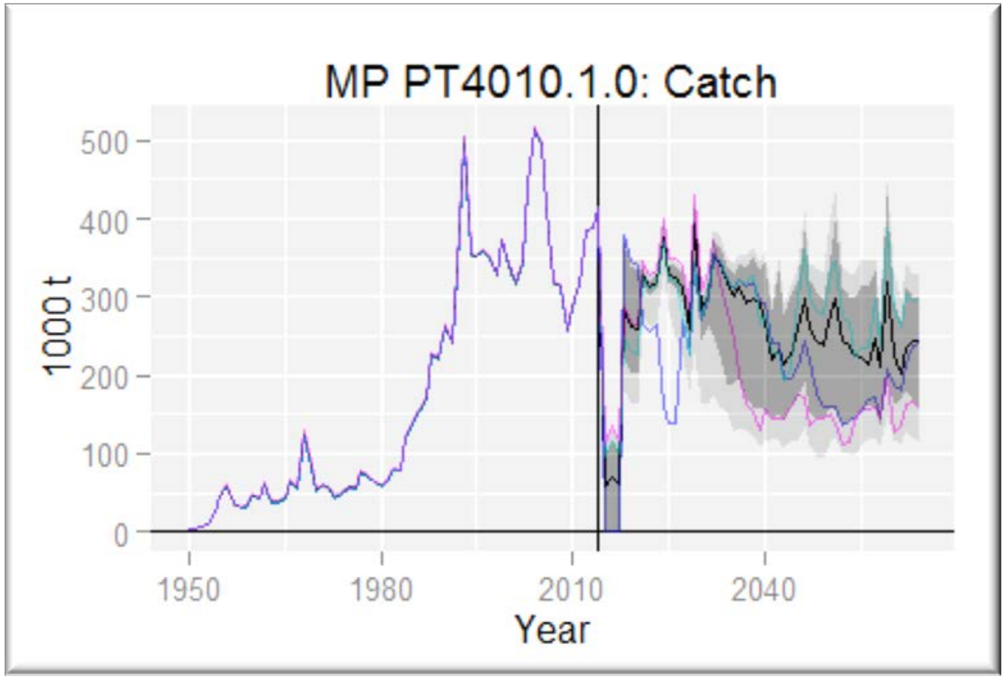
MSE: Fishery Management Cycle

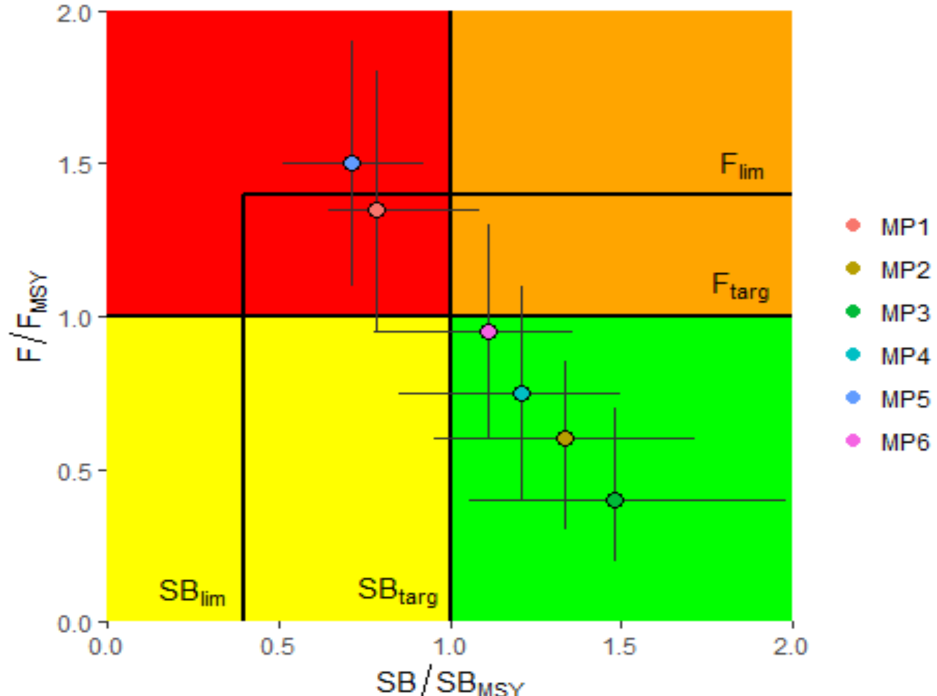


(adapted from Dankel & Edwards 2016)


MP PT4010.1.0: B/BMSY
B/BMSY
3
2
1
0
1950
1980
2010
2040

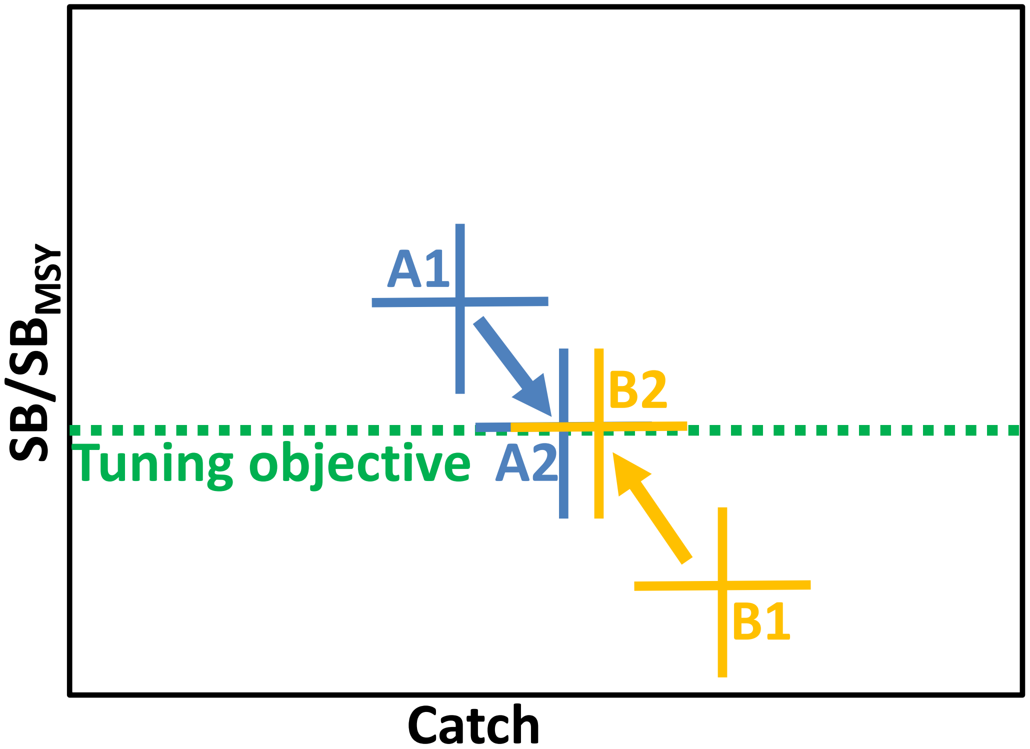

Yield (t)
300000
200000
100000
0
0.0
0.5
1.0
1.5
2.0


MP PT4010.1.0: Catch
1000 t
500
400
300
200
100
0
1950
1980
2010
2040
Year


F/F_MSY
SB/SB_MSY
F_lim
F_targ
SB_lim
SB_targ
MP1
MP2
MP3
MP4
MP5
MP6

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

MSE: “Meta-rules” higher level oversight MP-based management

“Exceptional Circumstances”

- Rare events, when the fishery system falls outside of the scope of the simulation testing, e.g.
  - Critical CPUE data are no longer available
  - Large IUU catches identified
  - Sustained recruitment failure, etc.
- Requires regular monitoring (e.g. indicator-based rather than comprehensive stock assessment)
- What to do?
  - Suspend MP with ad hoc management until a new MP can be developed and implemented

NOT a mechanism to simply avoid an inconvenient management action

ROLES AND RESPONSABILITIES

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Why MSE?

- Framework of "Evaluation of Management Procedures" is not only a computational tool !!

- Rather, a tool to bridge between

"Stakeholders/decision makers"

- Identify management objectives
- Make potential ideas plausible ways of management and feasibility
- Make decisions on the final set of management procedures

"Scientists"

- Translate the management objectives to performance measures and risk indicators
- Develop population dynamics with reality
- Improve better management procedures to meet the objectives

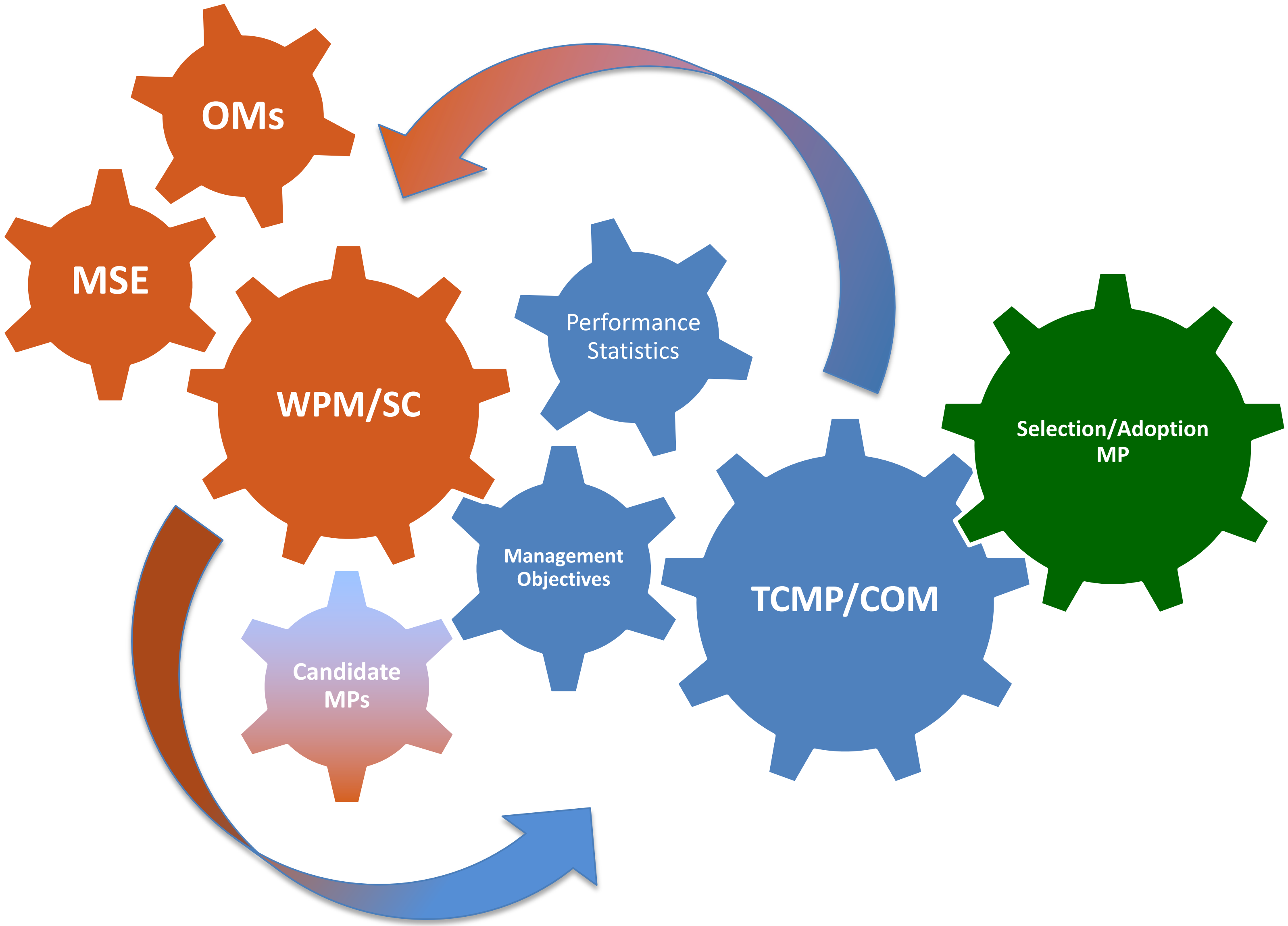
MP-MSE Process: Roles and Responsabilities

A simulation process like MSE does not consist of a series of linear steps, but rather feedback and rethinking need to be undertaken at each step in the process

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

MP-MSE Process: Roles and Responsabilities

A simulation process like MSE does not consist of a series of linear steps, but rather feedback and rethinking need to be undertaken at each step in the process



SELECTION of OBJECTIVES, TIMEFRAMES & PROBABILITIES = TUNING (i.e. FACILITATING THE PROCESS)

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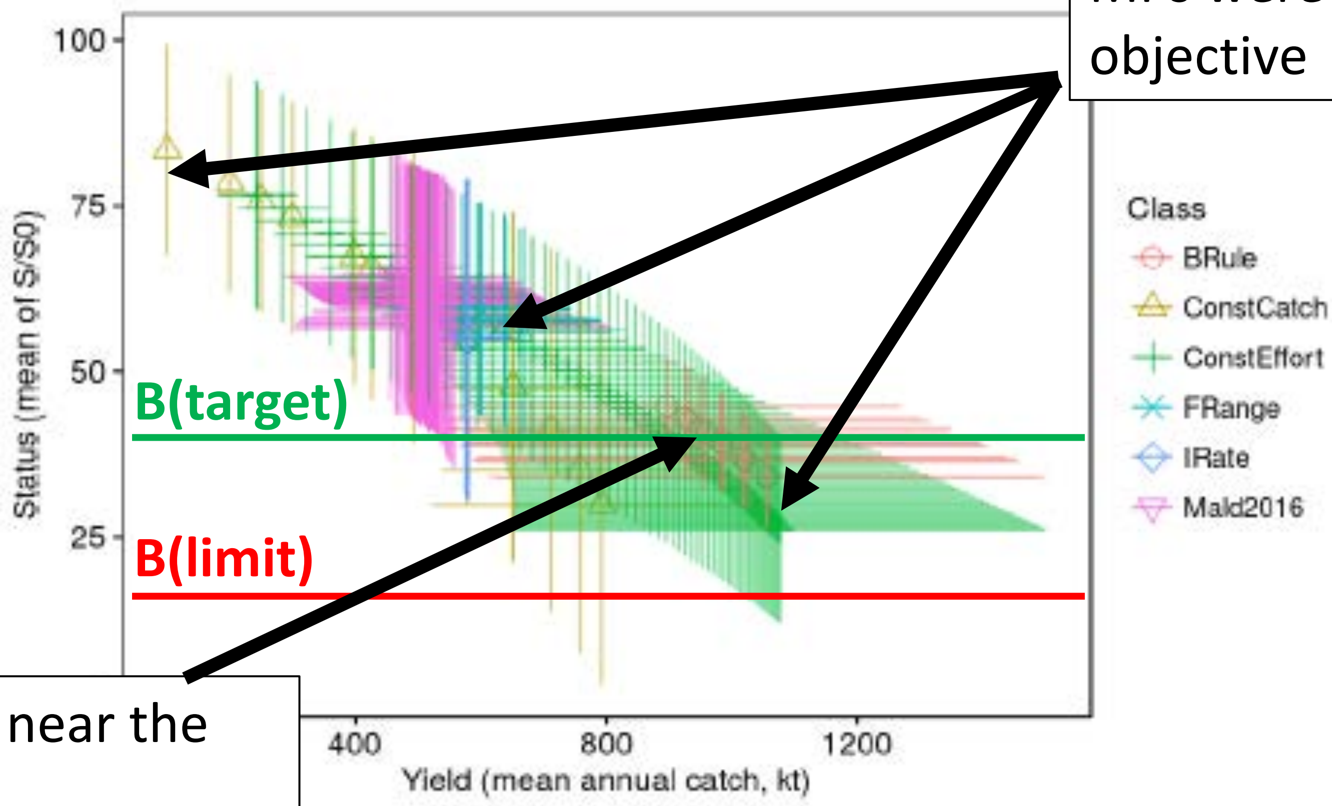
There are some management objectives expressed in the Commission documents

- e.g. Maintain the biomass at the B(target) reference point on average

Performance of most MPs were far from this objective



2-3 MPs were near the target

Tunning Criteria from TCMP02

TCMP02 AGREED in the following TUNING CRITERIA to be tested for TCMP03:

BIGEYE

- Pr(Kobe green zone 2030:2034) = 0.5.
- Pr(Kobe green zone 2030:2034) = 0.6.
- Pr(Kobe green zone 2030:2034) = 0.7.

The stock status is in the Kobe green quadrant over the period 2030-2034 exactly 50, 60 or 70% % of the time (averaged over all simulations).

YELLOFIN

- Pr(SB(2024)>=SB(MSY)) = 0.5.
- Pr(SB(2029)>=SB(MSY)) = 0.5.
- Pr(SB(2034)>=SB(MSY)) = 0.5.

Average SB in 2024, 2029 and 2034 exceeds SB_{MSY} in exactly 50% of the simulations.

KEY ISSUES TO CONSIDER FOR FEEDBACK

MSE

- Advice on key management objectives to aid tuning process
- Secondary objectives and improvement of performance indicators,
- Other considerations:
    - 3 year TAC setting,
    - TAC changes constrains,
    - Maximum TAC
- Time lag between MP-TAC implementation
- Time of MP revision

STOCK STATUS

- Advice on definition of overfished/overfishing

MSE

- Advice on key management objectives to aid tuning process
- Secondary objectives and improvement of performance indicators,

Status : maximize stock status	
1. Mean spawner biomass relative to pristine	SB/SB_0
2. Minimum spawner biomass relative to pristine	SB/SB_0
3. Mean spawner biomass relative to SB_{MSY}	SB/SB_{MSY}
4. Mean fishing mortality relative to target	F/F_{tar}
5. Mean fishing mortality relative to F_{MSY}	F/F_{MSY}
6. Probability of being in Kobe green quadrant	SB,F
7. Probability of being in Kobe red quadrant	SB,F

MSE

- Advice on key management objectives to aid tuning process
- Secondary objectives and improvement of performance indicators,

Safety : maximize the probability of remaining above low stock status (i.e. minimize risk)	
8. Probability of spawner biomass being above 20% of SB_0	*SB*
9. Probability of spawner biomass being above B_{Lim}	*SB*
Yield : maximize catches across regions and gears	
10. Mean catch (1’000 t)	*C*
11. Mean catch by region and/or gear (1’000 t)	*C*
12. Mean catch relative to MSY	*C/MSY*

MSE

- Advice on key management objectives to aid tuning process
- Secondary objectives and improvement of performance indicators,

Abundance: maximize catch rates to enhance fishery profitability	
13. Mean catch rates (by region and gear) (for fisheries with meaningful catch-effort relationship)	*I*
Stability: maximize stability in catches to reduce commercial uncertainty	
14. Mean absolute proportional change in catch	*C*
15. % Catch co-efficient of variation	*C*
16. Probability of shutdown	*C*

BUT ALSO TO CONSIDER THE

- Different behavior of the MP simulations depending on the Population Starting point: healthy stock vs. overfished stock.
  - Not only the objective is important but also how it is reached.
- 1 phase MP including Recovery + maintaining the stock in good condition or 2 phase MP with recovery phase + after recovery phase,
- Timeframe of averaging performance statistics when in recovery vs maintaining healthy stock

Advantages of Management Procedure Tuning

- Helps clarify the Commission objectives
  - Can achieve highest priority objective exactly
  - Much easier to select among MPs on the basis of secondary and tertiary performance measures
- Simplifies communication of results
  - i.e. from many (100s) of MPs to a small number (5-10)
- Allows MP developers to focus on the appropriate trade-off space
  - Better MP performance is achievable with a narrower focus
- The guiding principle for MP selection is the management performance, not the HCR
- MP control parameters may or may not correspond to TRPs and LRPs

PRESENTATION OF MSE RESULTS AGREED BY SC

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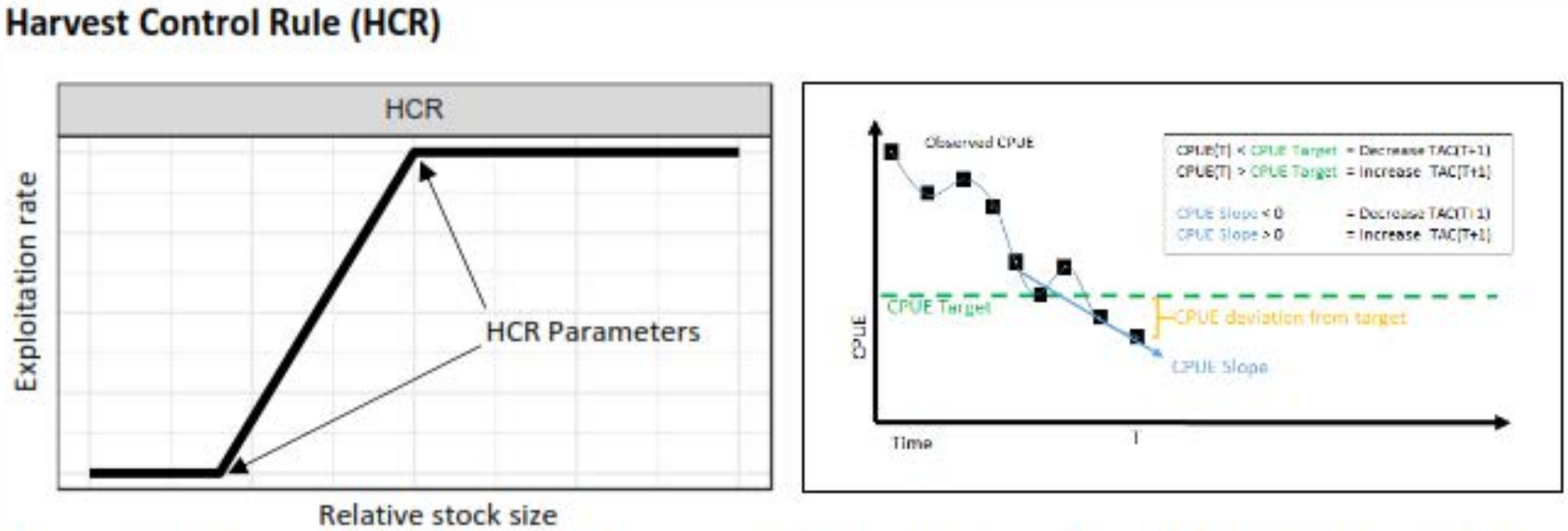
Proposal for presenting MSE results

1. **Illustrate the MPs** that have been evaluated in a figure and/or briefly define them in text.
2. Present the results for the performance of each MP in:
   a. **Boxplots** for a representative subset of performance measures
   b. **Trade-off plots** for a representative subset of performance measures
   c. **A summary table** that ranks the performance of each MP against a subset of performance measures
   d. **A Kobe plot** for the B/B_{MSY} and F/F_{MSY} performance measures
   e. **Time series plots** for stock size and fishing intensity performance measures.
3. Provide a clear and **succinct summary** of the performance of each MP.
4. Provide the numerical results for each MP across all 16 performance measures endorsed by the SC in a table in an appendix.

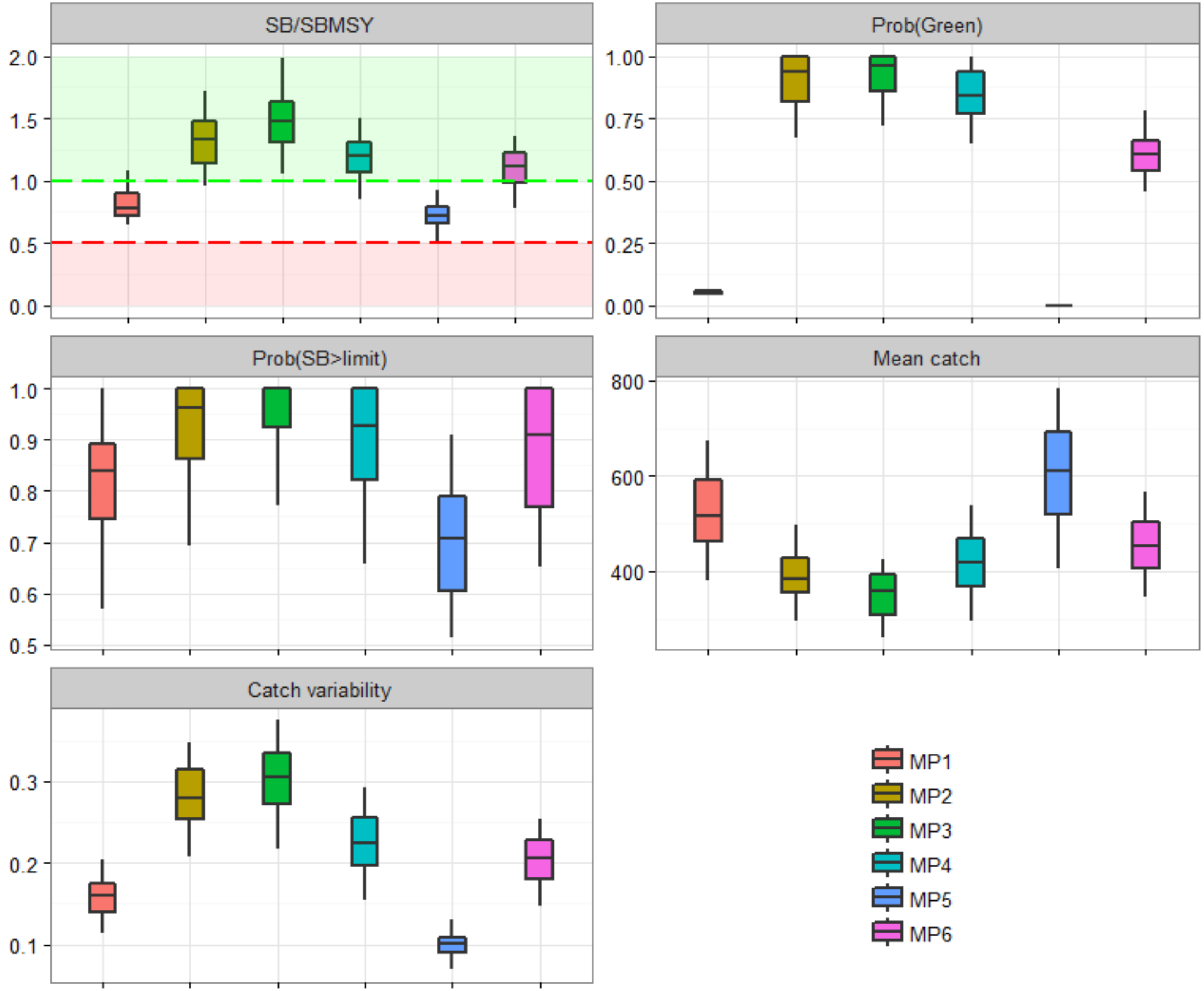
1. Illustrate candidate MPs or HCRs



Examples of two different types of harvest control rules: Biomass-based HCR relating exploitation rate to relative stock size (left), and cpue-based HCR relating observed cpue to a target level cpue. (right).

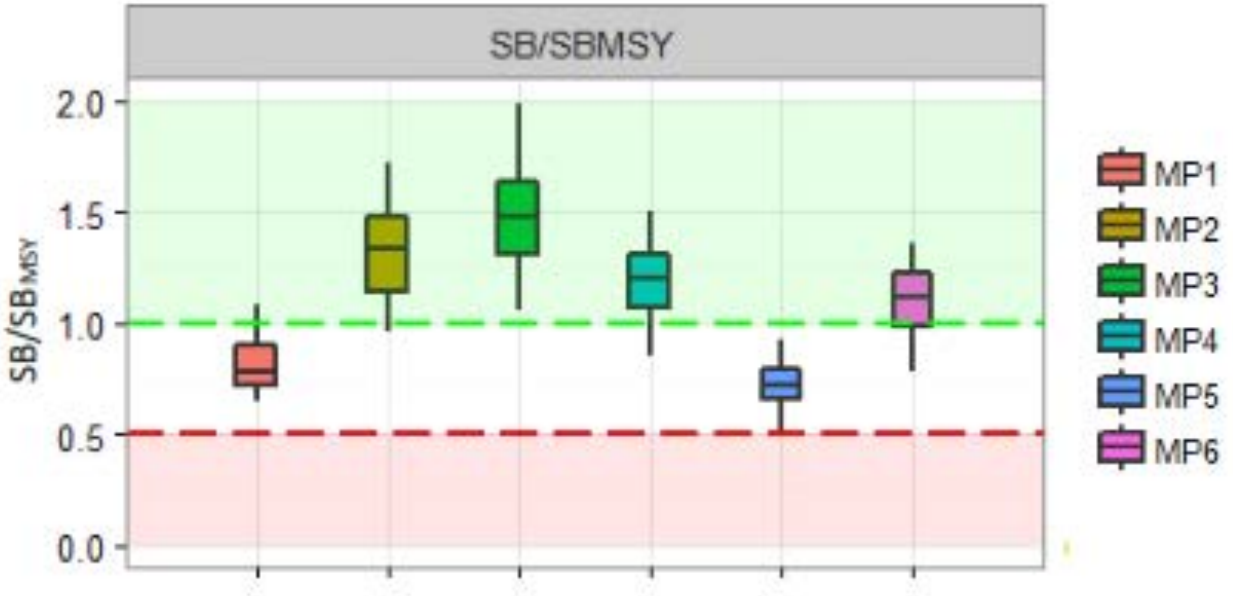
It will be important that decision makers have a clear understanding of the MPs (or HCRs) that have been evaluated. **To achieve this, a clear description of each MP (or HCR) should be presented prior to the MSE results**, along with an explanation of the relevant decision steps involved.

2. Performance of MPs – (a) Box plots



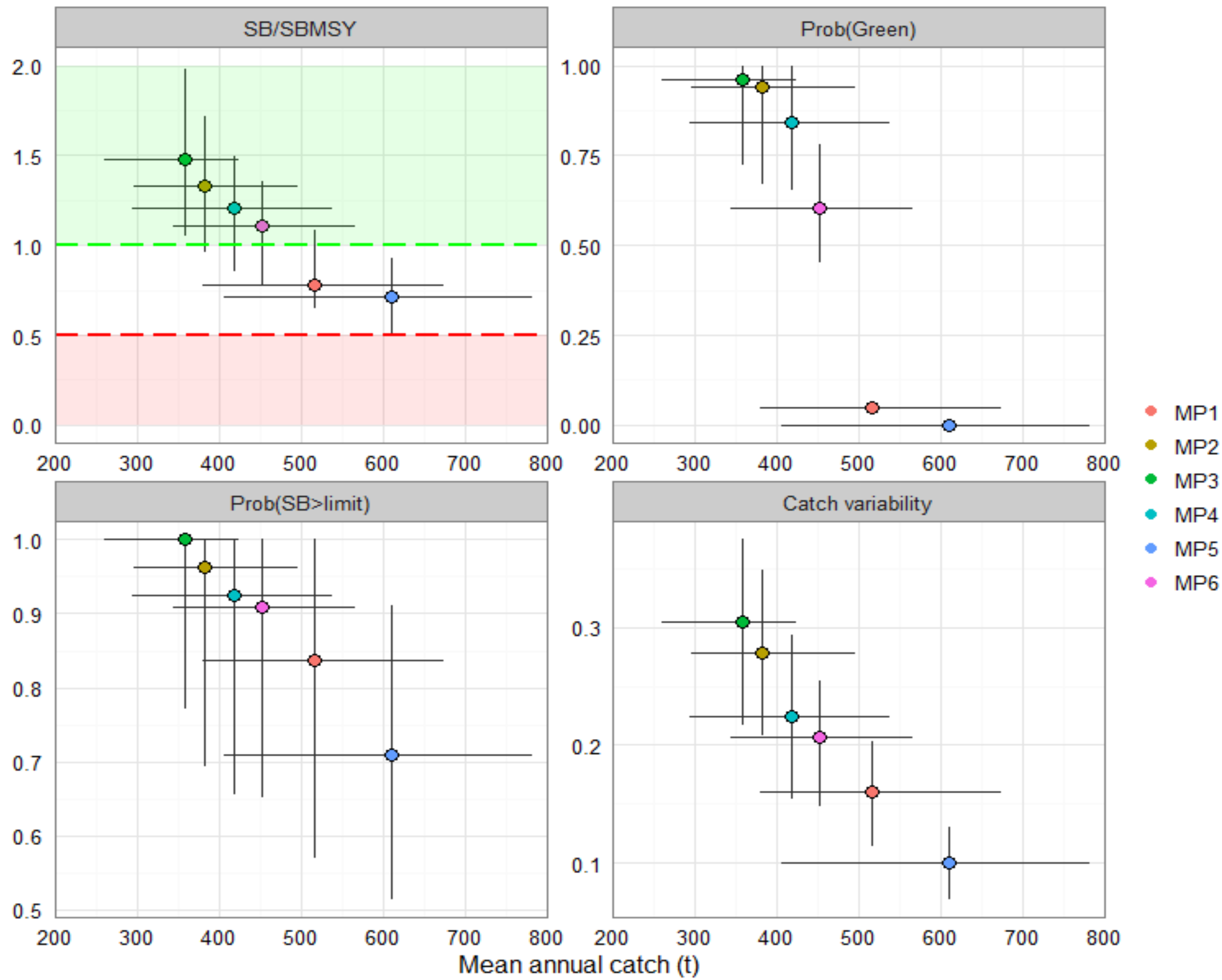
2. Performance of MPs – Box plots

Boxplot comparing performance of Management Procedures (MPs)



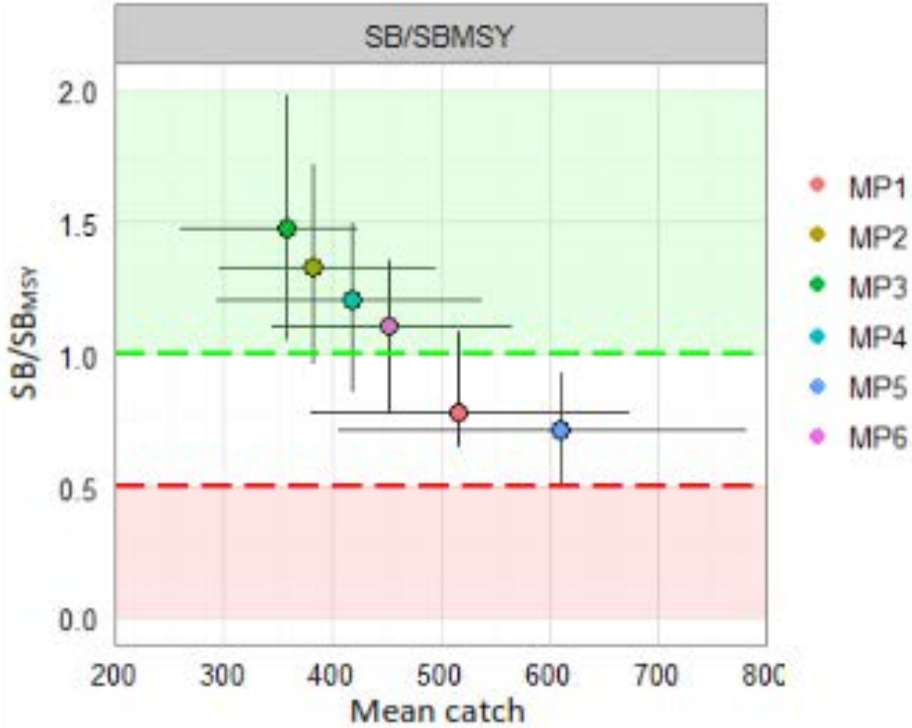
This example boxplot compares the performance of 6 MPs against SB/SB$_{MSY}$. Each data point represents the median over 20 years of simulation in the projection period as the horizontal line, 25th - 75th percentiles as coloured bars, and 10th - 90th percentiles as thin lines. Limit and target reference points are indicated by red and green dashed lines respectively.

2. Performance of MPs – (b) Trade-off plots



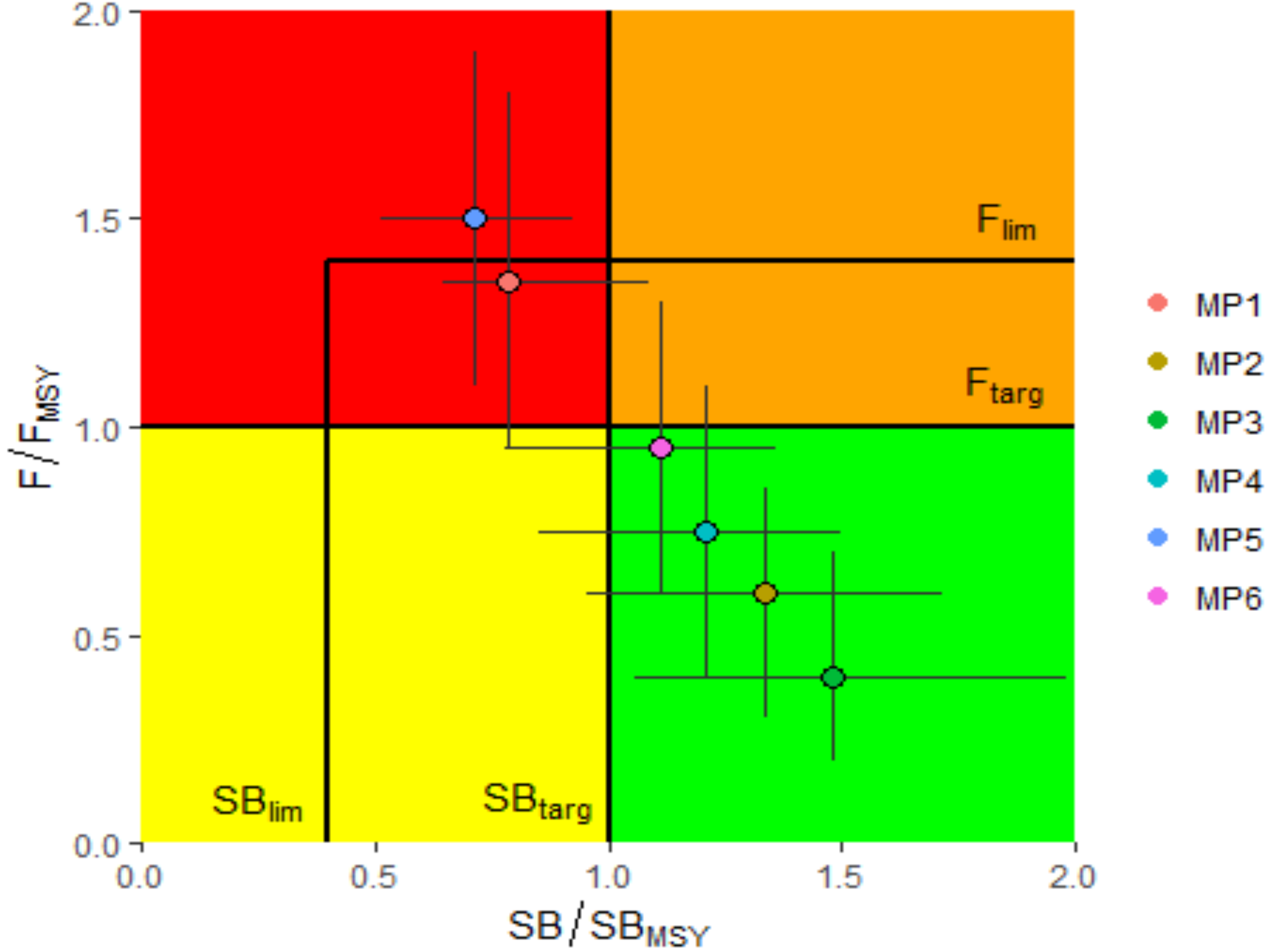
2. Performance of MPs – (b) Trade-off plots

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.

2. Performance of MPs – (d) Kobe plot

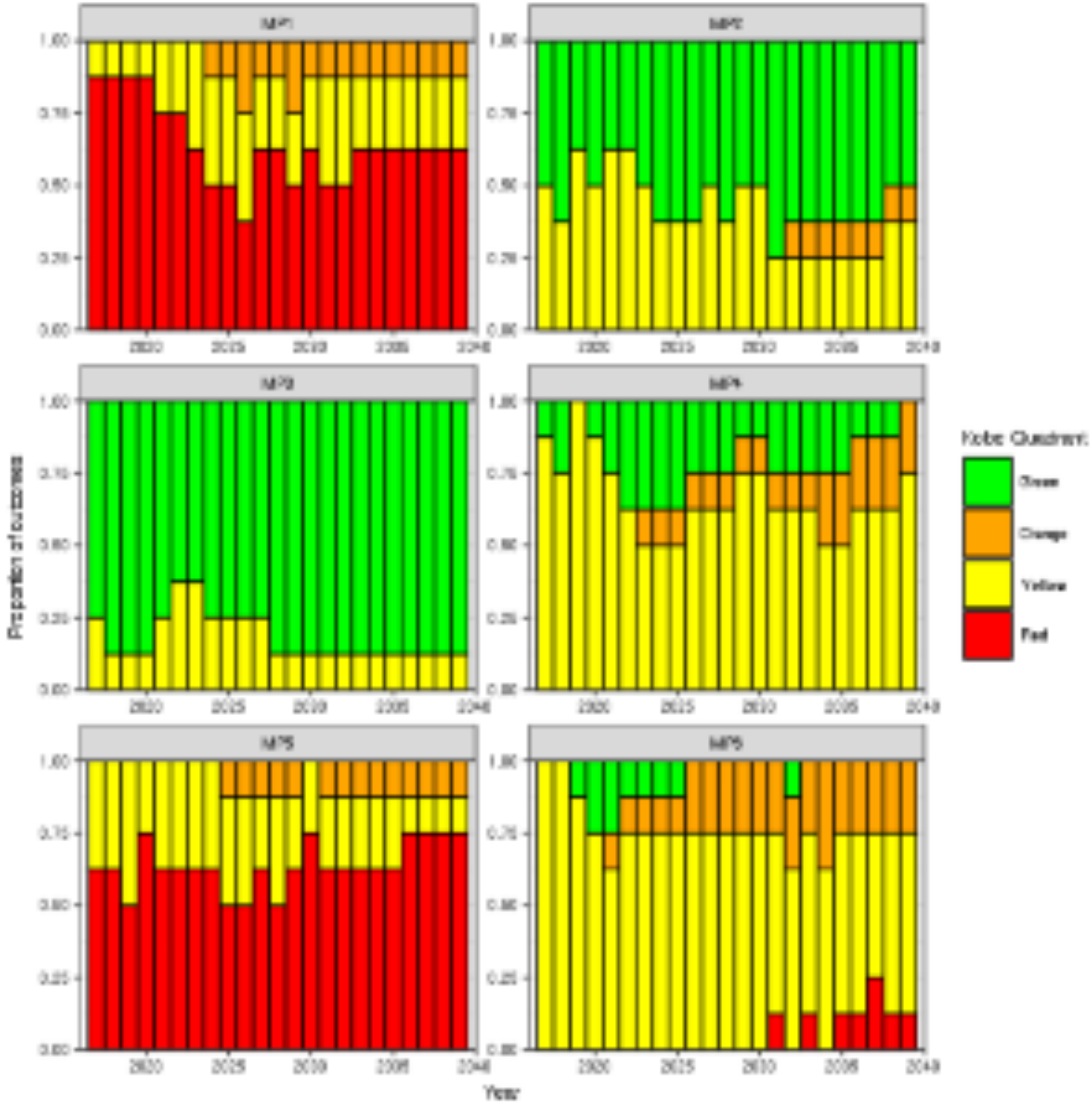


2. Performance of MPs – (c) summary table

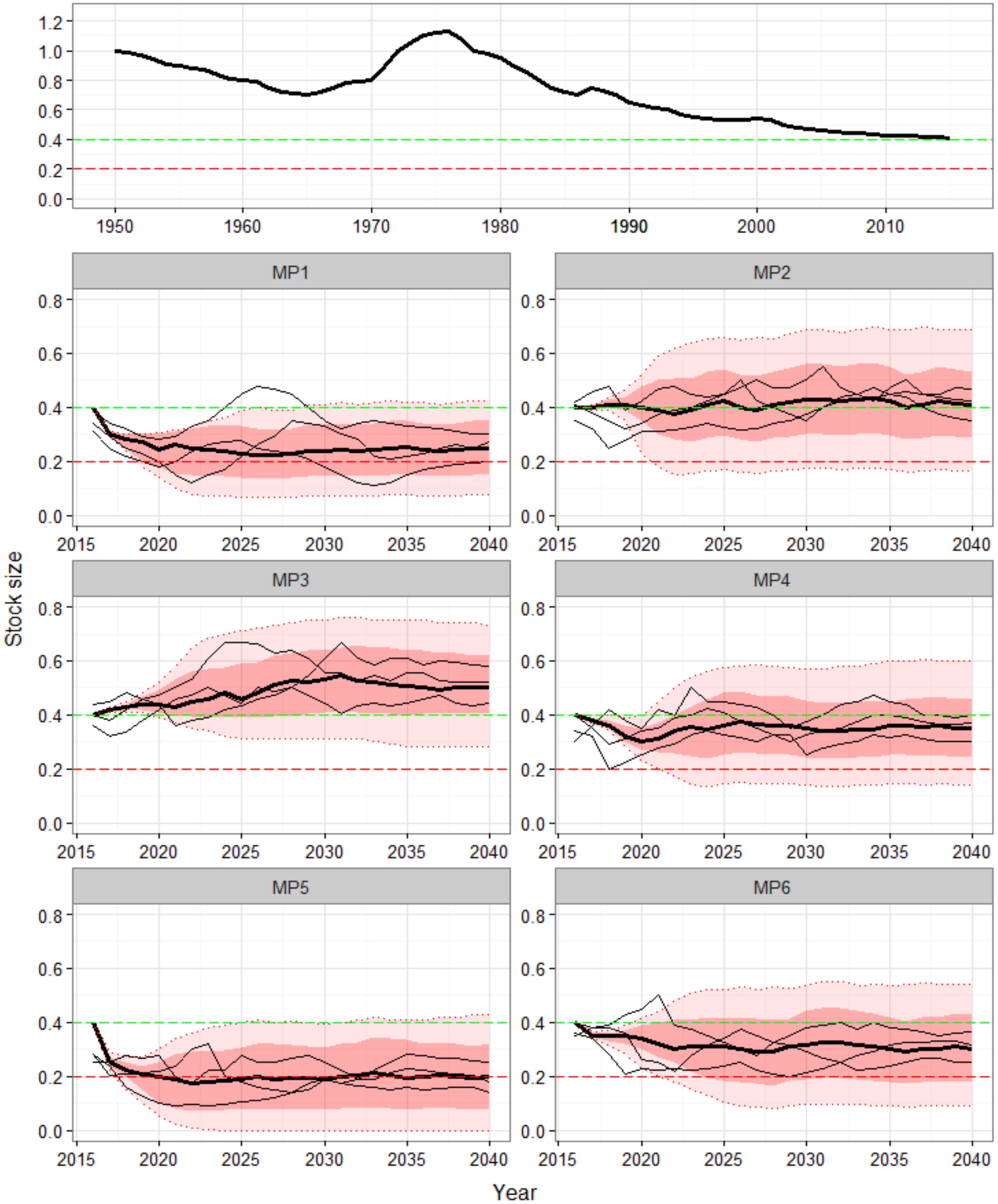
Management Procedure	Performance Measure				
	SB/SB_{MSY}	Prob(Green)	Prob(SB>limit)	Mean Catch	Catch variability
MP1	0.78	0.05	0.84	516	0.16
MP2	1.33	0.94	0.96	383	0.28
MP3	1.48	0.96	1	358	0.3
MP4	1.21	0.84	0.93	419	0.22
MP5	0.72	0	0.71	611	0.1
MP6	1.11	0.61	0.91	452	0.21

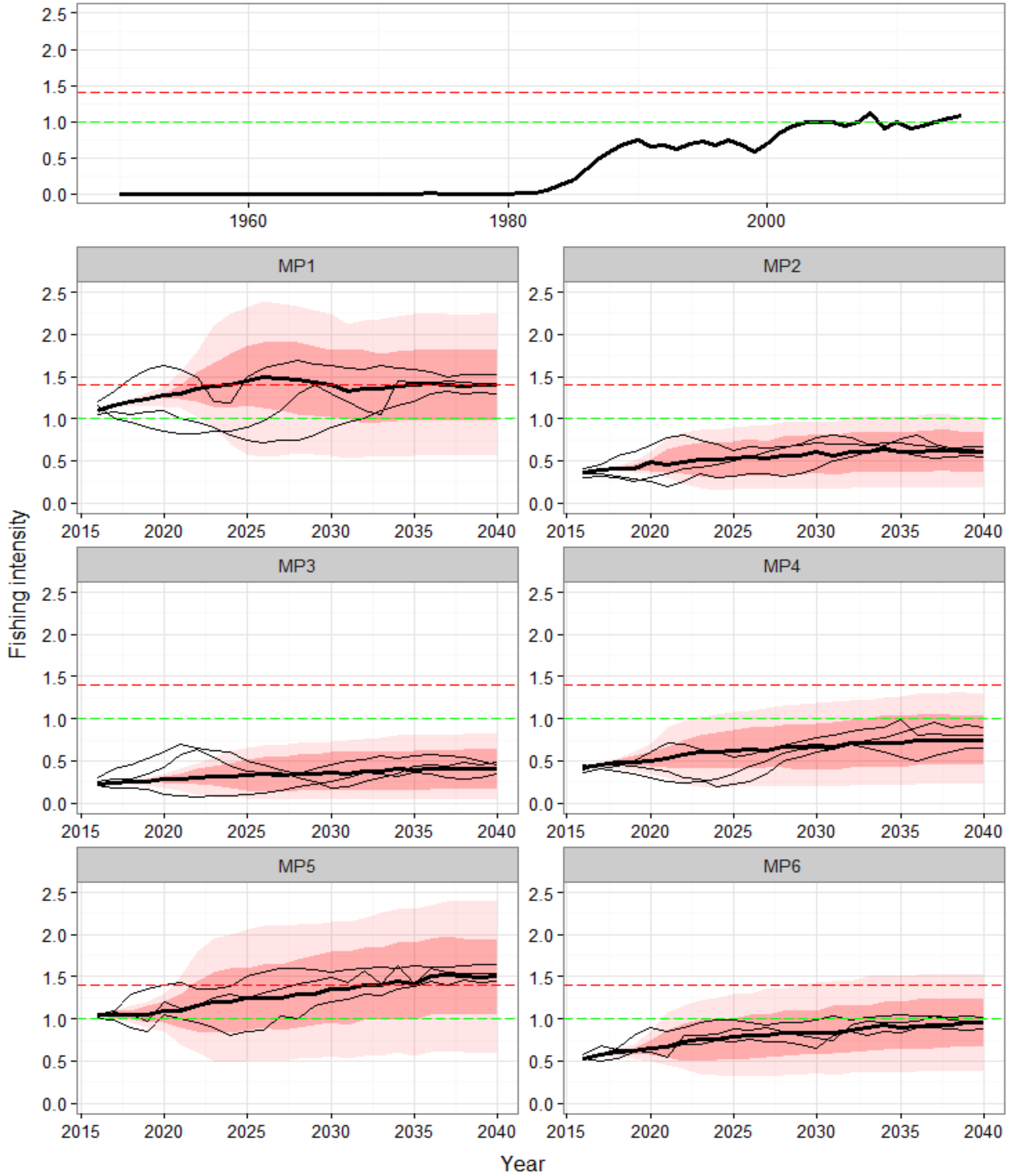
Summary table of performance of Management Procedures (MPs). Performance of 6 MPs against 5 performance measures averaged over 20 years of simulation in the projection period. Shading indicates the relative performance for each MP (dark = better, light = worse).

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



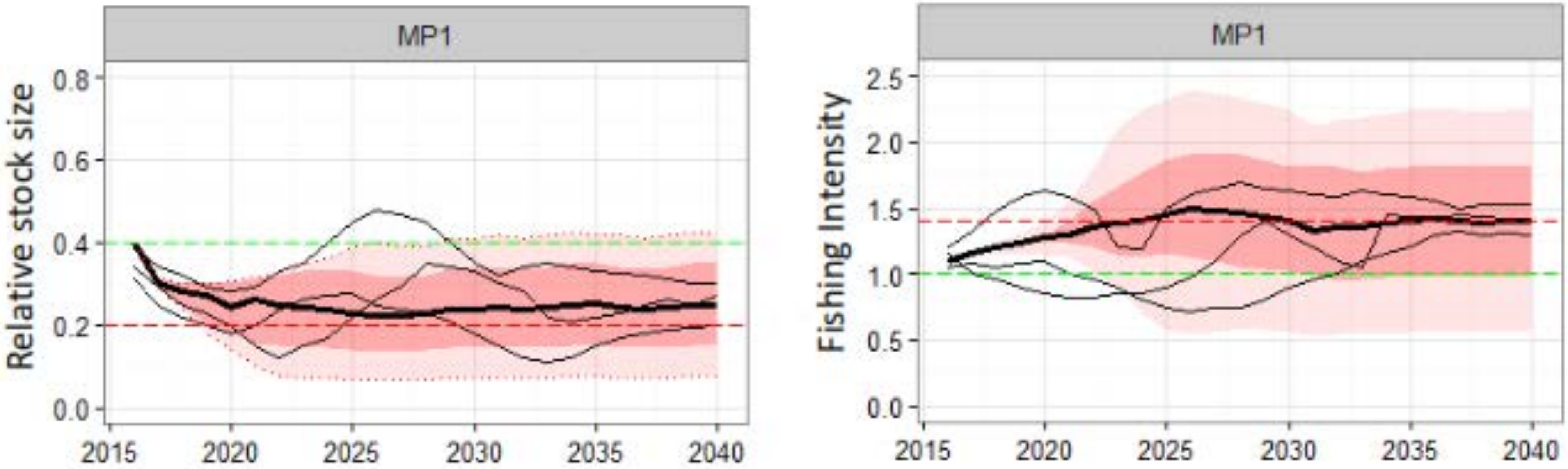
2. Performance of MPs – (e) Time series plots





2. 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.

3. Summary performance of MPs

- **MP1** MP1 achieved the second highest catches, and second lowest level of catch variability. There was a 5% chance that MP1 would be at or above the biomass target reference point and 2% chance it would be at or below the fishing mortality target reference point. There is a 25% risk that MP1 will cause the spawning biomass to fall below the limit reference point and a 50% risk that MP1 will cause the fishing mortality to exceed the limit reference point over the next 20 years.
- **MP2** performed …
- **MP3** performed …
- **MP4** performed …
- **MP5** performed …
- **MP6** performed …

4. Details of performance of MPs across all indicators

Status : maximize stock status		1 year						5 years					
		MP1	MP2	MP3	MP4	MP5	MP6	MP1	MP2	MP3	MP4	MP5	MP6
1. Mean spawner biomass relative to pristine	*SB/SB*0	0.5	0.8	0.9	0.7	0.4	0.6	0.5	0.8	1.0	0.7	0.4	0.6
2. Minimum spawner biomass relative to pristine	*SB/SB*0	0.3	0.6	0.6	0.5	0.2	0.4	0.3	0.5	0.6	0.5	0.2	0.4
3. Mean spawner biomass relative to SB_{MSY}	*SB/SBMSY*	0.8	1.3	1.4	1.2	0.7	1.1	0.9	1.2	1.3	1.1	0.7	1.2
4. Mean fishing mortality relative to target	*F/Ftar*	1.4	0.6	0.4	0.8	1.5	0.9	1.4	0.6	0.4	0.8	1.5	0.9
5. Mean fishing mortality relative to *Fmsy*	*F/FMSY*	1.4	0.6	0.4	0.8	1.5	0.9	1.5	0.5	0.4	0.8	1.6	0.9
6. Probability of being in Kobe green quadrant	*SB,F*	0.5	0.9	1	0.8	0.3	0.7	0.5	0.9	0.9	0.8	0.3	0.7
7. Probability of being in Kobe red quadrant	*SB,F*	0.3	0.1	0	0.1	0.5	0.2	0.3	0.1	0.0	0.1	0.5	0.2
Safety : *maximize the probability of remaining above low stock status (i.e. minimize risk)*													
8. Probability of spawner biomass being above 20% of *SB0*	*SB*	0.8	0.9	0.9	0.8	0.7	0.8	0.8	0.8	0.9	0.8	0.7	0.8
9. Probability of spawner biomass being above *B*Lim	*SB*	0.8	1.0	1.0	0.9	0.7	0.9	0.8	1.0	1.0	0.9	0.7	0.8
Yield : maximize catches across regions and gears													
10. Mean catch (1'000 t)	*C*	520	390	350	430	600	460	551	417	378	434	600	460
11. Mean catch by region and/or gear (1'000 t)	*C*	250	200	180	210	310	220	248	194	176	229	335	218
12. Mean catch relative to MSY	*C/MSY*	1.1	0.7	0.6	0.8	1.2	0.9	1.2	0.6	0.6	0.8	1.3	1.0
Abundance: maximize catch rates to enhance fishery profitability													
13. Mean catch rates (by region and gear) (for fisheries with meaningful catch-effort relationship)	*I*	3.2	3.8	3.9	2.7	2.5	2.6	3.0	3.8	4.0	2.6	2.3	2.8
Stability: maximize stability in catches to reduce commercial uncertainty													
14. Mean absolute proportional change in catch	*C*	0.2	0.3	0.3	0.2	0.1	0.2	0.2	0.3	0.3	0.2	0.1	0.2
15. % Catch co-efficient of variation	*C*	20	25	24	18	12	21	19.4	27.3	26.2	17.6	11.5	21.0
16. Probability of shutdown	*C*	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

4. Details of performance of MPs across all indicators

Status : maximize stock status		10 years						20 years					
		MP1	MP2	MP3	MP4	MP5	MP6	MP1	MP2	MP3	MP4	MP5	MP6
1. Mean spawner biomass relative to pristine	*SB/SB*0	0.5	0.8	0.9	0.7	0.4	0.6	0.5	0.8	1.0	0.7	0.4	0.6
2. Minimum spawner biomass relative to pristine	*SB/SB*0	0.3	0.6	0.6	0.5	0.2	0.4	0.3	0.5	0.6	0.5	0.2	0.4
3. Mean spawner biomass relative to SB_{MSY}	*SB/SBMSY*	0.8	1.3	1.4	1.2	0.7	1.1	0.9	1.2	1.3	1.1	0.7	1.2
4. Mean fishing mortality relative to target	*F/Ftar*	1.4	0.6	0.4	0.8	1.5	0.9	1.4	0.6	0.4	0.8	1.5	0.9
5. Mean fishing mortality relative to *Fmsy*	*F/FMSY*	1.4	0.6	0.4	0.8	1.5	0.9	1.5	0.5	0.4	0.8	1.6	0.9
6. Probability of being in Kobe green quadrant	*SB,F*	0.5	0.9	1	0.8	0.3	0.7	0.5	0.9	0.9	0.8	0.3	0.7
7. Probability of being in Kobe red quadrant	*SB,F*	0.3	0.1	0	0.1	0.5	0.2	0.3	0.1	0.0	0.1	0.5	0.2
Safety : *maximize the probability of remaining above low stock status (i.e. minimize risk)*													
8. Probability of spawner biomass being above 20% of *SB0*	*SB*	0.8	0.9	0.9	0.8	0.7	0.8	0.8	0.8	0.9	0.8	0.7	0.8
9. Probability of spawner biomass being above *B*Lim	*SB*	0.8	1.0	1.0	0.9	0.7	0.9	0.8	1.0	1.0	0.9	0.7	0.8
Yield : maximize catches across regions and gears													
10. Mean catch (1'000 t)	*C*	520	390	350	430	600	460	551	417	378	434	600	460
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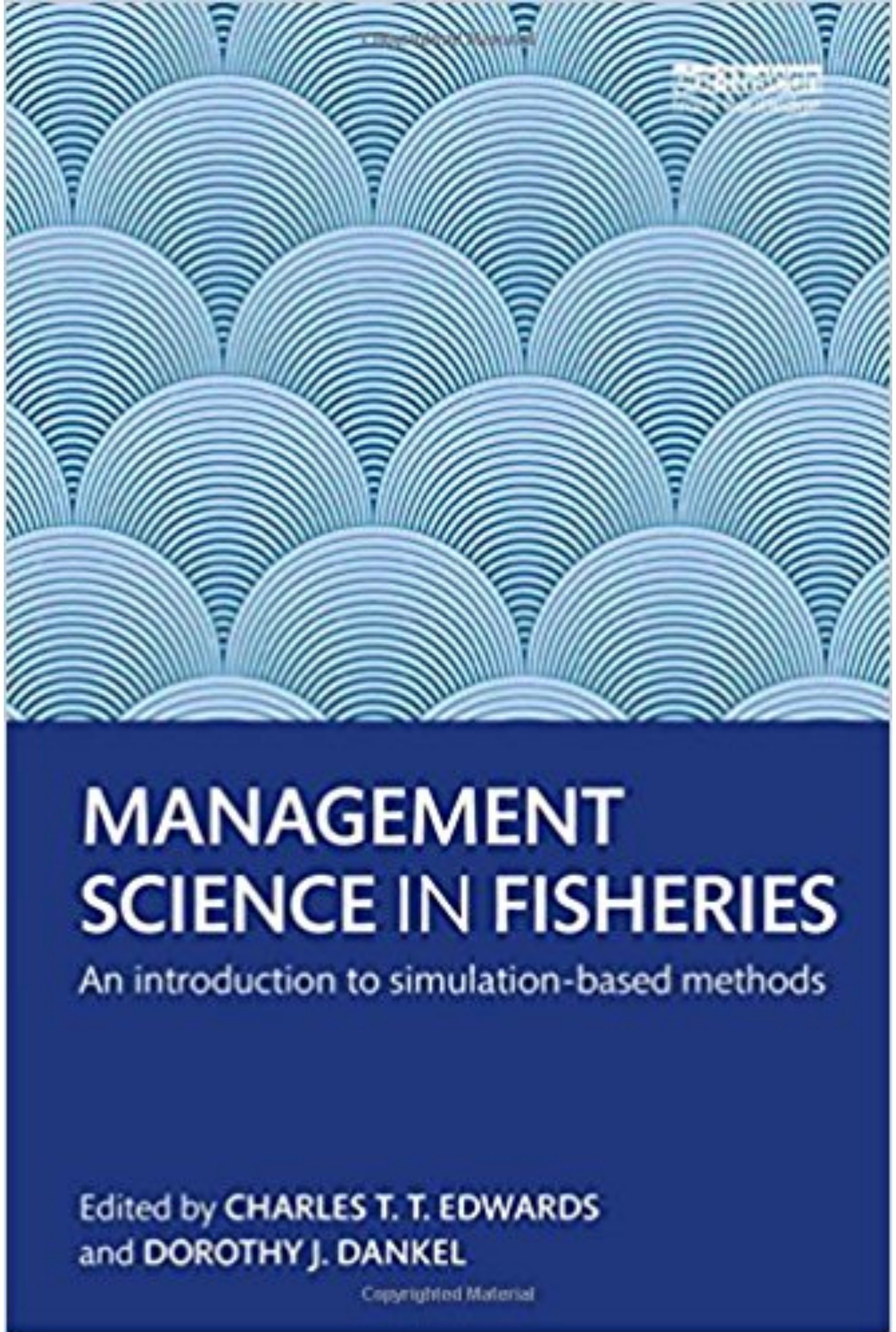
Abundance: maximize catch rates to enhance fishery profitability													
13. Mean catch rates (by region and gear) (for fisheries with meaningful catch-effort relationship)	*I*	3.2	3.8	3.9	2.7	2.5	2.6	3.0	3.8	4.0	2.6	2.3	2.8
Stability: maximize stability in catches to reduce commercial uncertainty													
14. Mean absolute proportional change in catch	*C*	0.2	0.3	0.3	0.2	0.1	0.2	0.2	0.3	0.3	0.2	0.1	0.2
15. % Catch co-efficient of variation	*C*	20	25	24	18	12	21	19.4	27.3	26.2	17.6	11.5	21.0
16. Probability of shutdown	*C*	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01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SCIENCE IN FISHERIES
An introduction to simulation-based methods
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apter 13: Empirical and model-based contr
ata Hiroaki

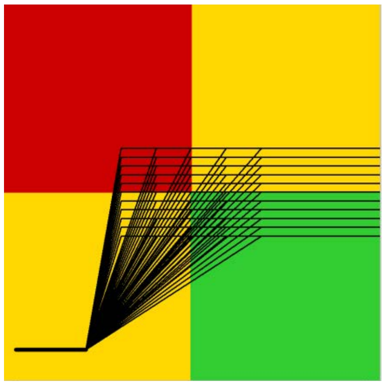
Introduction to Management Strategy Evaluation with TunaMSE: Stock assessment vs MPs

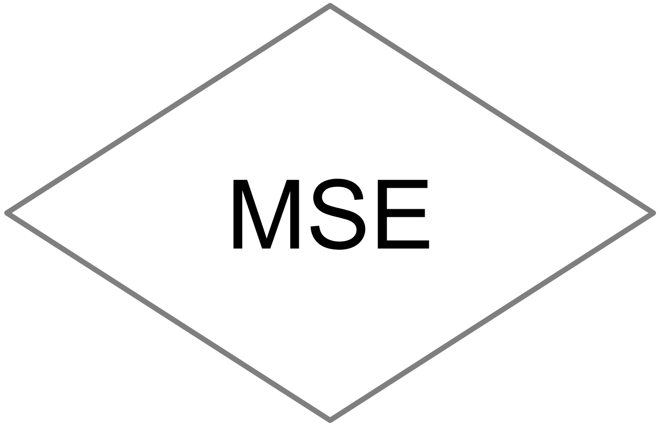
Dan Fu (IOTC)

Bangkok, Thailand, 21-22 January 2020

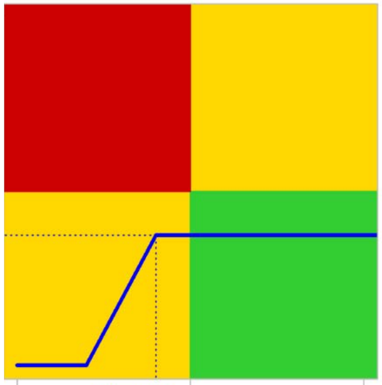
Management strategy evaluation

Candidate management procedures





Agreed management procedures



- Management objectives
- Operating models
- Simulation testing
- Performance measures

Management Strategy Evaluation

- Assess the performance of a potential MP
  - Meet management objectives ?
- Compare amongst MPs
  - Considering many possibilities – we don't know what future/reality is
  - Considering trade-off among objectives – we cannot get everything,

A hypothetic MSE example (Smith A.D.M.)

- Select amongst 4 MP
  - Constant catch (high and/or low)
  - Constant harvest rate
  - Constant biomass strategy
- Against three objectives
  - Maximise the catch
  - Minimise year-to-year catch variability
  - Minimise the risks of stock falling below a threshold

A hypothetic MSE example

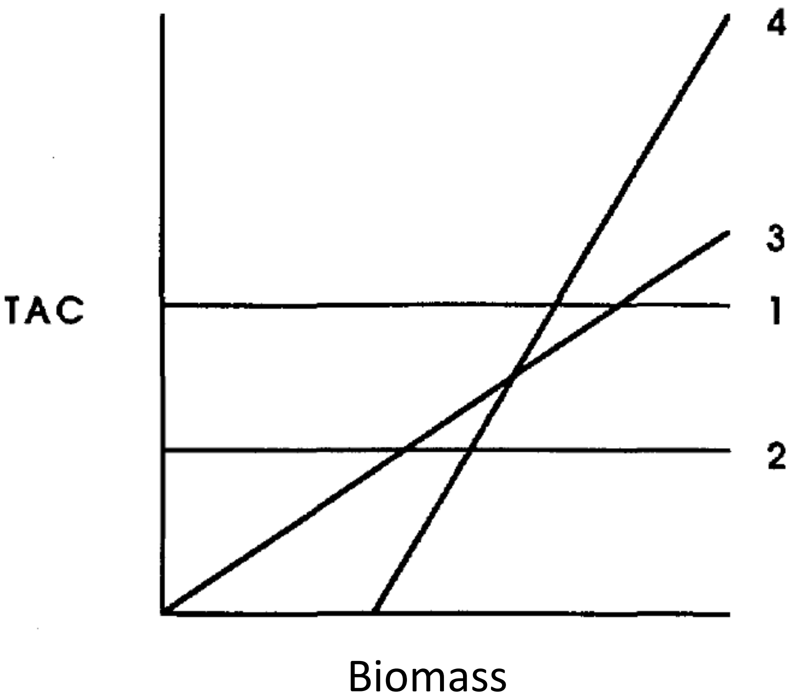
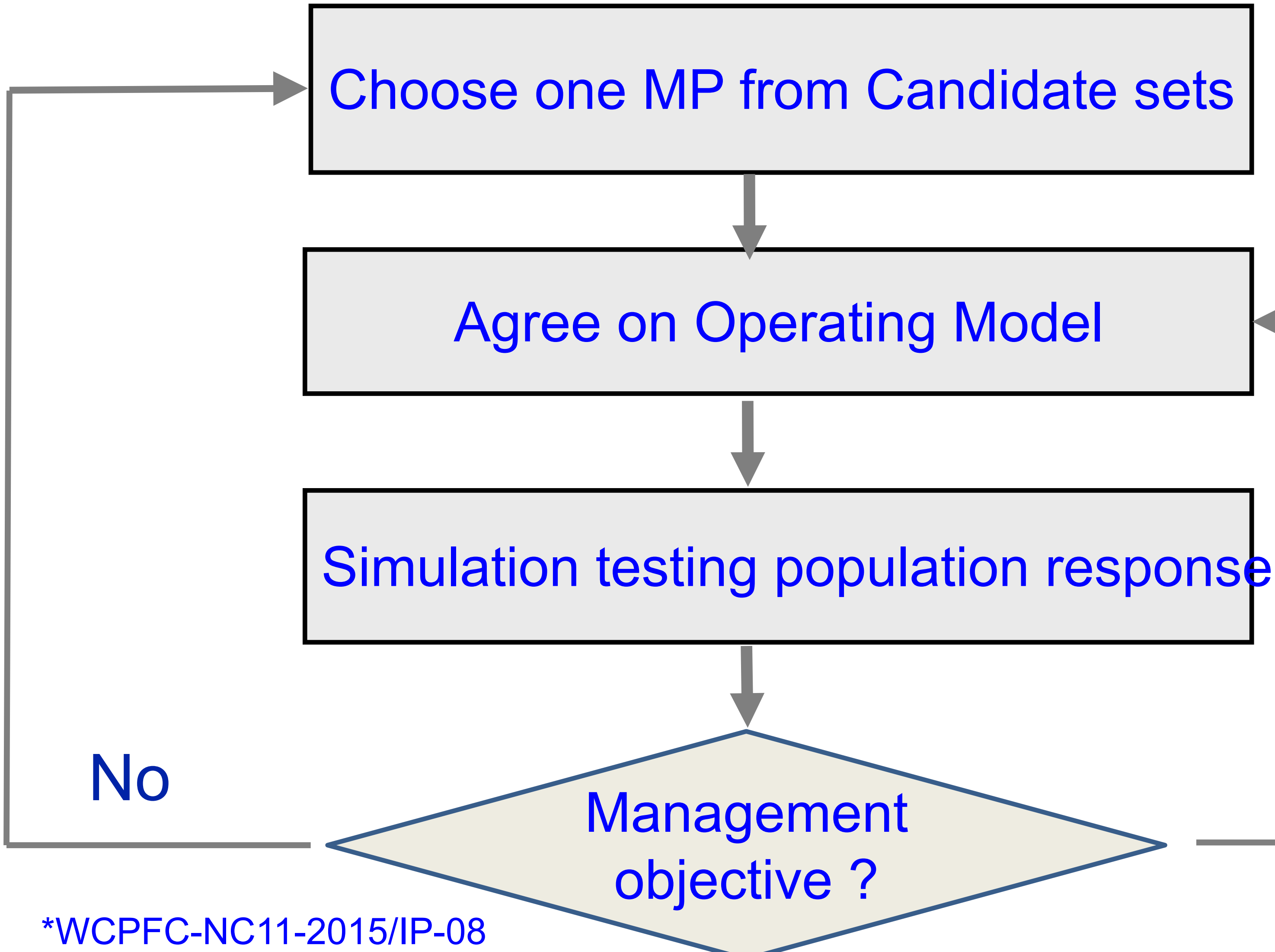


Table 1. Performance of strategies against objectives.

	OBJECTIVE		
	Maximize catch	Minimize variability	Minimize risk
STRATEGY			
Constant high catch	Moderate	Moderate	Poor
Constant low catch	Poor	Good	Moderate
Constant harvest rate	Moderate	Moderate	Moderate
Constant biomass	Good	Poor	Good

Management Strategy evaluation*



*WCPFC-NC11-2015/IP-08

What are we evaluating?

- MSE evaluates management procedure
  - a set of rules that determine TAC from the data

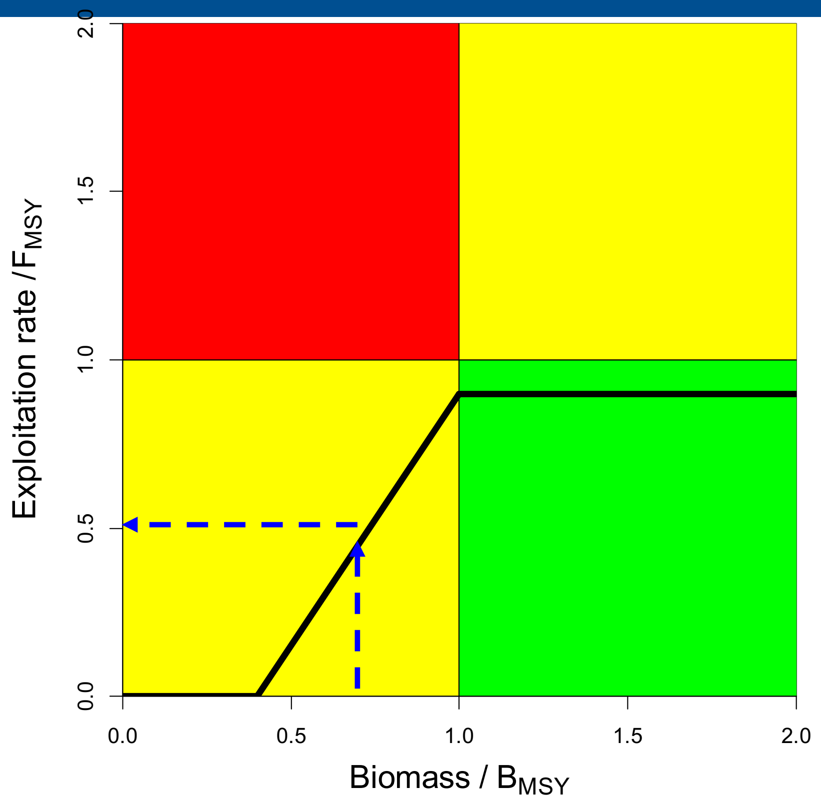
Data + analysis + Harvest control rule

Harvest control rules

- Constant catch or exploitation rate
- CPUE-based rules
- Thresh-hold rules
  - Triggered when stock status approach reference points

Threshold rule example

Output –
exploitation rate
or catch

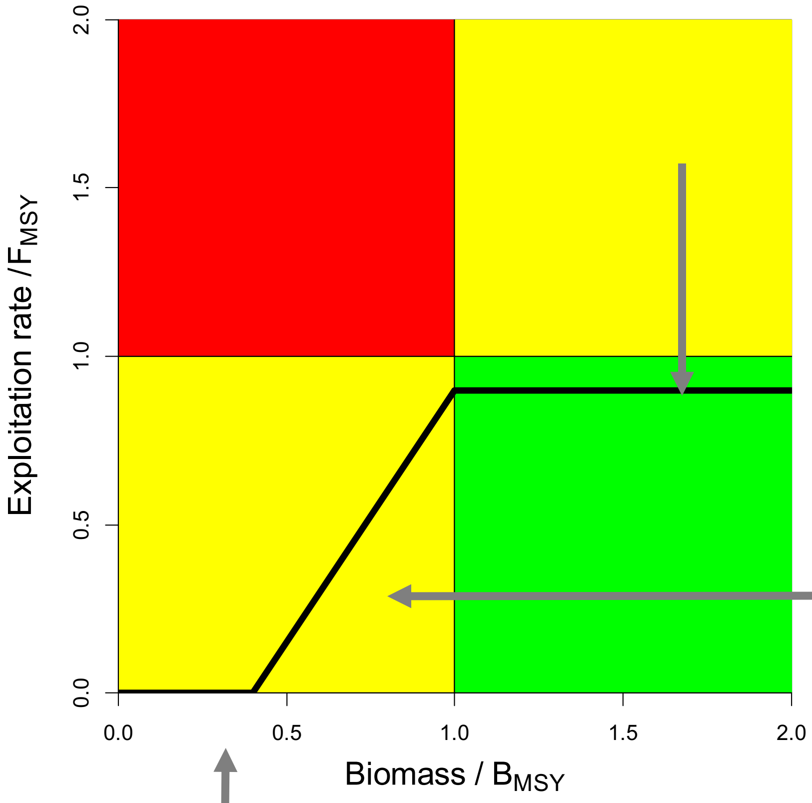


If stock status is 70% Bmsy

Then set F = 50% Fmsy

Input – stock status

Threshold rule example

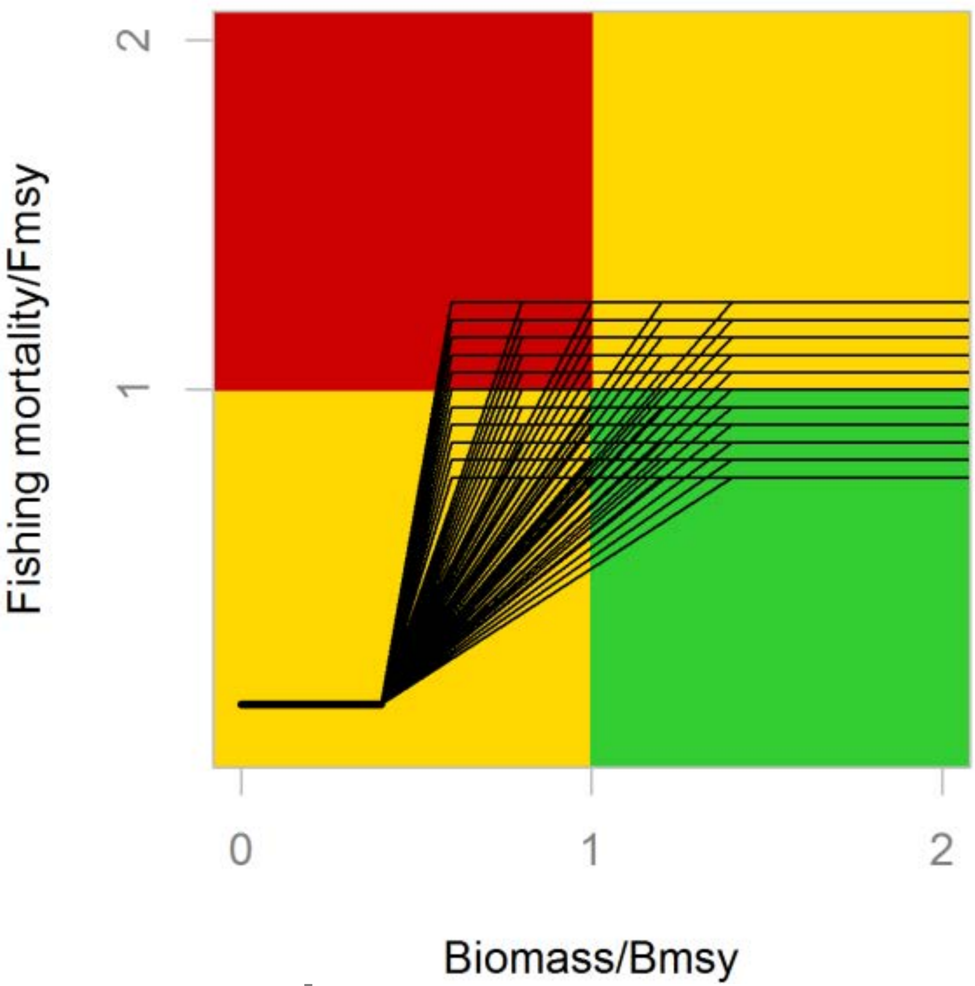


Fishing at maximum F if biomass is above Bmsy

Reduce fishing if biomass is below Bmsy

Stop fishing if biomass is below 40% Bmsy

Threshold rule – control parameters



at's the maximum F

When to reduce

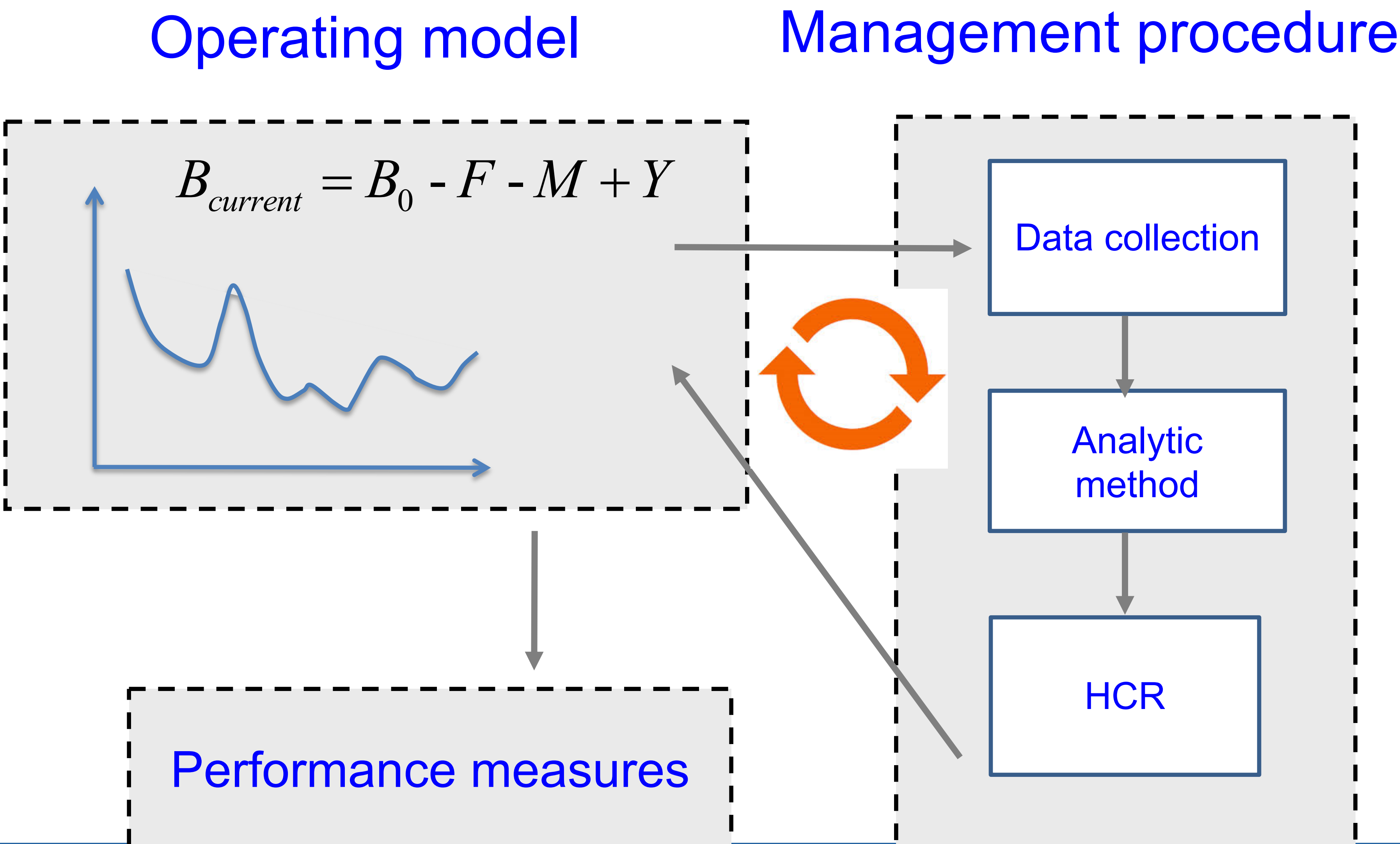
How quickly to reduce?

When to stop

Why HCR needs to be tested

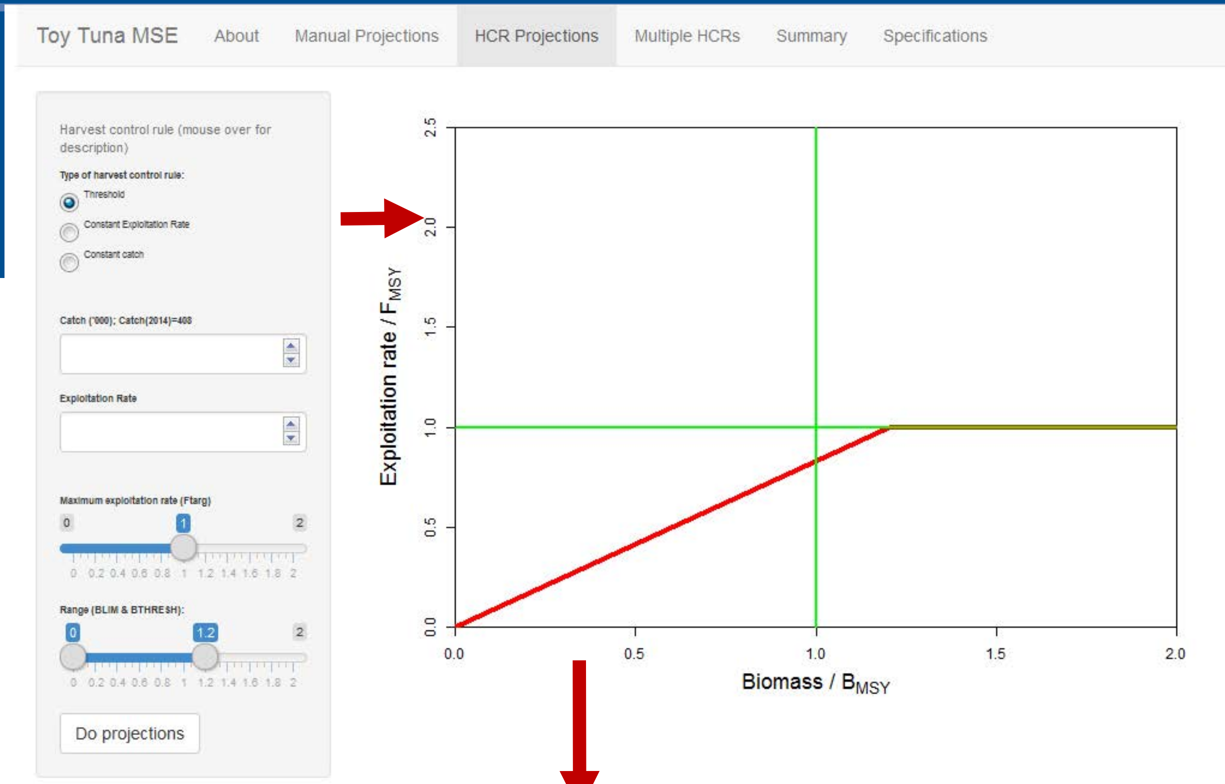
- Performance of a HCR may depend on
  - fishery dynamics
  - Stock productivity
  - Random (recruitment) variability
- Trade-offs in management objectives

Management Strategy evaluation



HCR

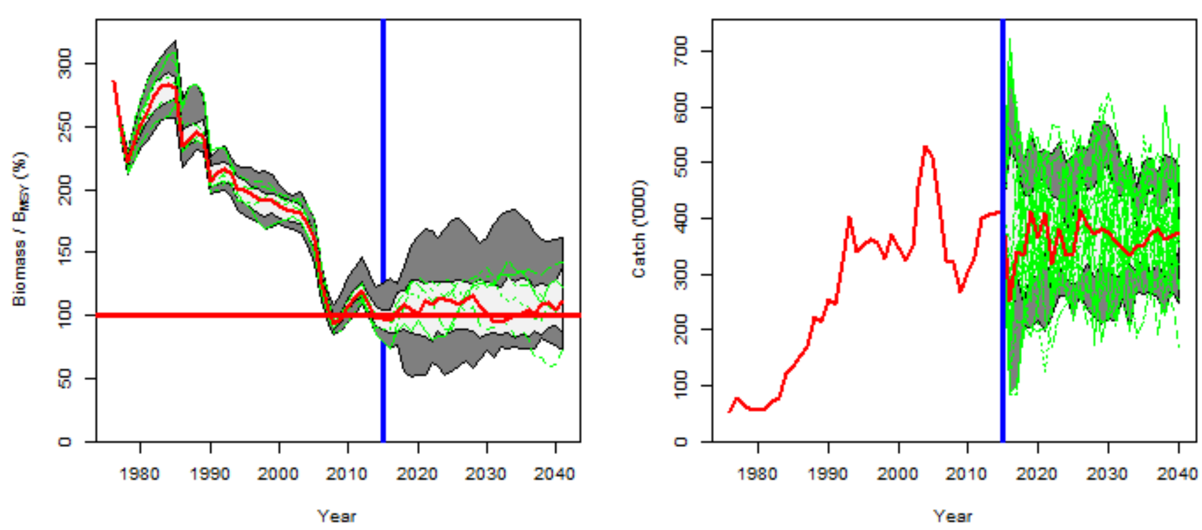
Control parameter



MP output

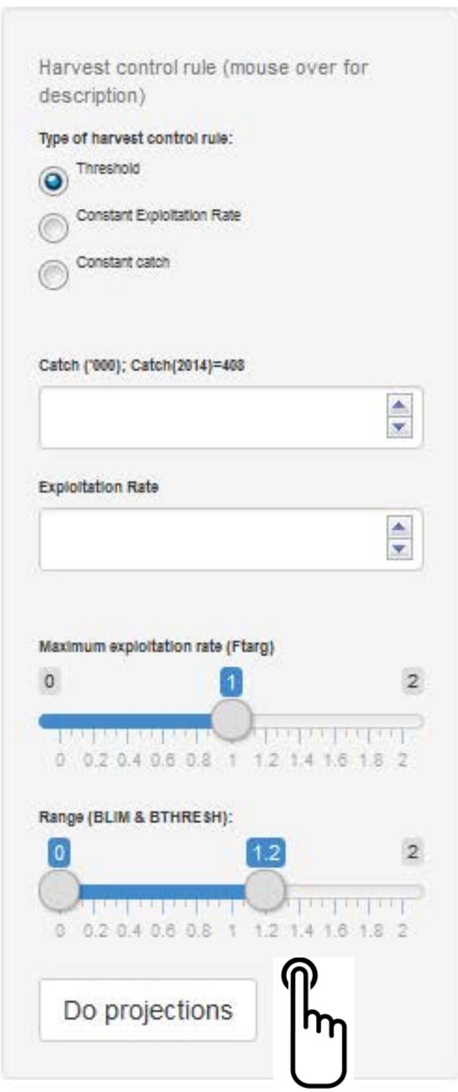
Stock status

Catch



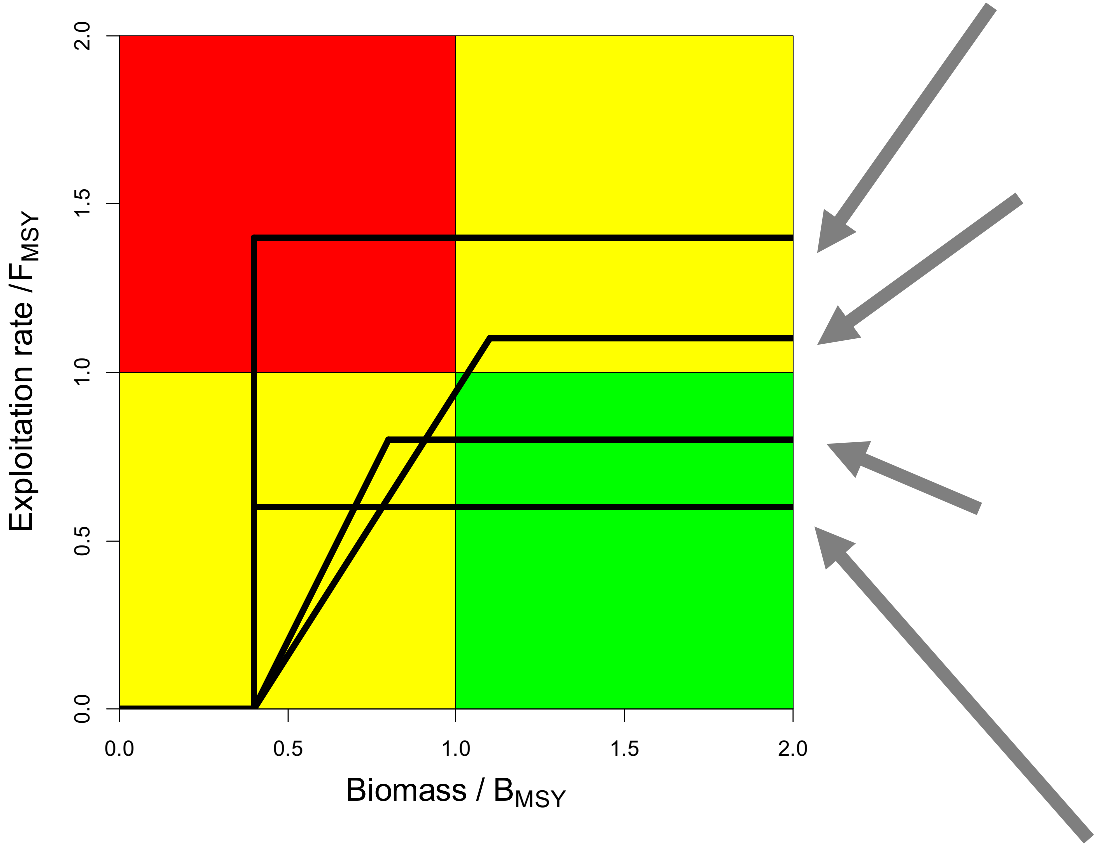
‘Tuna MSE’ – Process

Toy Tuna MSE | About | Manual Projections | **HCR Projections** | Multiple HCRs | Summary | Specifications



1. OM runs from 1950 to 2016
2. Year 2017:
   i. CPUE (1950-2016) collected
   ii. stock status estimated
   iii. Catch for 2017 calculated
   iv. Catch removed from the population
3. Year 2018,… repeat!

HCR examples

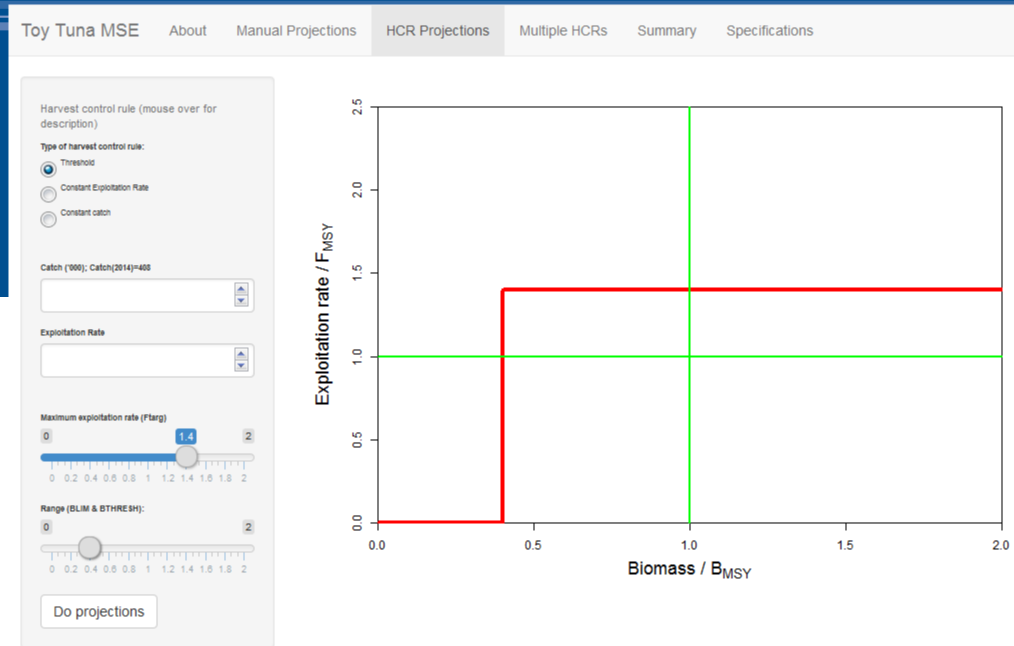


Very Aggressive –
F = 1.4Fmsy

Aggressive –
High F at healthy stocks but quick reaction when stocks start to decline

Conservative –
low F, with less action when stocks start to decline

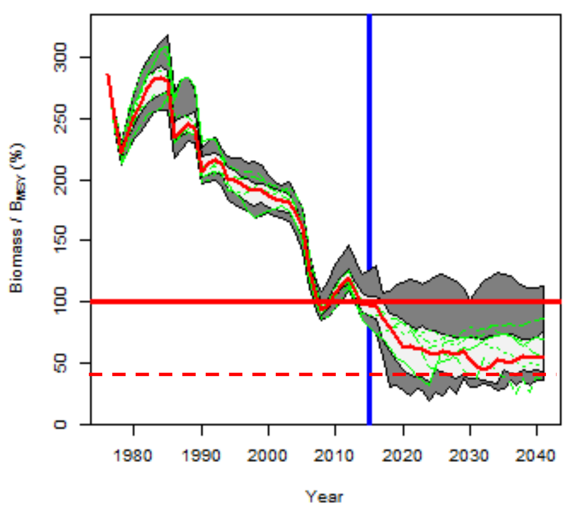
Very conservative –
F = 0.6 Fmsy

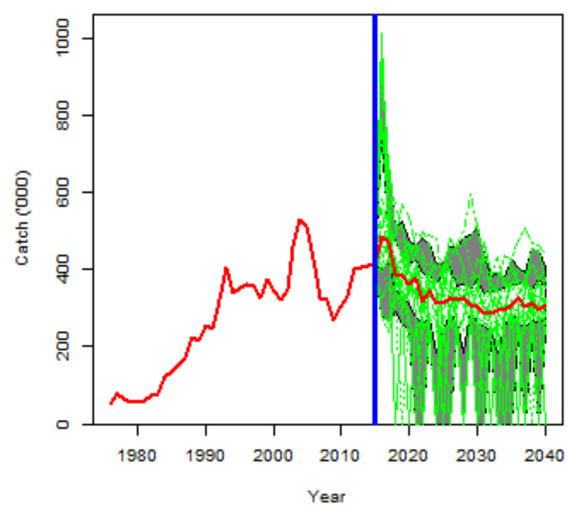


Very Aggressive

Stock status

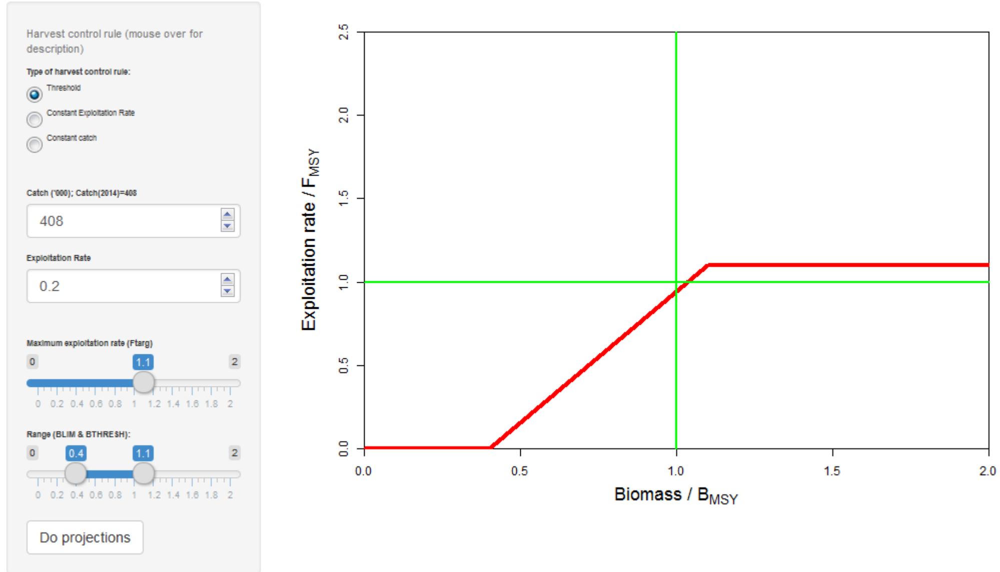
Catch





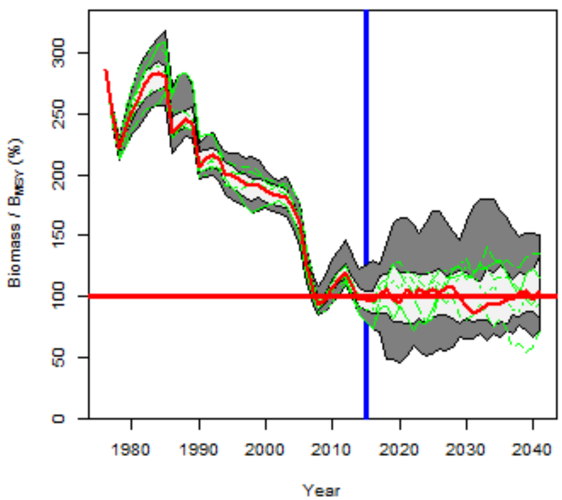
Biomass well below the target

Catch also decline

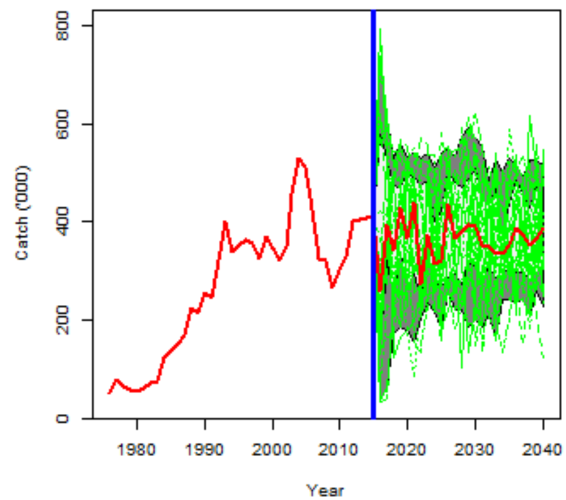


Aggressive

Stock status

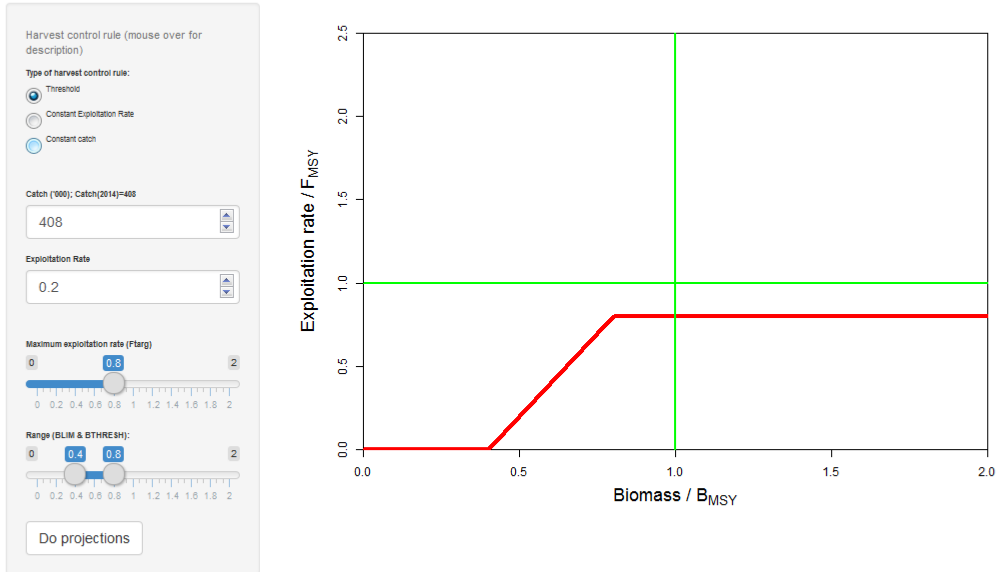


Catch



Biomass below target
for some years

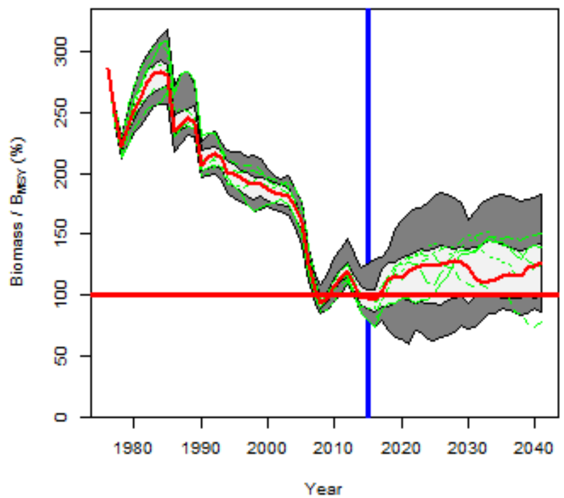
Catch very variable

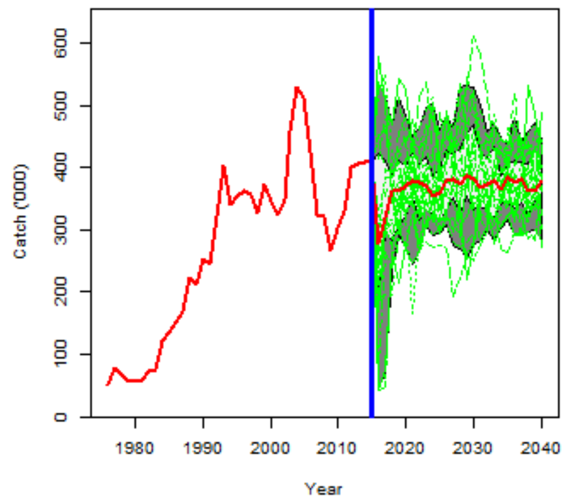


Conservative

Stock status

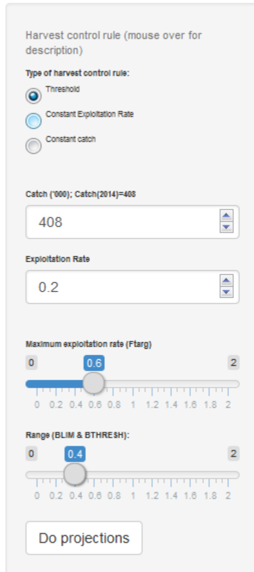
Catch

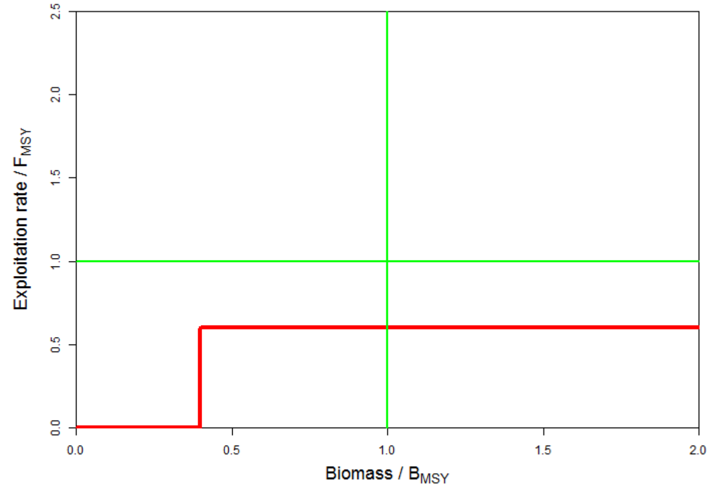




Biomass above the target on average

catch less variable

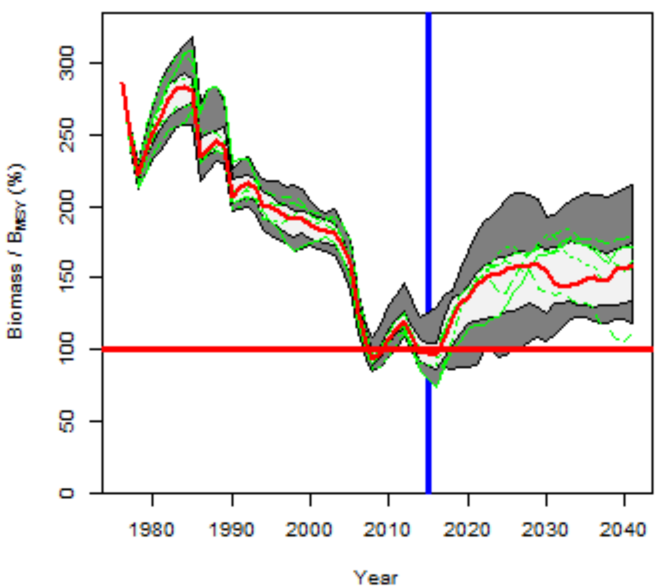


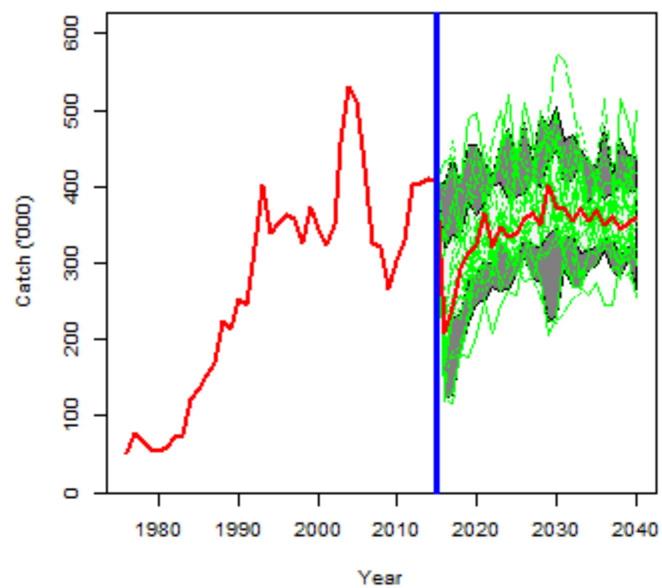


Very conservative

Stock status

Catch

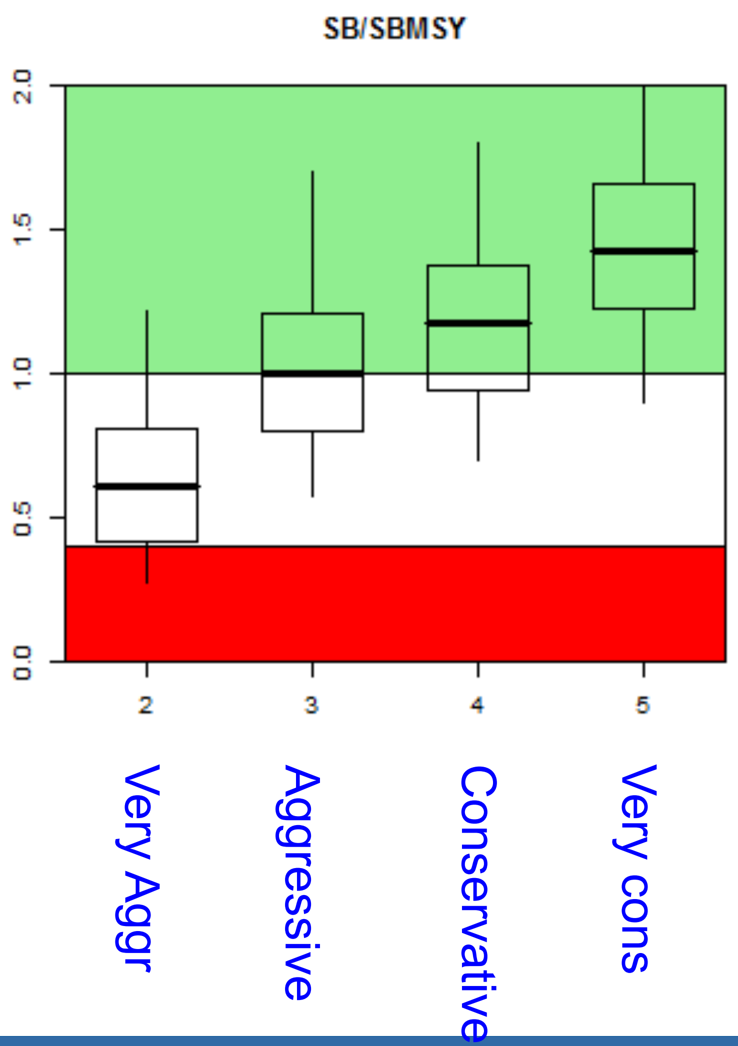


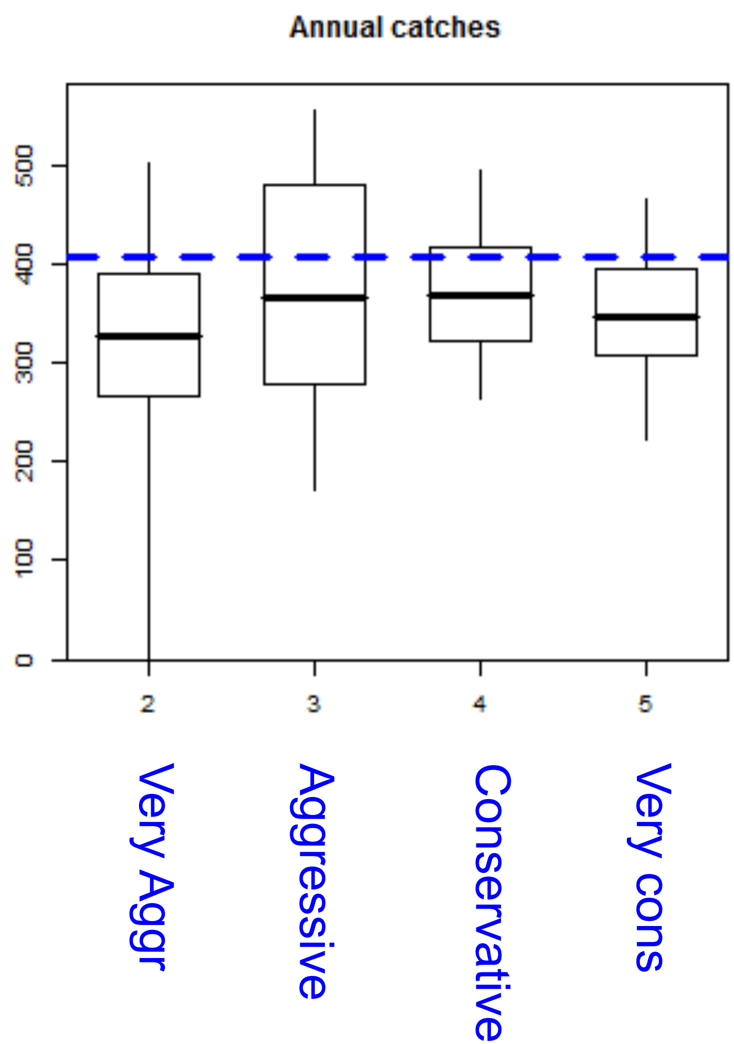


Biomass above target

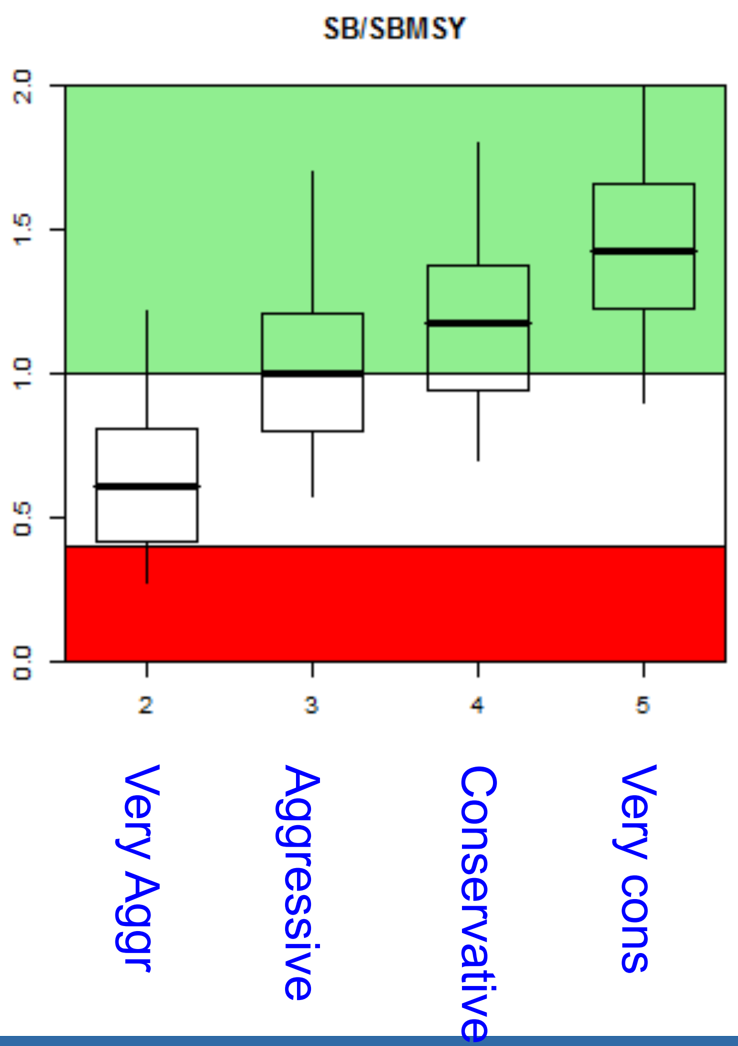
Catch low and variable

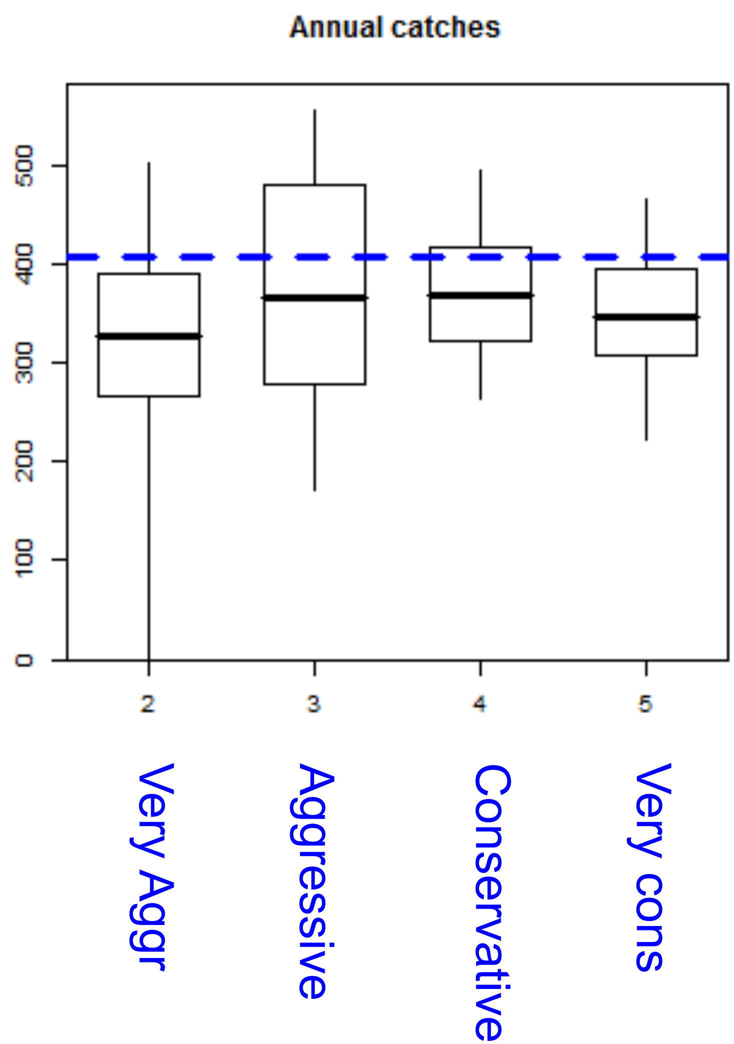
Performance measures





Performance measures





Introduction to Management Strategy Evaluation with TunaMSE: Tuna Shiny App

Dan Fu (IOTC)

Bangkok, Thailand, 21-22 January 2020

Start the tool

- https://puntapps.shinyapps.io/tunamse/
- Go to the location of the HSDTool folder on your computer and double-click on run

Stock projection

Toy Tuna MSE | Ex 1. Manual Management | Ex 2. HCR Management | Ex 3. HCR selection | Settings

Manage the fishery 'manually' by changing the catch limit each year.

Each time you change the catch limit, discuss amongst the group why you are making the change. Your aim is to get the highest overall catch while maintaining stock status, avoiding overfishing and keeping catch variation low.

Catch limit ('000t)

180

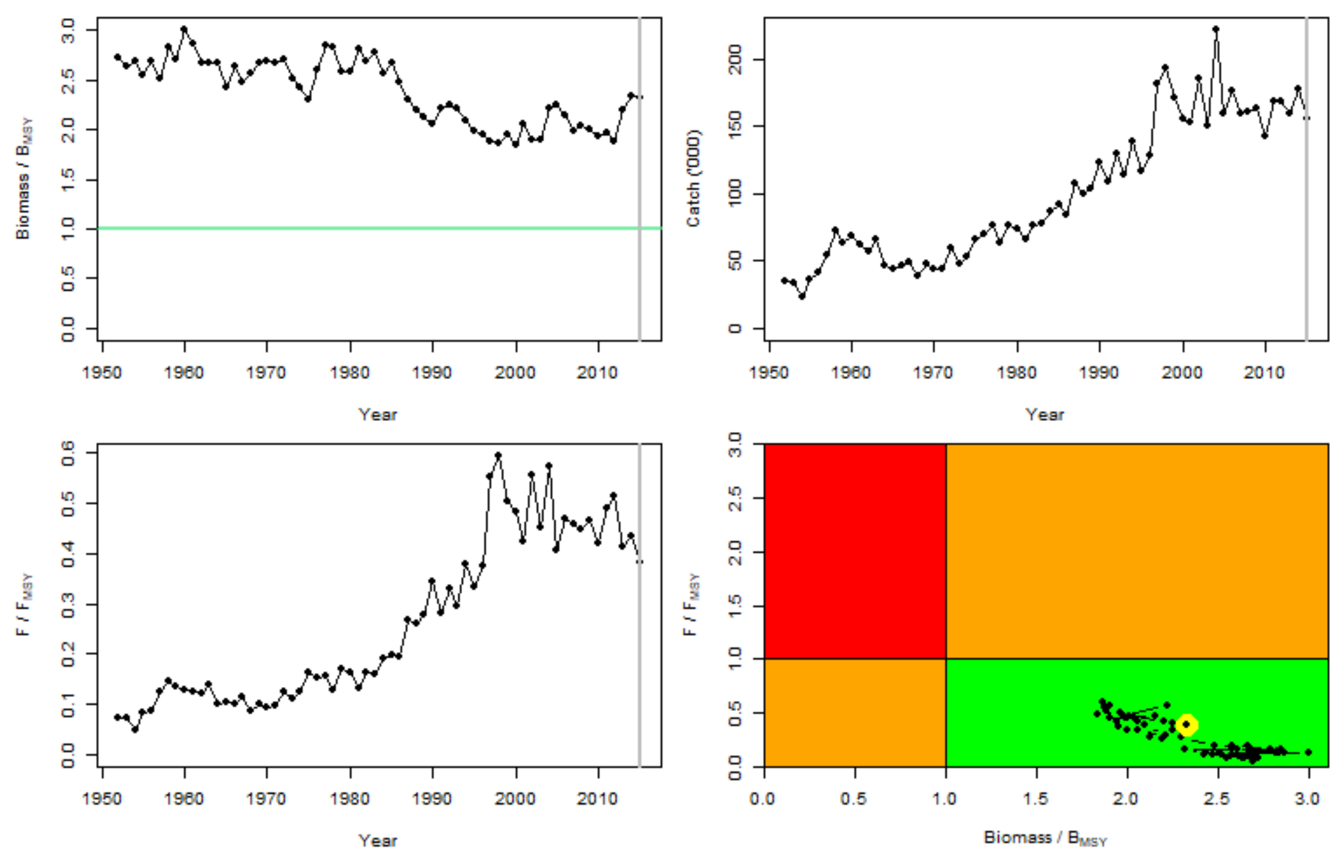
Catch limit duration (yrs)

3

Apply management | Restart

This tool was originally developed by André Punt and funded via WWF under the GEF/FAO ABNJ project and subsequently developed by several others.

Performance indicators: plots



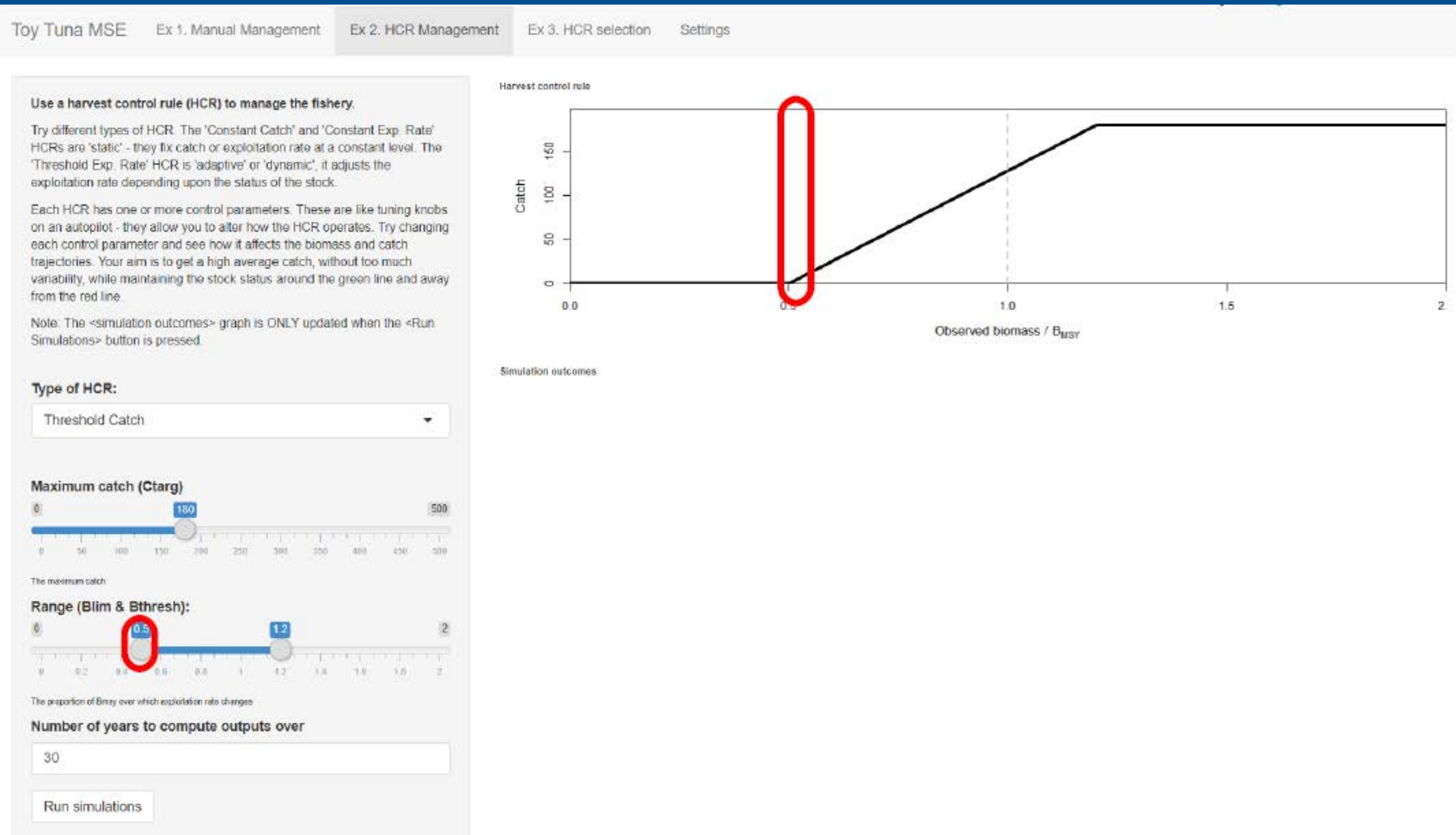
Exercise 1

Find the maximum catch that can allow the stock be in the Kobe green in 10 years (**Prob. Green =1**)

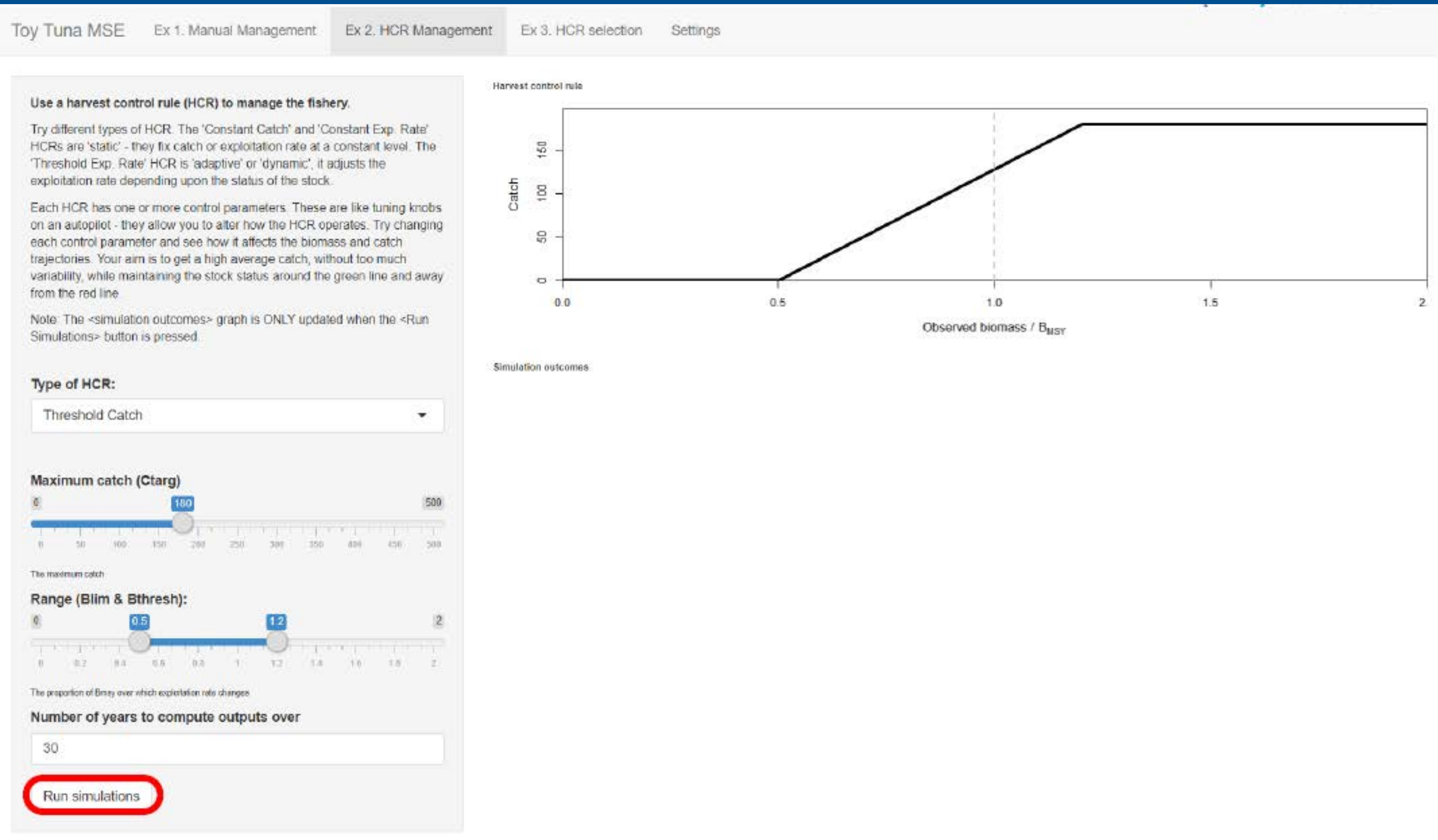
A test harvest control rule

- Blim = 0.5
- Bthresh = 1.2
- Ctarg = 180

HCR 1.1 Set the Blim slider to 0.5



HCR 1.2 Press the Run Simulations button



HCR 1.3 What happened?

Toy Tuna MSE | Ex 1. Manual Management | Ex 2. HCR Management | Ex 3. HCR selection | Settings

Use a harvest control rule (HCR) to manage the fishery.

Try different types of HCR. The 'Constant Catch' and 'Constant Exp. Rate' HCRs are 'static' - they fix catch or exploitation rate at a constant level. The 'Threshold Exp. Rate' HCR is 'adaptive' or 'dynamic', it adjusts the exploitation rate depending upon the status of the stock.

Each HCR has one or more control parameters. These are like tuning knobs on an autopilot - they allow you to alter how the HCR operates. Try changing each control parameter and see how it affects the biomass and catch trajectories. Your aim is to get a high average catch, without too much variability, while maintaining the stock status around the green line and away from the red line.

Note: The <simulation outcomes> graph is ONLY updated when the <Run Simulations> button is pressed.

Type of HCR:

Threshold Catch

Maximum catch (Ctarg)

0 180 500

The maximum catch

Range (Blim & Bthresh):

0 0.5 1.2 2

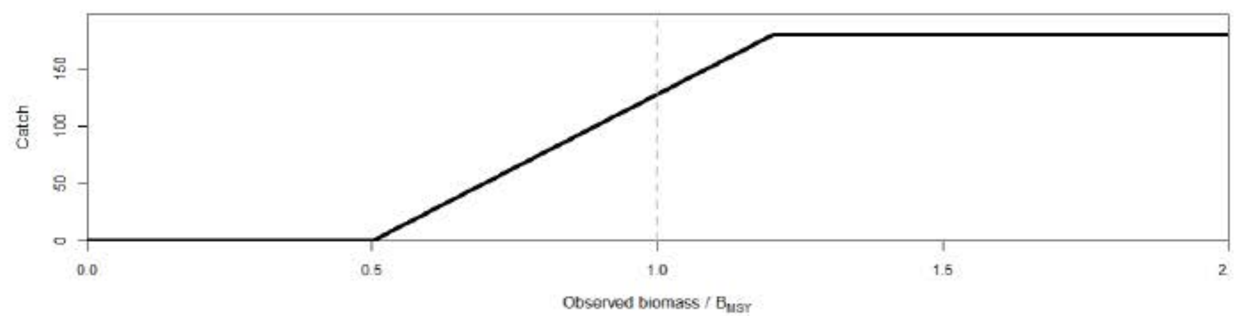
The proportion of Bmsy over which exploitation rate changes

Number of years to compute outputs over

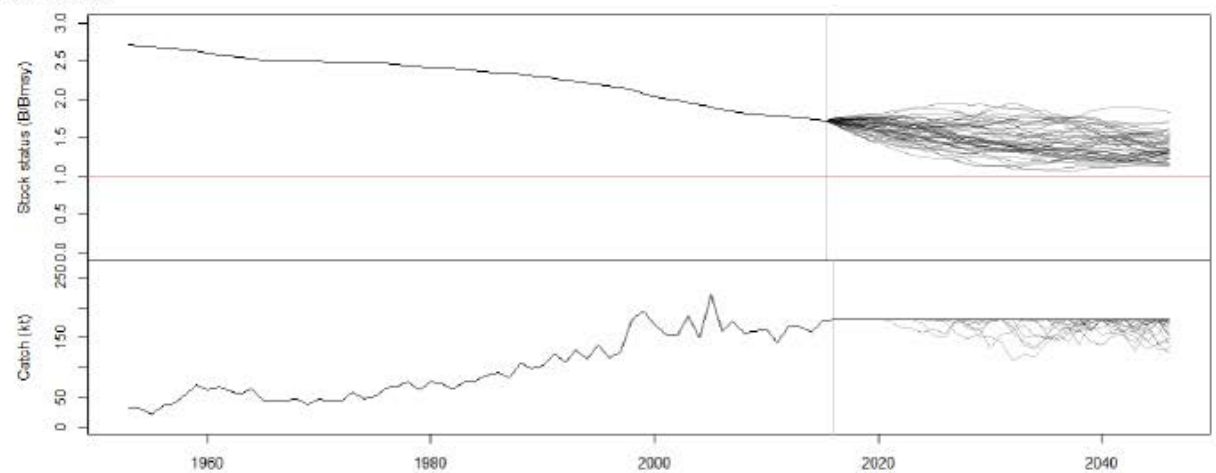
30

Run simulations

Harvest control rule



Simulation outcomes



HCR 1.3 What happened?

Toy Tuna MSE | Ex 1. Manual Management | Ex 2. HCR Management | Ex 3. HCR selection | Settings

Use a harvest control rule (HCR) to manage the fishery.

Try different types of HCR. The 'Constant Catch' and 'Constant Exp. Rate' HCRs are 'static' - they fix catch or exploitation rate at a constant level. The 'Threshold Exp. Rate' HCR is 'adaptive' or 'dynamic', it adjusts the exploitation rate depending upon the status of the stock.

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Note: The <simulation outcomes> graph is ONLY updated when the <Run Simulations> button is pressed.

Type of HCR:

Threshold Catch

Maximum catch (Ctarg)

0 — 180 — 500

The maximum catch

Range (Blim & Bthresh):

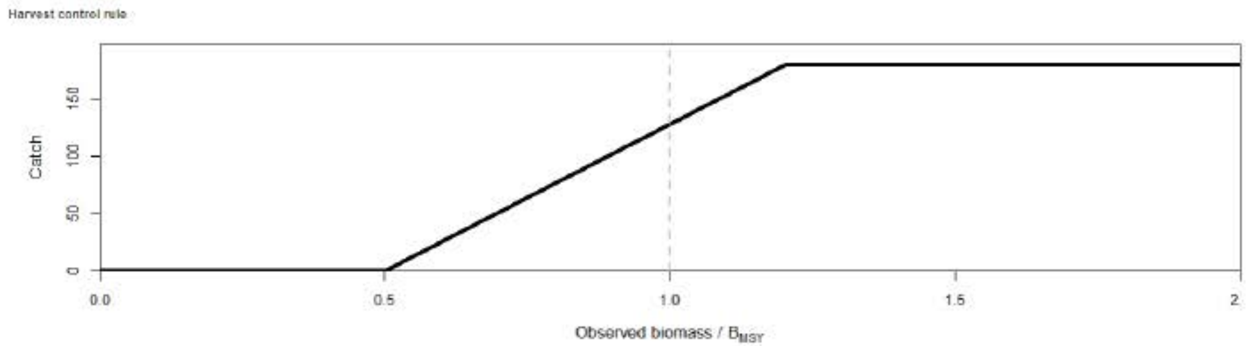
0 — 0.5 — 1.2 — 2

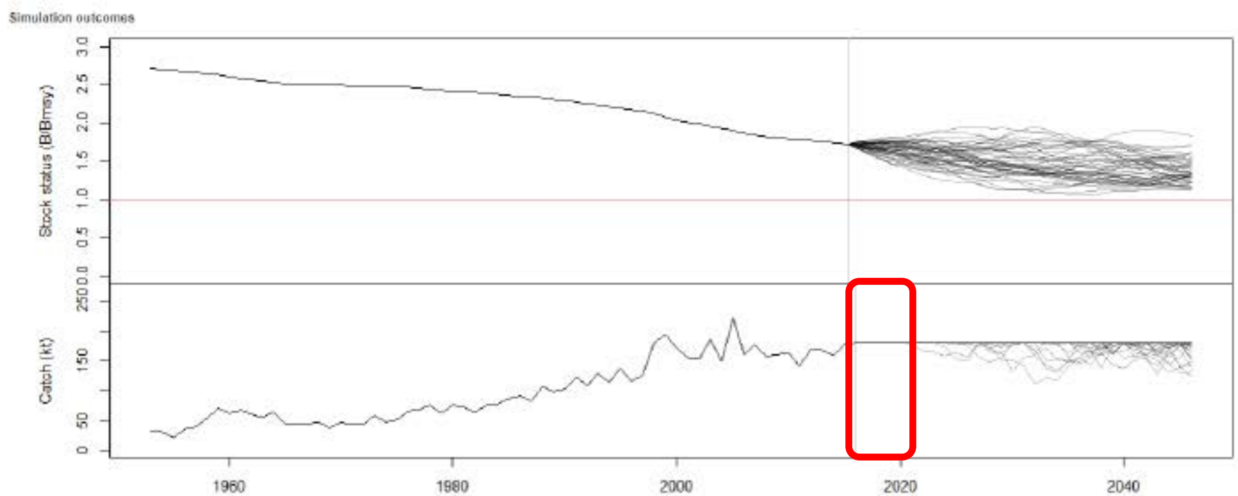
The proportion of Bmsy over which exploitation rate changes

Number of years to compute outputs over

30

Run simulations





HCR 1.6 When B/BMSY > Bthresh (1.2), catches = Ctarg

Toy Tuna MSE | Ex 1. Manual Management | Ex 2. HCR Management | Ex 3. HCR selection | Settings

Use a harvest control rule (HCR) to manage the fishery.

Try different types of HCR. The 'Constant Catch' and 'Constant Exp. Rate' HCRs are 'static' - they fix catch or exploitation rate at a constant level. The 'Threshold Exp. Rate' HCR is 'adaptive' or 'dynamic', it adjusts the exploitation rate depending upon the status of the stock.

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Type of HCR:

Threshold Catch

Maximum catch (Ctarg)

0 180 500

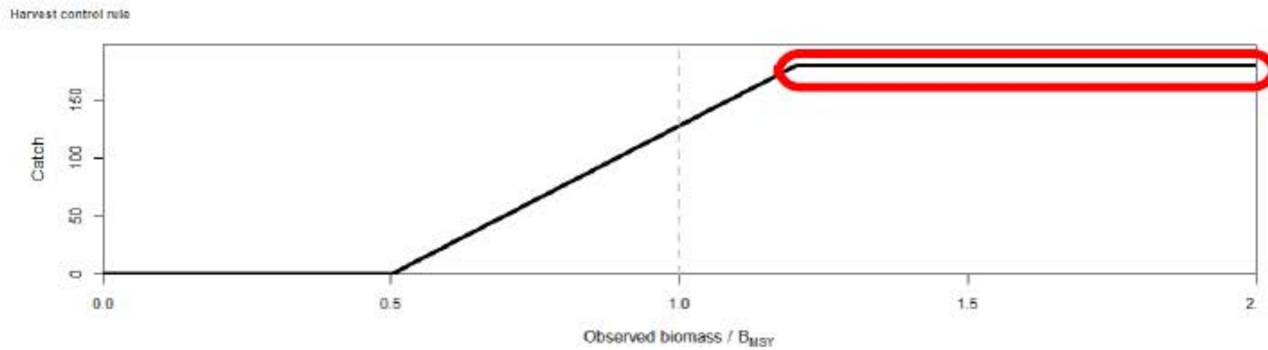
Range (Blim & Bthresh):

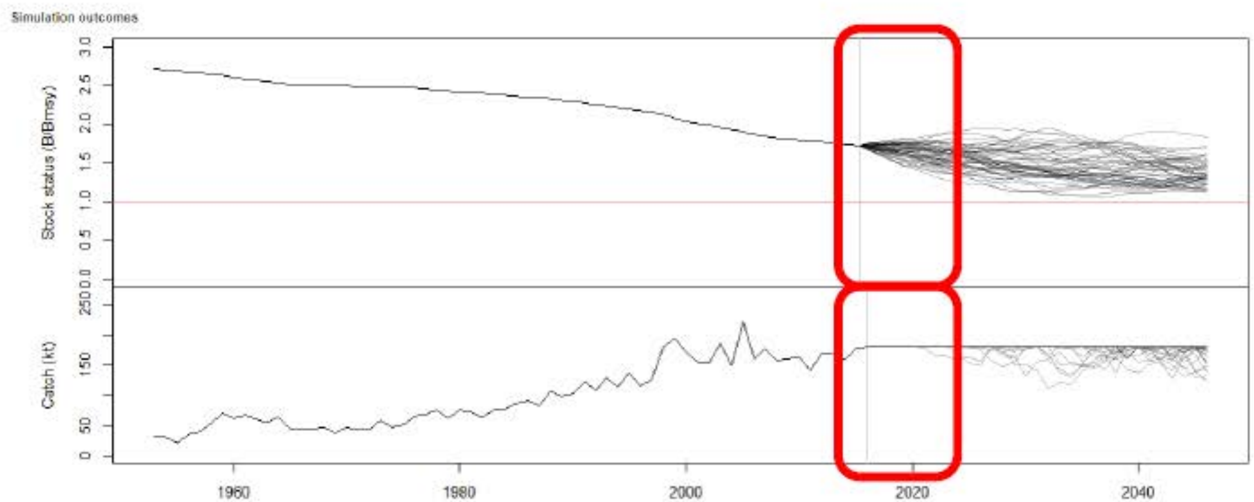
0 0.5 1.2 2

Number of years to compute outputs over

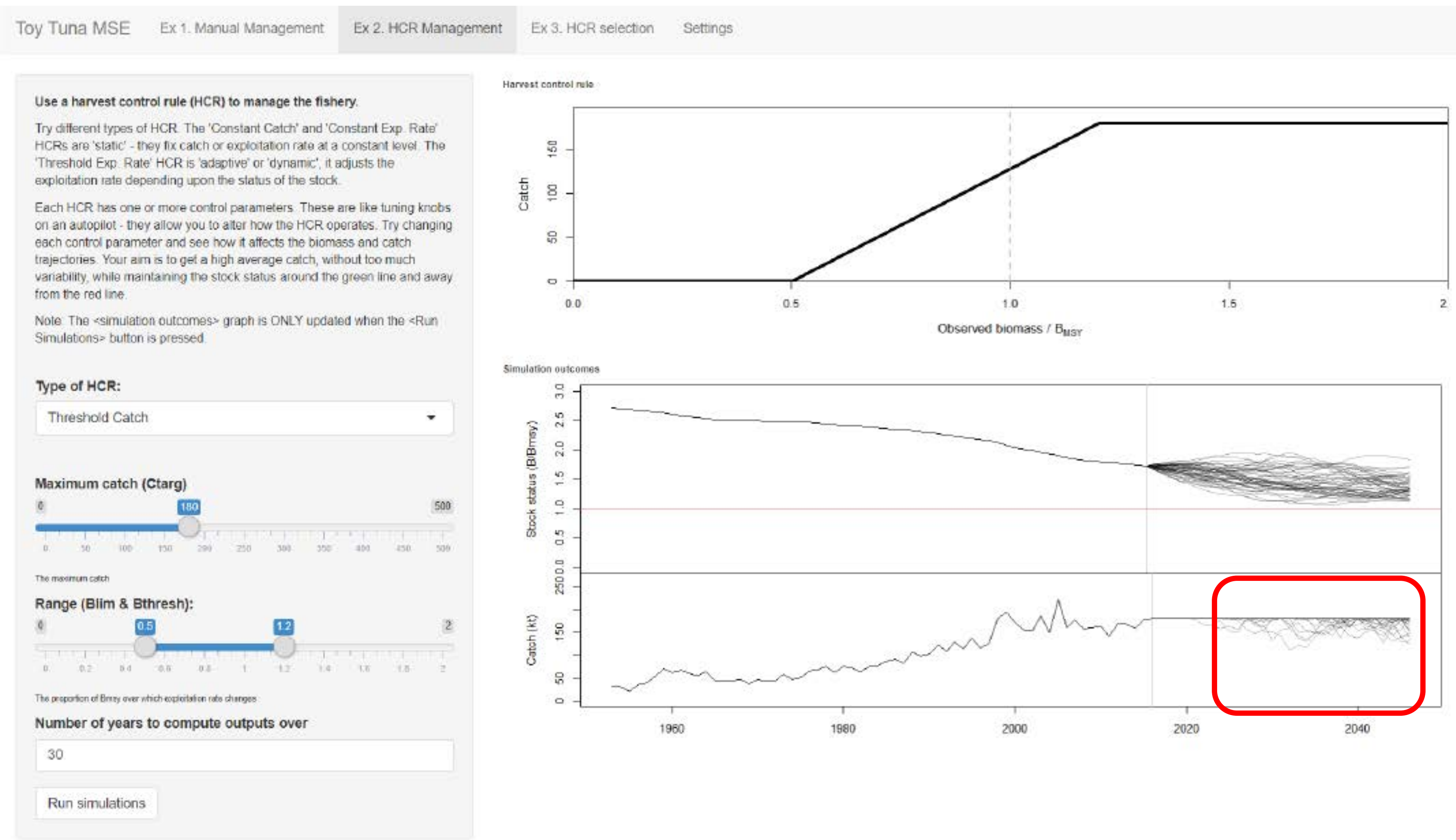
30

Run simulations





HCR 1.3 What happened?



HCR 1.7 When B/BMSY drops below Bthresh, catches are reduced

Toy Tuna MSE | Ex 1. Manual Management | Ex 2. HCR Management | Ex 3. HCR selection | Settings

Use a harvest control rule (HCR) to manage the fishery.

Try different types of HCR. The 'Constant Catch' and 'Constant Exp. Rate' HCRs are 'static' - they fix catch or exploitation rate at a constant level. The 'Threshold Exp. Rate' HCR is 'adaptive' or 'dynamic', it adjusts the exploitation rate depending upon the status of the stock.

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Type of HCR:

Threshold Catch

Maximum catch (Ctarg)

0 — 180 — 500

The maximum catch

Range (Blim & Bthresh):

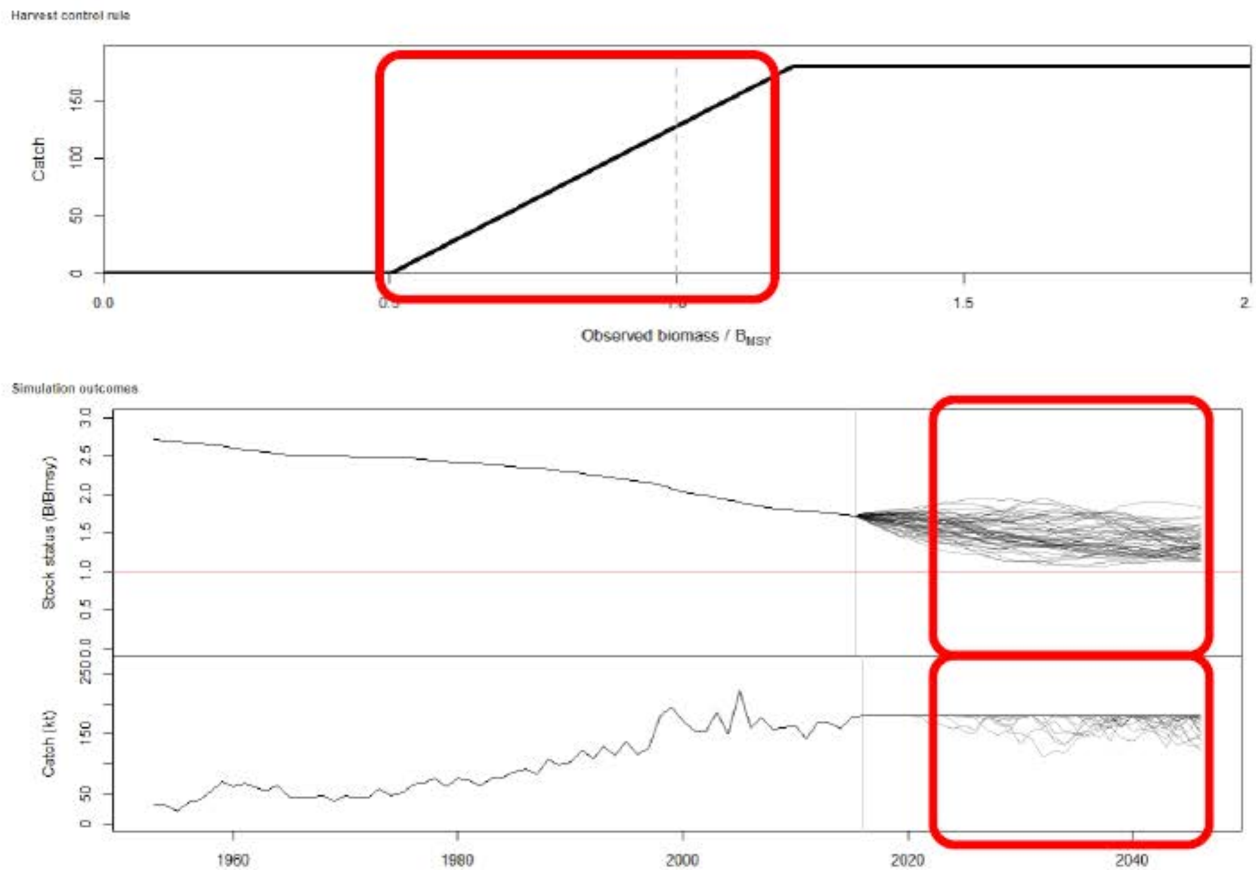
0 — 0.5 — 1.2 — 2

The proportion of Bmsy over which exploitation rate changes

Number of years to compute outputs over

30

Run simulations



HCR 1.9 Performance Indicators

Toy Tuna MSE | Ex 1. Manual Management | Ex 2. HCR Management | Ex 3. HCR selection | Settings

Select the HCR that best acheives your management objectives.

The performance indicators have been recorded for each of the HCR's that you tested during Excercise 2. Select one HCR that you think has the best tradeoffs amongst the performance indicators. You can go back to Excercise 2 and evaluate more HCRs to try and find a HCR with even better performance.

Plot trajectories for which HCR?

1

Use this to choose which HCR to plot trajectories for.

Type of plot:

Kobe

Use this to choose between a Kobe and Majuro plot. Note that these plots show the results in the final year of the projection.

Key

HCR control parameters

Catch is the constant catch.

*Exp. rate is the constant exploitation rate.

Ftarg and Ctarg define the maximum output of the threshold HCRs.

Blim and Bthresh are the input limits of the HCR. If an threshold exploitation rate HCR is used they are biomass relative to Bmsy. If a threshold catch HCR is used they are biomass relative to BF0

Performance indicators

Median depletion (%) : Median of B/unfished B.

*Prob. green : probability of being above B > BMSY and F < FMSY.

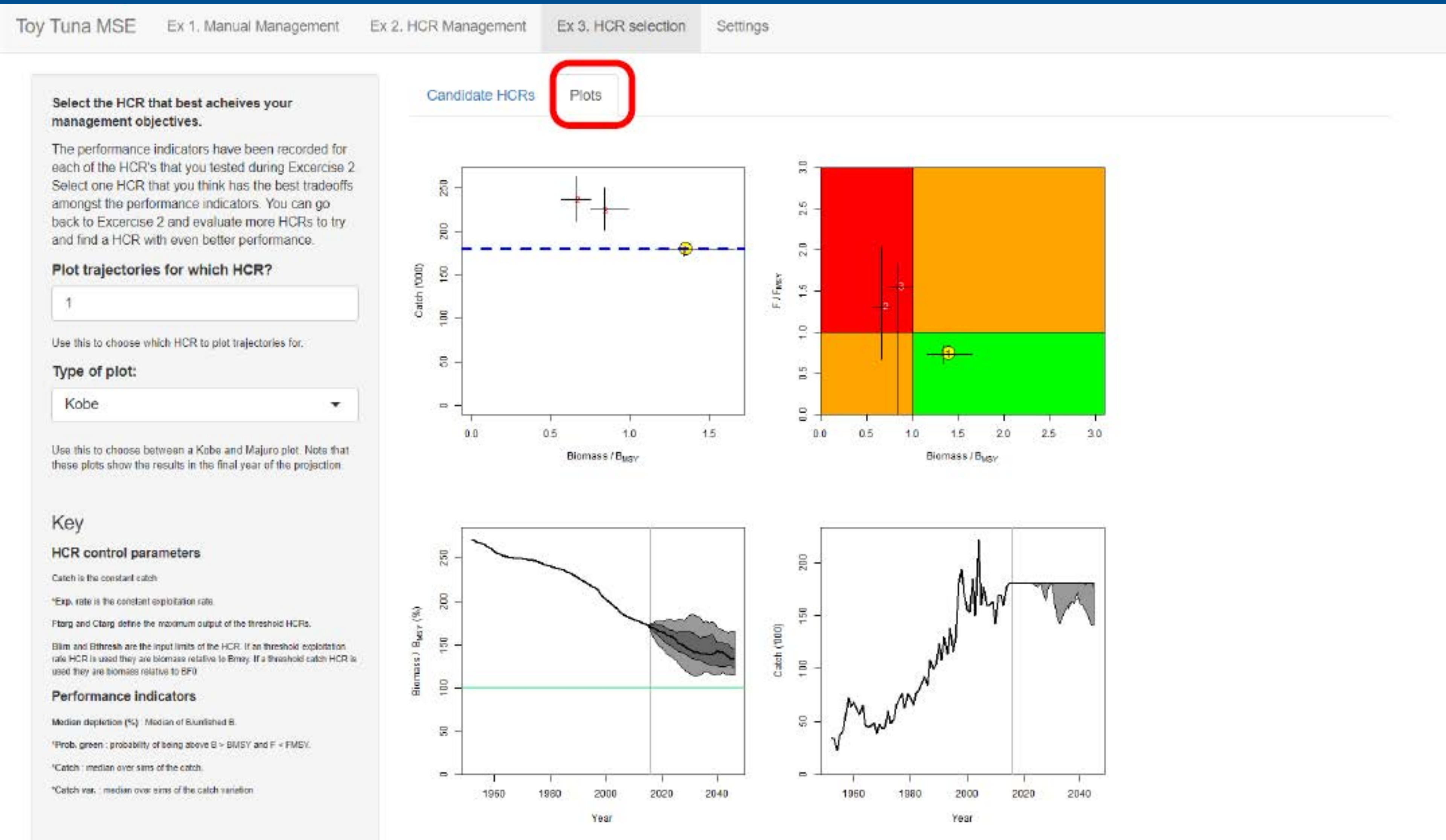
*Catch : median over sims of the catch.

*Catch var. : median over sims of the catch variation

Candidate HCRs | Plots

HCR	Type	Catch	Exp. rate	Fmult	Cmax	Blim	Bthresh	Median B/BMSY	*Prob. green	*Catch	*Catch var.	No. yrs average
1	Threshold Catch	NA	NA	NA	180	0.5	1.2	1.48	1	179.8	0.009	30

Plotting the HCRs 1



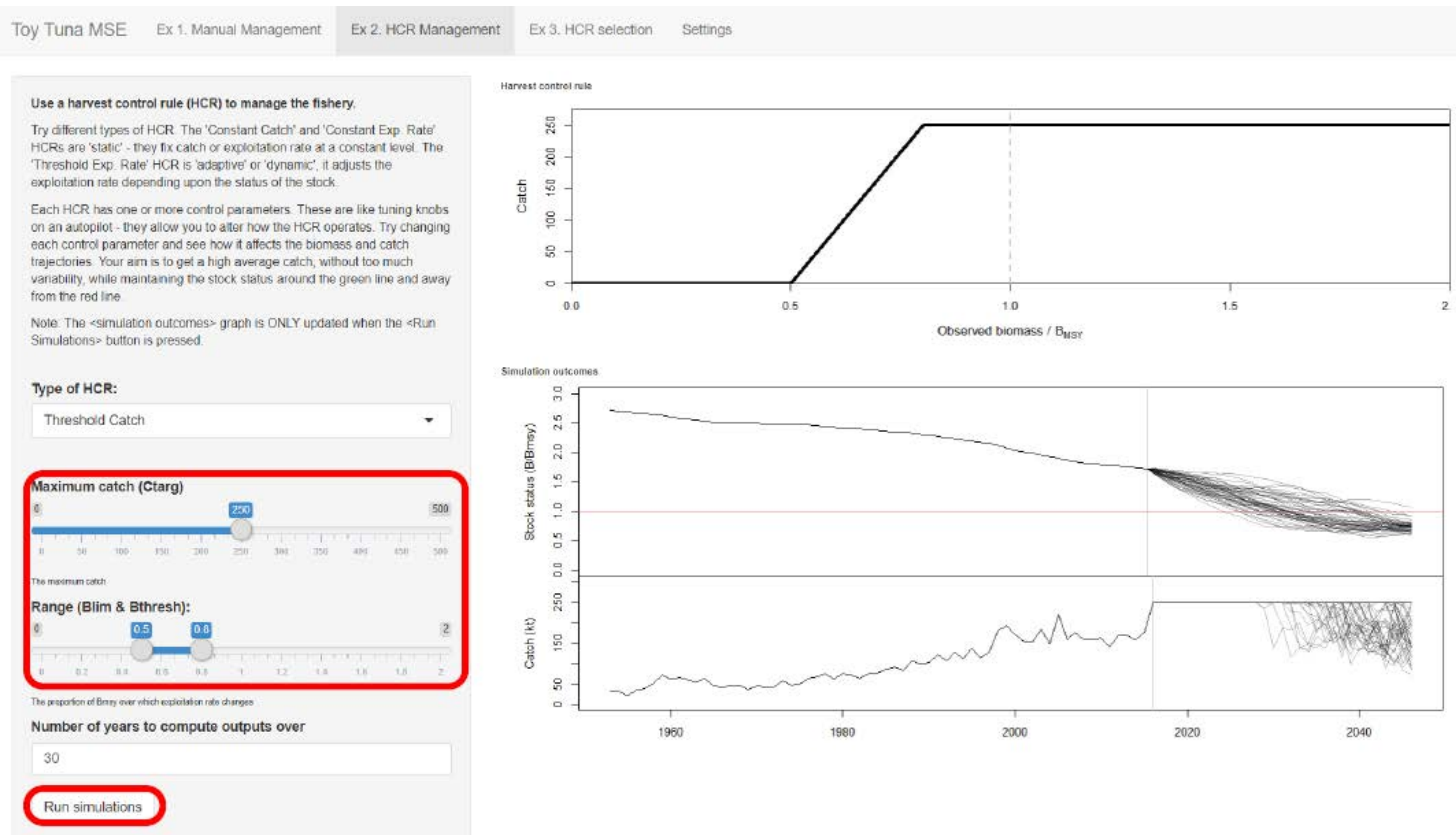
Another Harvest Control Rule

Let's set up another Harvest Control Rule.

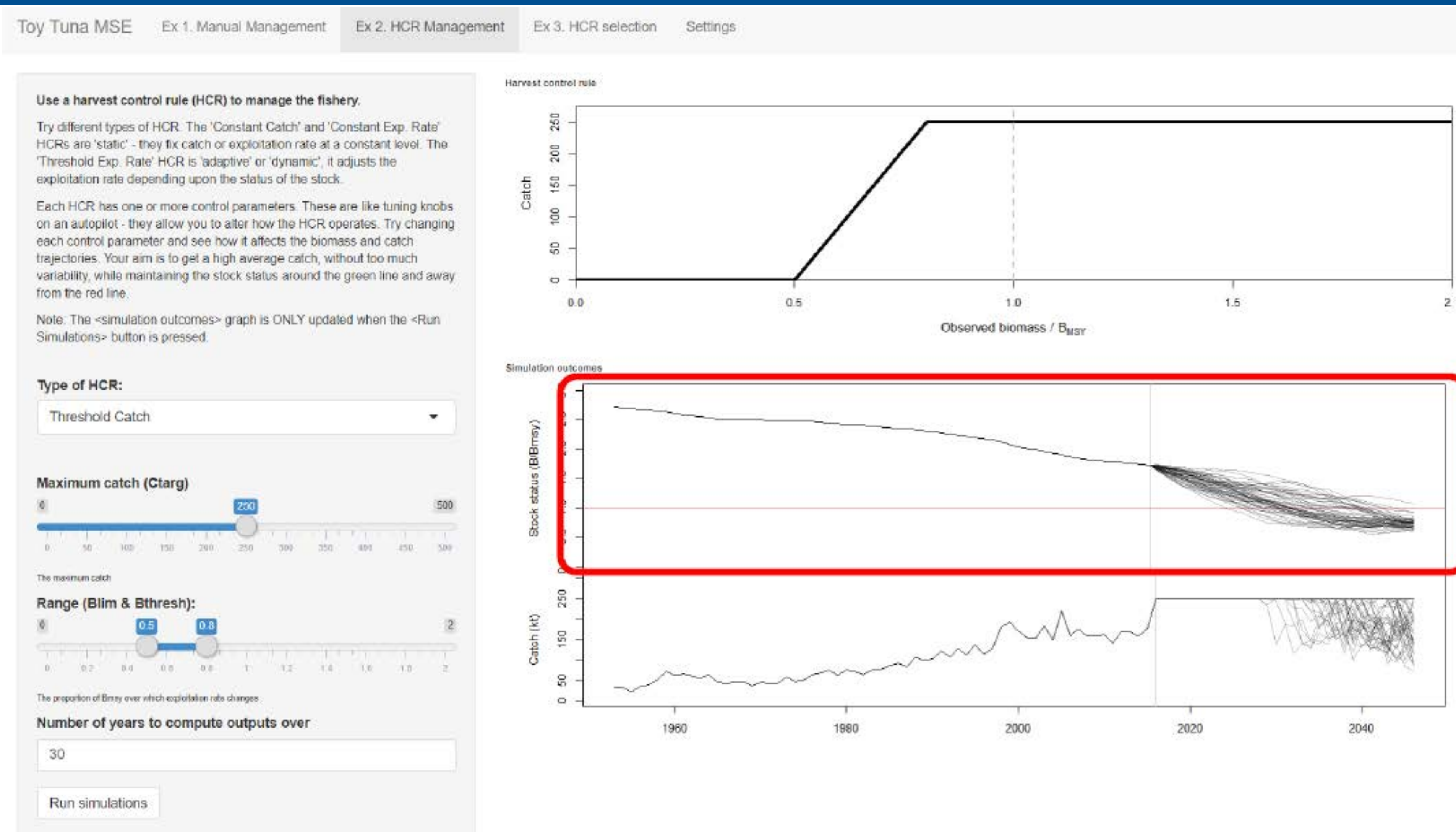
Can we improve performance?

- Blim = 0.5
- Bthresh = 0.8
- Ctarg = 250

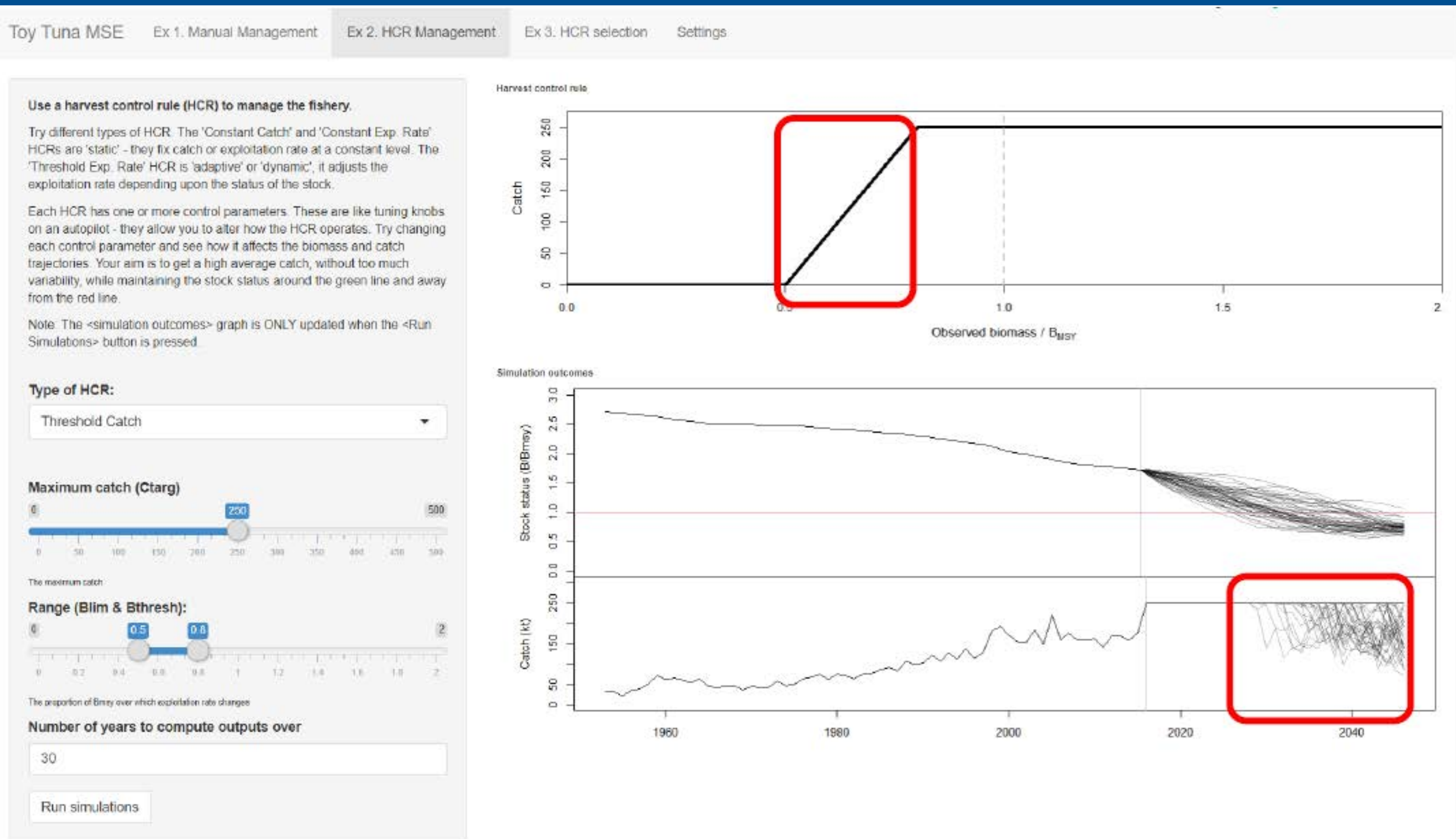
HCR 2.1 Blim=0.5, Bthresh=0.8, Ctarg=250



HCR 2.2 What happened? Biomass starts to declines below BMSY...



HCR 2.3 ...but catches not cut until B/BMSY < Bthresh (0.8)



HCR 2.5 Compare the HCRs

Toy Tuna MSE | Ex 1. Manual Management | Ex 2. HCR Management | Ex 3. HCR selection | Settings

Select the HCR that best acheives your management objectives.

The performance indicators have been recorded for each of the HCR's that you tested during Excercise 2. Select one HCR that you think has the best tradeoffs amongst the performance indicators. You can go back to Excercise 2 and evaluate more HCRs to try and find a HCR with even better performance.

Plot trajectories for which HCR?

1

Use this to choose which HCR to plot trajectories for.

Type of plot:

Kobe

Use this to choose between a Kobe and Majuro plot. Note that these plots show the results in the final year of the projection.

Key

HCR control parameters

Catch is the constant catch.

*Exp. rate is the constant exploitation rate.

Ftarg and Ctarg define the maximum output of the threshold HCRs.

Blim and Bthresh are the input limits of the HCR. If an threshold exploitation rate HCR is used they are biomass relative to Bmsy. If a threshold catch HCR is used they are biomass relative to BF0.

Performance indicators

Median depletion (%) : Median of B/unfished B.

*Prob. green : probability of being above B > BMSY and F < FMSY.

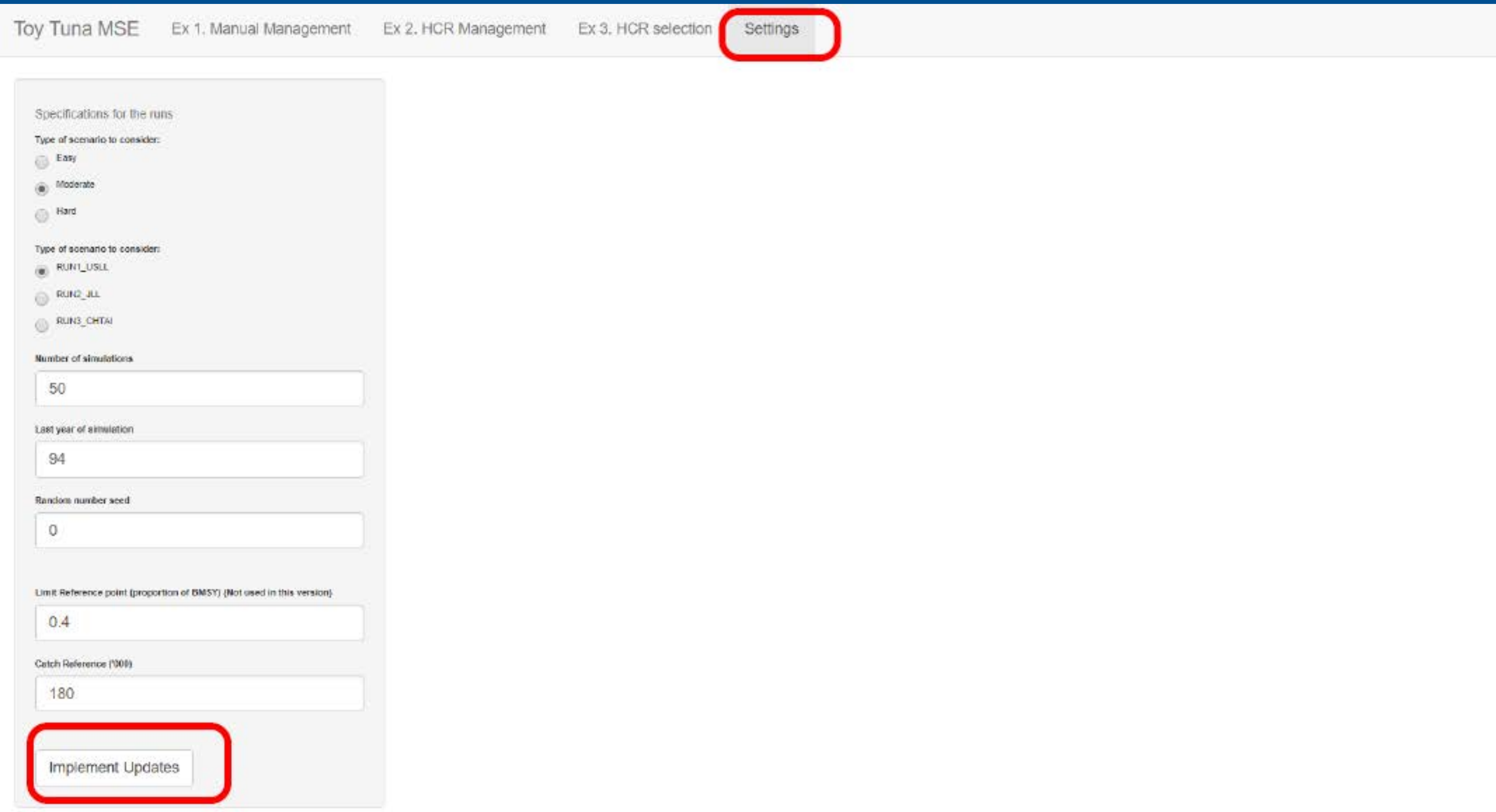
*Catch : median over sims of the catch.

*Catch var. : median over sims of the catch variation.

Candidate HCRs | Plots

HCR	Type	Catch	Exp. rate	Fmult	Cmax	Blim	Bthresh	Median B/BMSY	*Prob. green	*Catch	*Catch var.	No. yrs average
1	Threshold Catch	NA	NA	NA	180	0.5	1.2	1.48	1	179.8	0.009	30
2	Threshold Catch	NA	NA	NA	250	0.5	0.8	1.07	0.219	234.7	0.036	30

Clearing HCRs



Now you try. Competition time!

OBJECTIVES

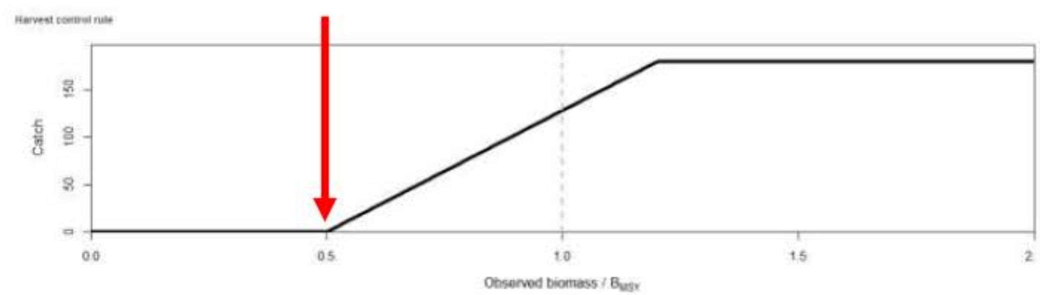
- $SB/SB_{msy} = 1$
- Maximise catch

CONSTRAINTS

- Use threshold catch HCR (the one we have been using
- Fix B_{lim} at 0.5 SB/SB_{msy}

MANAGEMENT

- Find combination of B_{thresh} and C_{targ} that achieves objectives



Now you try. Competition time!

OBJECTIVES

- High catches
- Biological sustainability

CONSTRAINTS

- Use threshold catch HCR (the one we have been using
- Fix B_{lim} at 0.5 SB/SB_{msy}

MANAGEMENT

- Find combination of B_{thresh} and C_{targ} that:
  - Gives highest catches
  - But probability of being in the green zone of the Kobe plot must be greater than or equal to 0.7

IOTC-2018-TCMP03-10

CURRENT STATUS OF IOTC MANAGEMENT STRATEGY EVALUATIONS

Bigeye Tuna

Dale Kolody & Paavo Jumppanen – CSIRO
With guidance from the IOTC MSE Task Force

TCMP-02 (2018) : 3 Tuning Objectives

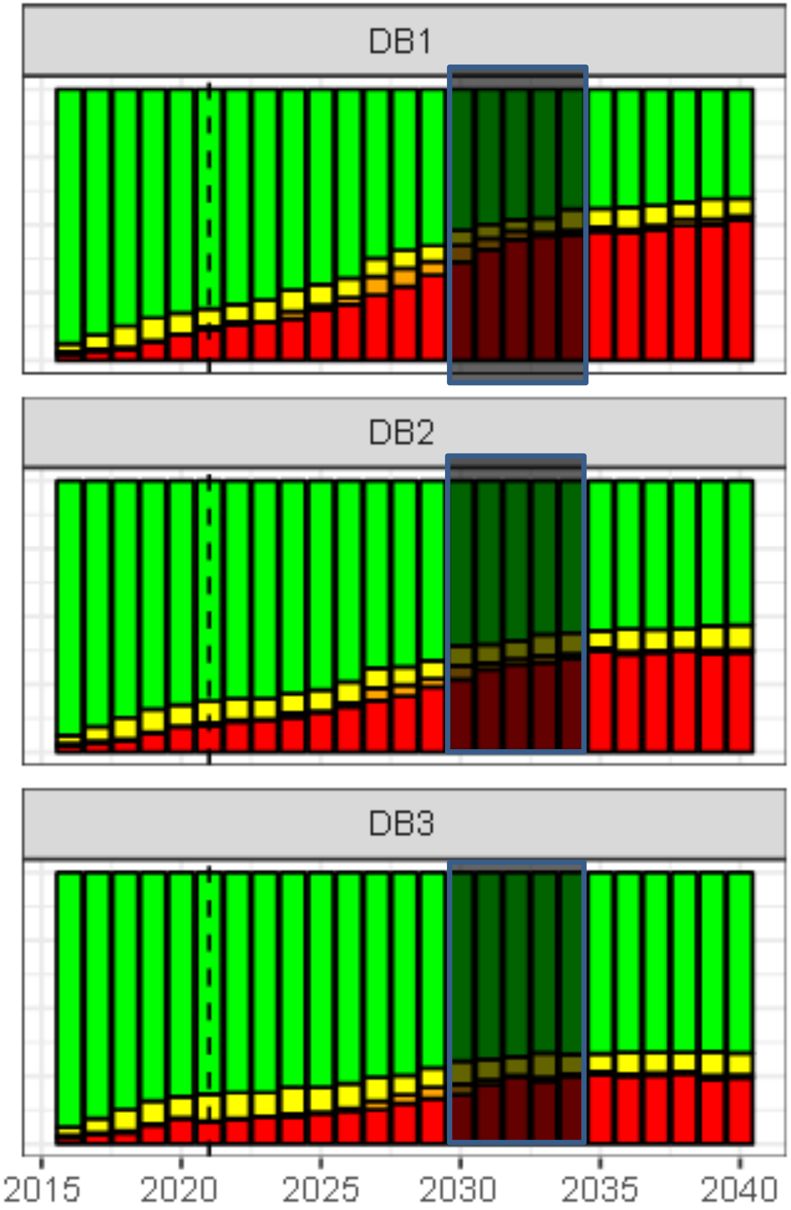
B1: Pr(Kobe green zone 2030:2034) = **0.5**

B2: Pr(Kobe green zone 2030:2034) = **0.6**

B3: Pr(Kobe green zone 2030:2034) = **0.7**

The stock status is in the Kobe green quadrant over the period 2030:2034 exactly 50, 60 or 70 % of the time (averaged over all simulations).

Visualizing the Tuning Objectives:
Time series of Kobe quadrant probabilities



B1: 50% **K**obe green zone

B2: 60% **K**obe green zone

B3: 70% **K**obe green zone

TCMP-01 Initial MP development guidance

Other MP implementation constraints:

- Frequency of quota setting
  - First MP setting: 2021
  - Then every 3 years
- TAC change constraints
  - Maximum 15% change (increase or decrease)
  - (achievable for all BET tuning objectives)
- 2 year Implementation data lag
  - E.g. 2019 CPUE available for 2021 TAC setting

Fig. 3

2021-2040

performance summary

- All tuning levels likely to result in catch equal to or exceeding current catch

- Higher catch = higher risk

- i.e. no surprises

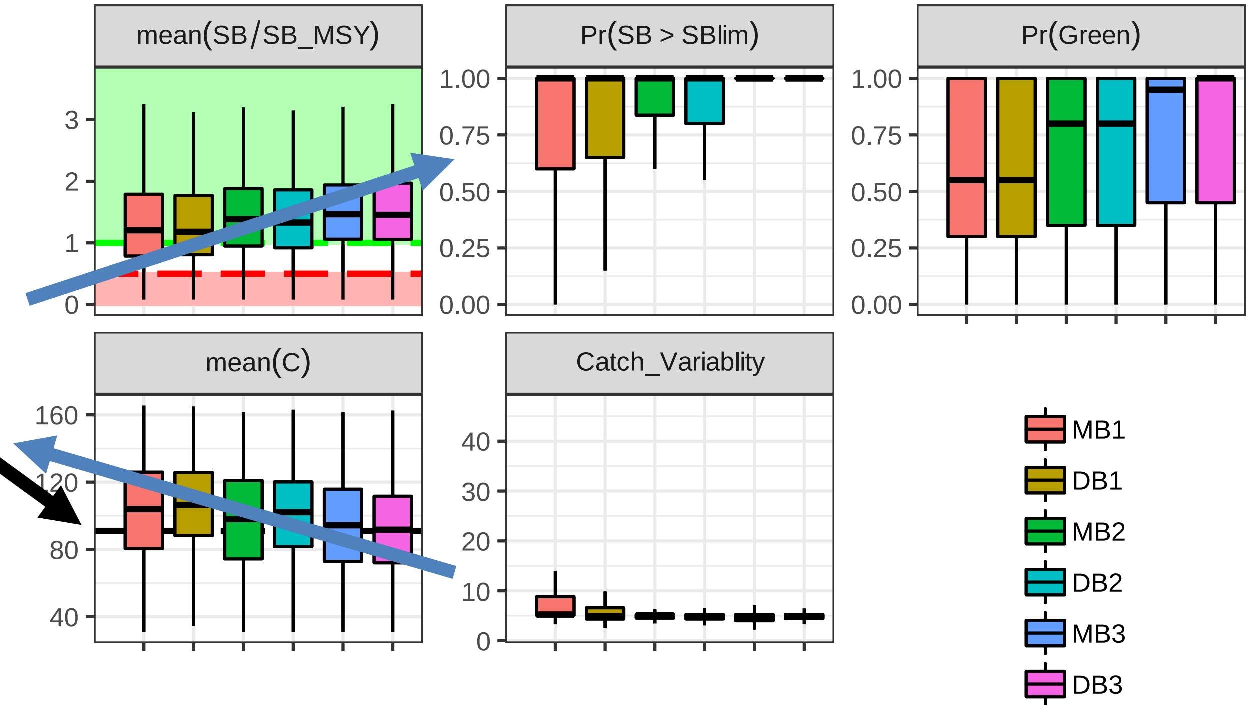


Fig. 4

2021-2040

performance summary

- All tuning levels likely to result in catch equal to or exceeding current catch

- Higher catch = higher risk

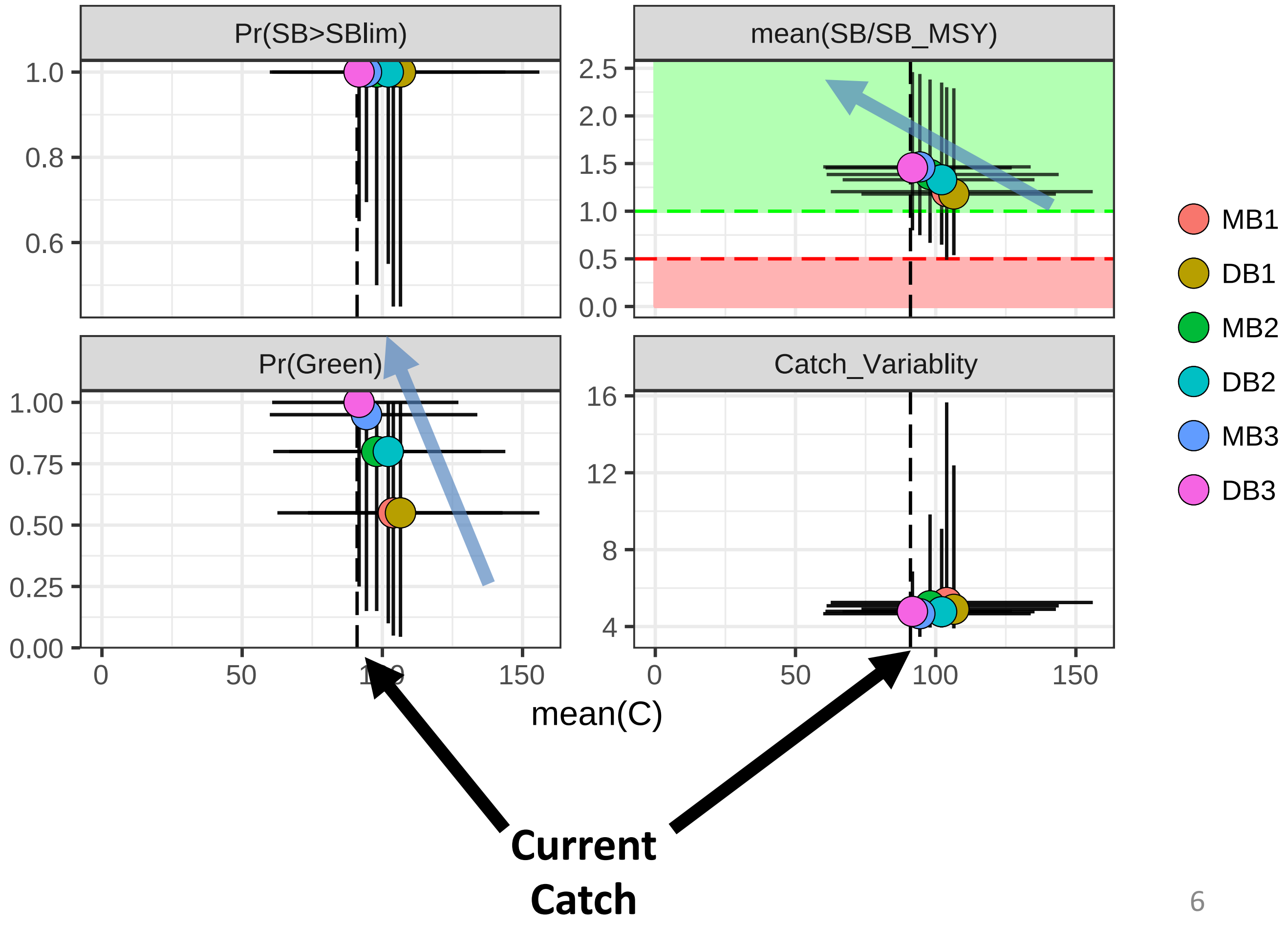


Fig.5

2021-2040

performance summary

- Tuning level more important than MP-Class
- 3 Tuning levels cover broad range of trade-off space

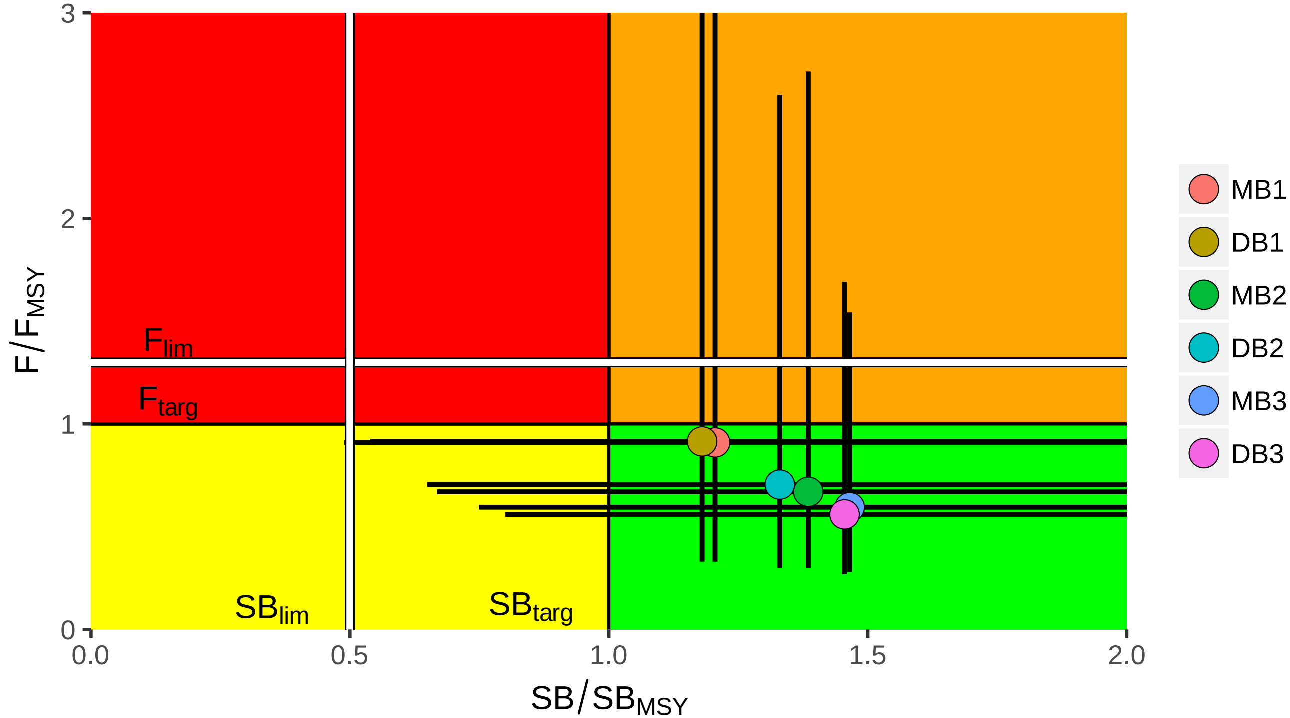
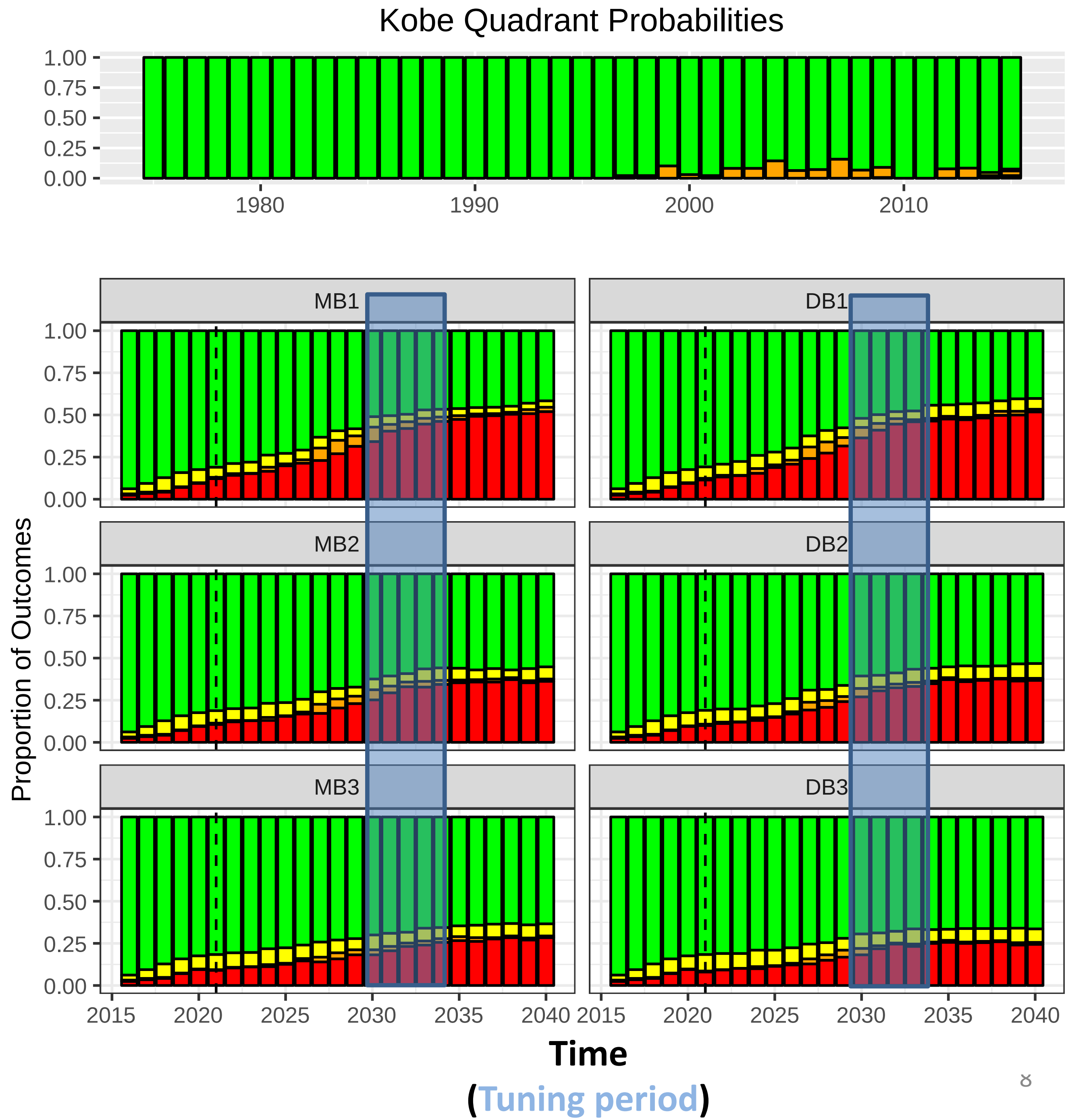


Fig. 6

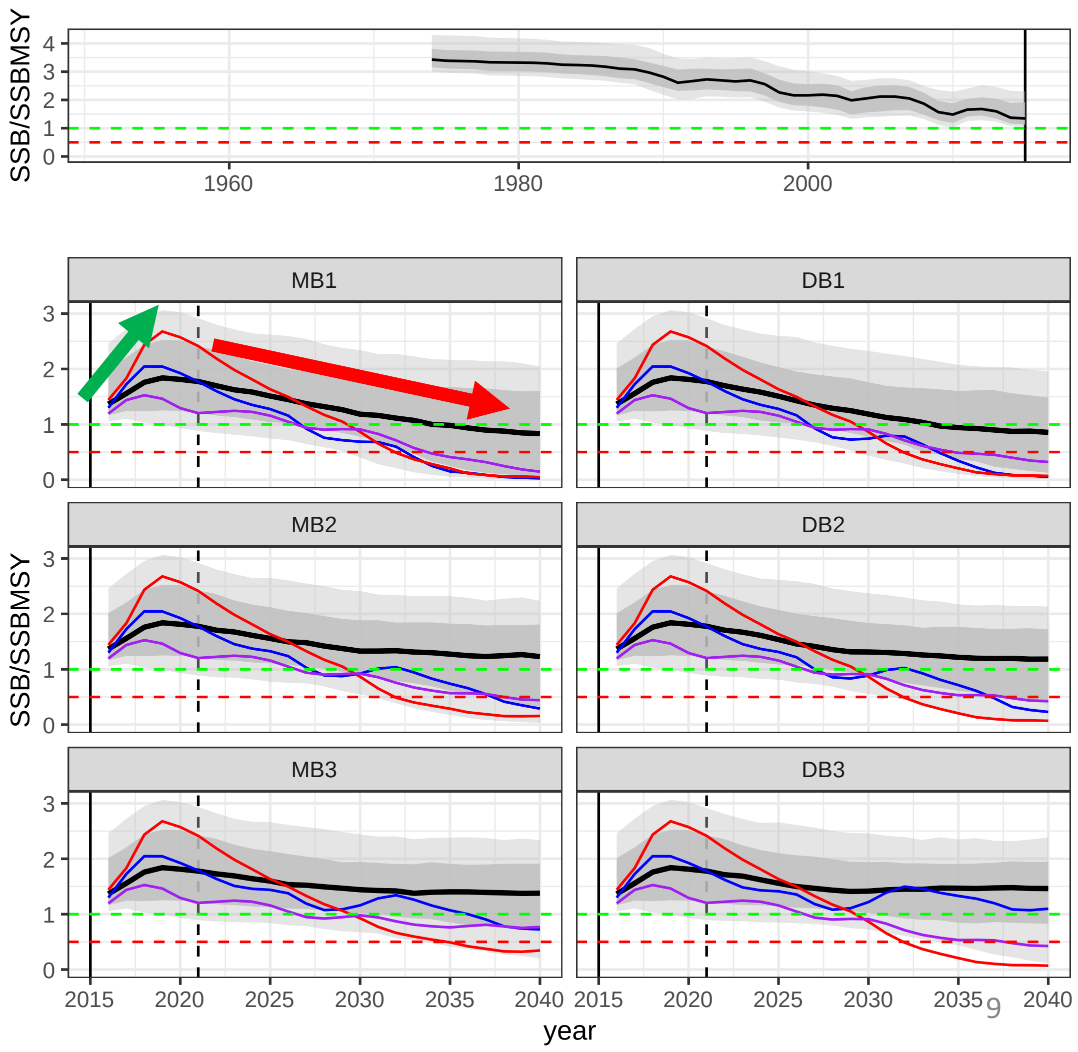


Kobe Quadrant Probabilities
1.00
0.75
0.50
0.25
0.00
1980
1990
2000
2010
MB1
DB1
MB2
DB2
MB3
DB3
Proportion of Outcomes
2015
2020
2025
2030
2035
2040
Time
(Tuning period)

Key Results of Candidate MP Evaluations

- Fig. 7
- Current low catches cause Biomass rebuilding prior to first MP setting
- MP must cause biomass decline to meet defined tuning objectives
- B1 requires the biggest biomass decrease.

Spawning Biomass

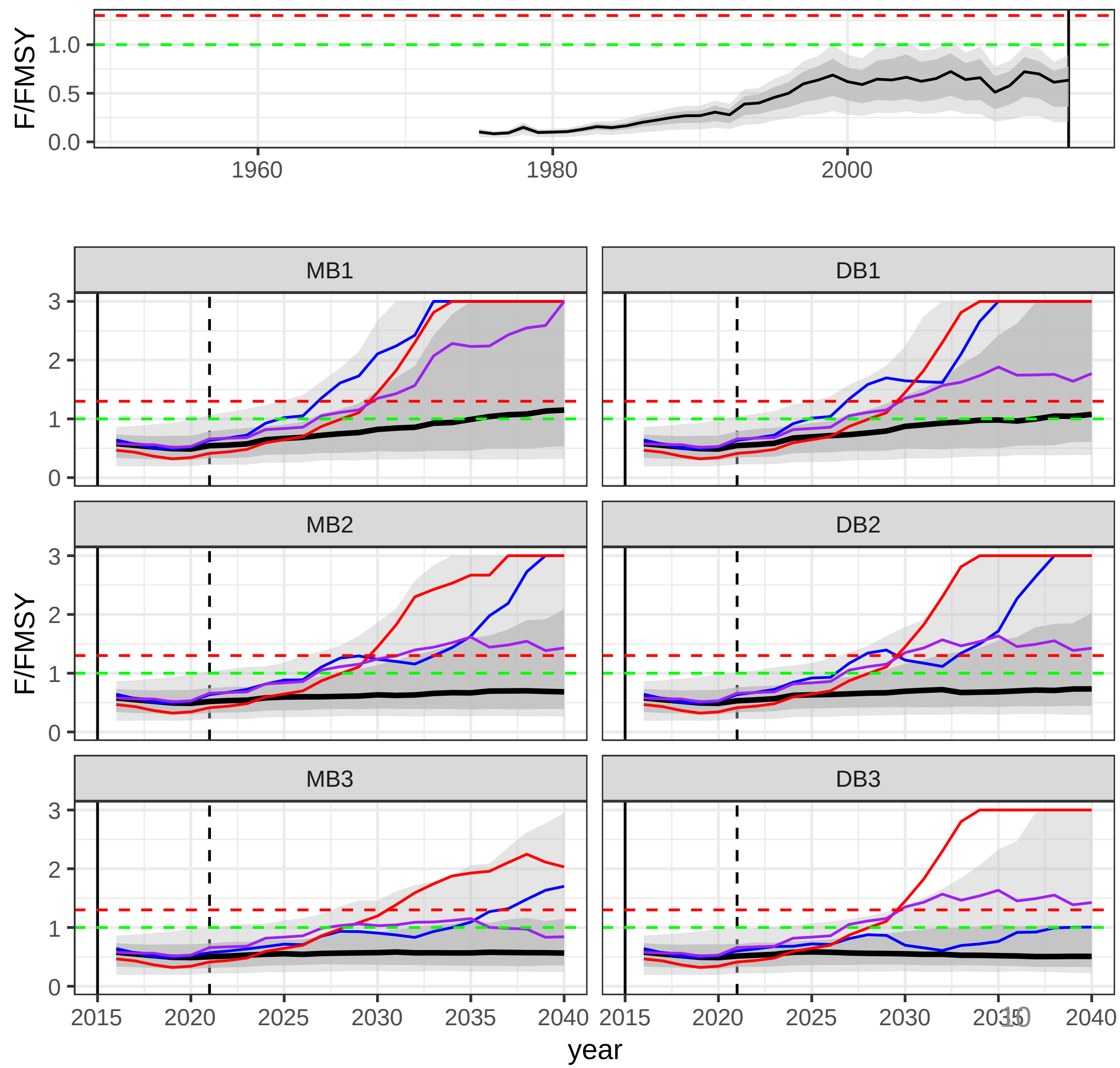


Key Results of Candidate MP Evaluations

Fig. 8

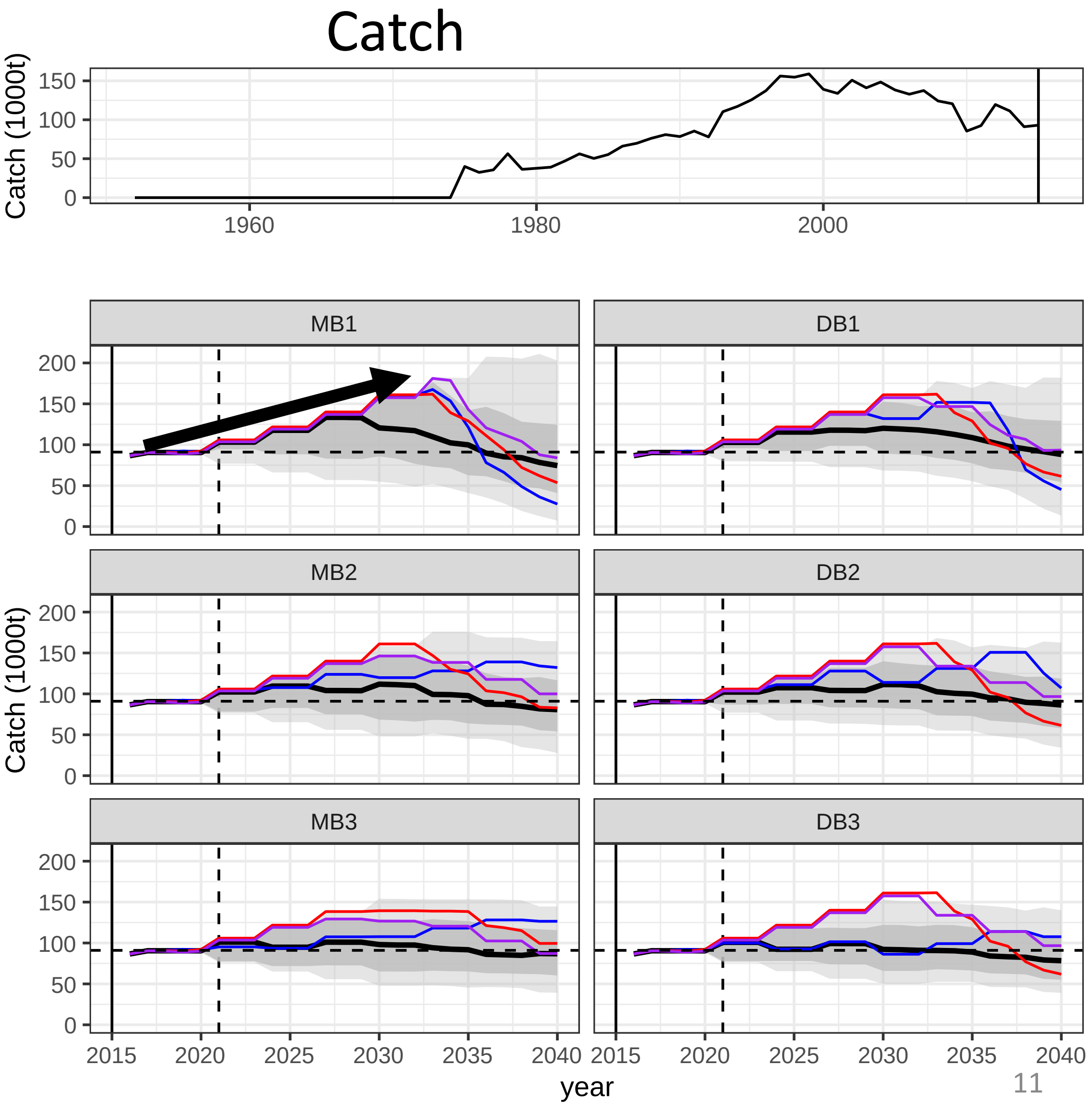
- F often very high post 2030

Fishing Intensity



Key Results of Candidate MP Evaluations

Fig. 9



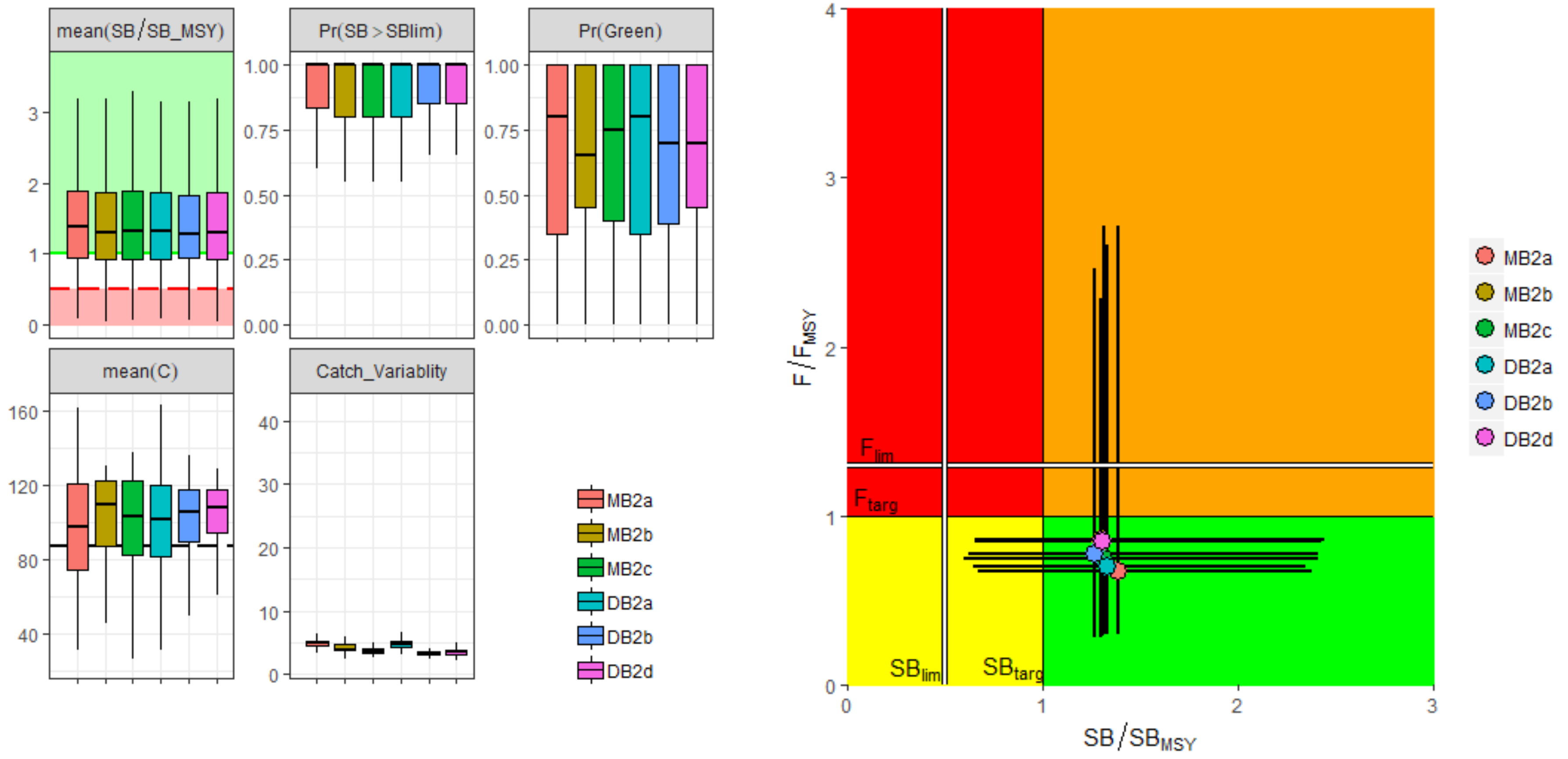
- Biomass decline achieved by increasing catch, mostly for B1

- B2, B3 fairly stable

Considerations for next iteration

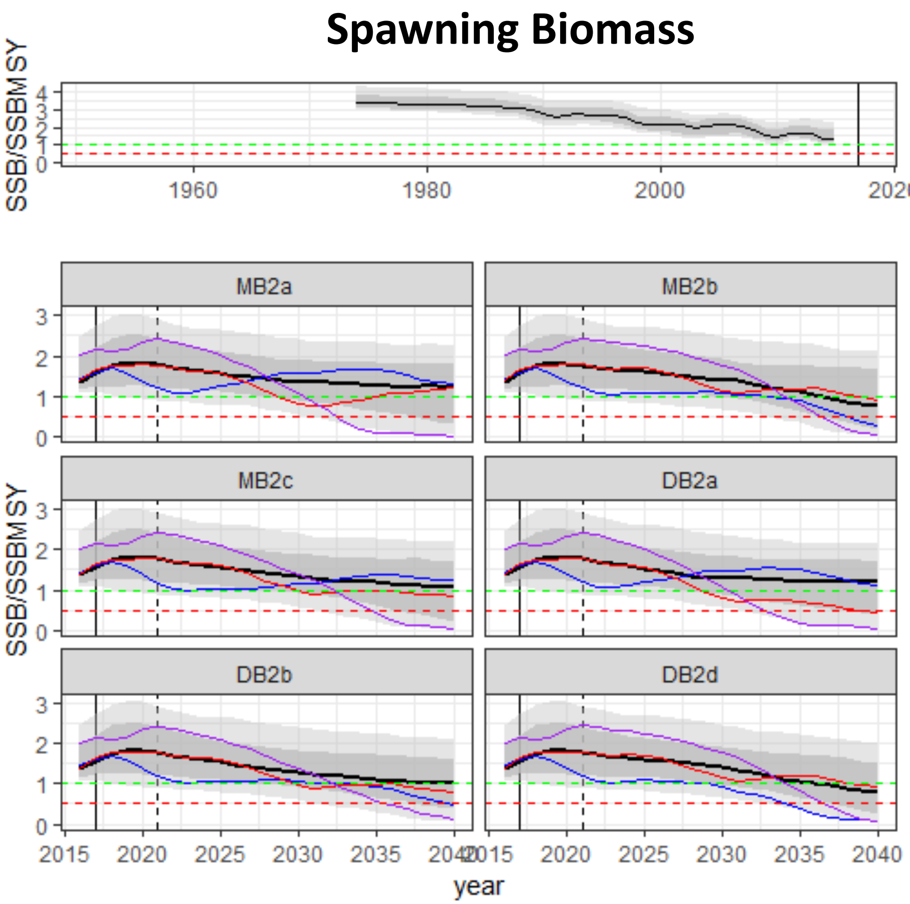
1) Current stock status is seemingly not over-exploited.
2) Catches have been declining in recent years.
3) Tuning objective B1 tends to require substantial catch increases.
4) There appears to be no incentive for industry to increase catches at this time.

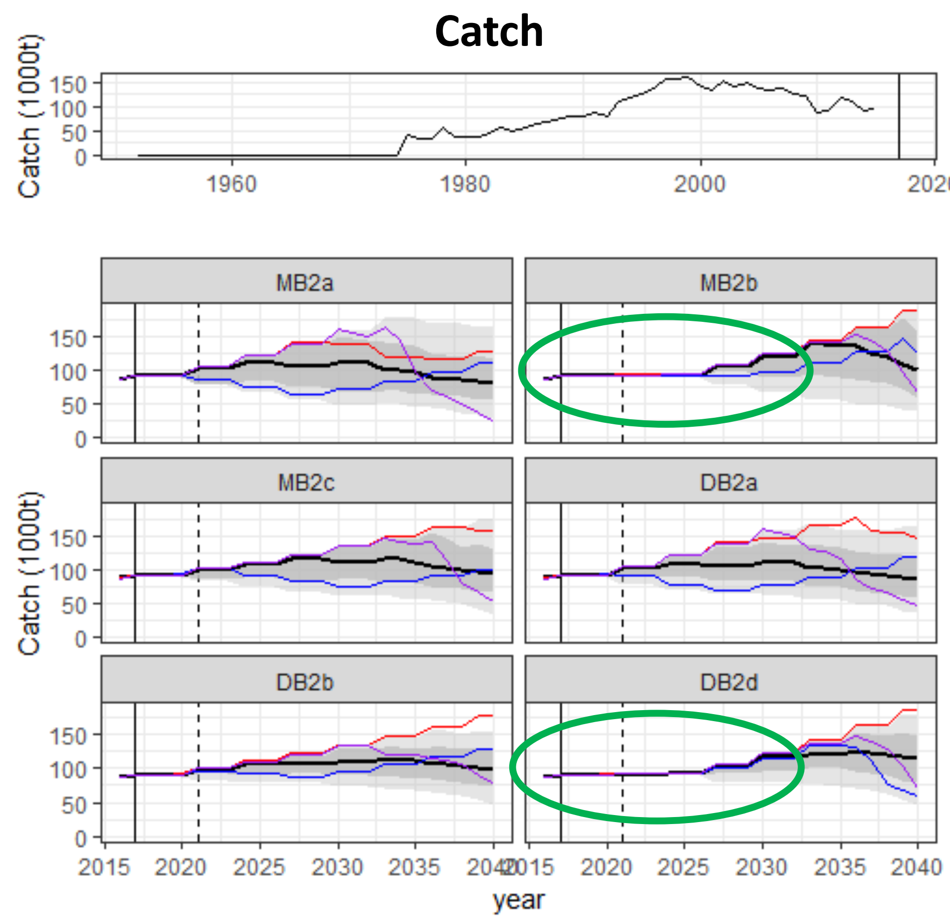
Given a single tuning objective(B2), how do 6 different MPs perform?



For the bigeye MPs tested, tuning objectives largely determine MP performance.

Given a single tuning objective(B2), how do 6 different MPs perform?





More time can be spent developing "smarter" MPs if managers can clearly describe what is desirable.

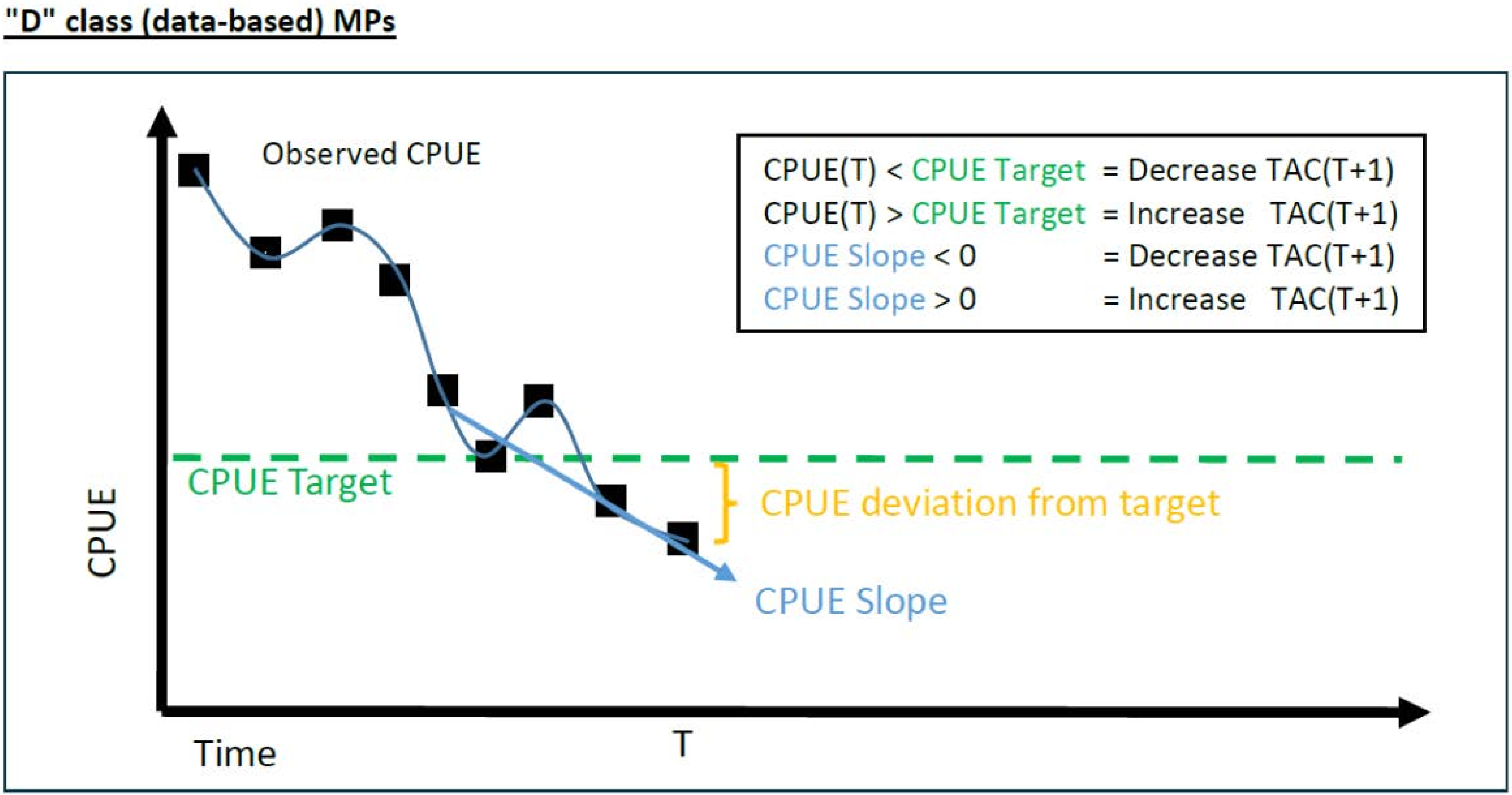
e.g. greater initial TAC stability

Questions for TCMP to advance bigeye MSE

1) Reduced set of tuning objectives for phase 2?
    - E.g. Is it worth retaining B1?
2) Frequency of quota setting?
    - First MP setting: 2021
    - Then every 3 years
3) TAC change constraints?
    - May be possible to increase initial stability
4) Implementation lag?
    - MP data (CPUE) available to 2019 for 2021 TAC

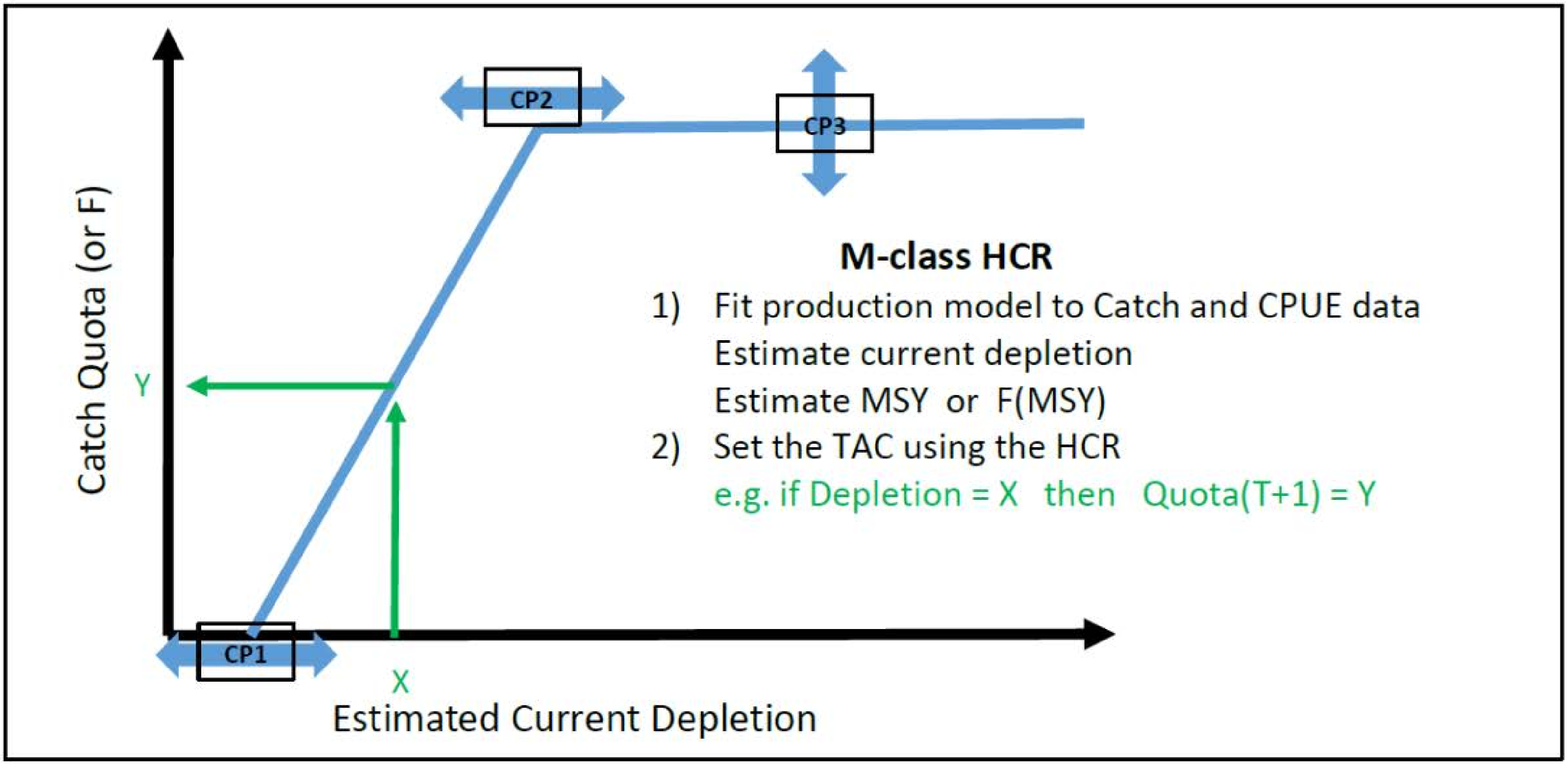
धन्यवाद
Merci
Thanks!

Empirical CPUE-based MP



Model-based MP

"M" class (model-based) MPs



Appendix 4. Results of the Question Poll

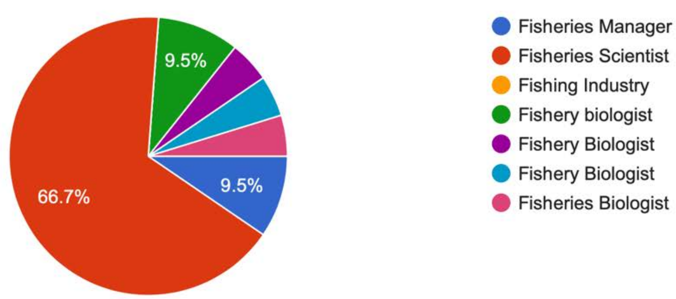
Furthering Capacity Building for Harvest Control Rules and Management Strategy Evaluation: Indian Ocean Tuna Management Workshop

21-22 January, 2020
Department of Fisheries, Bangkok, Thailand

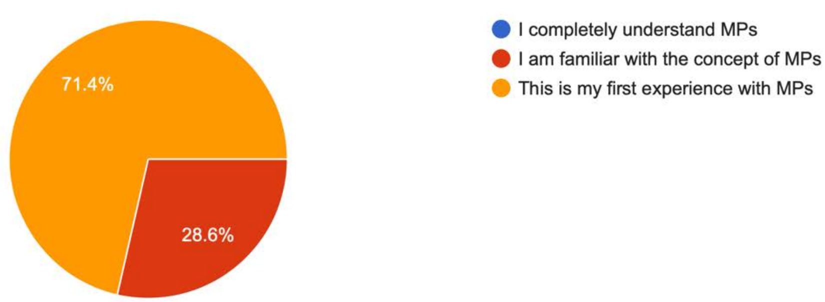
Bangkok Workshop Questionnaire (MSE)

21 responses

1. What is your position?
21 responses

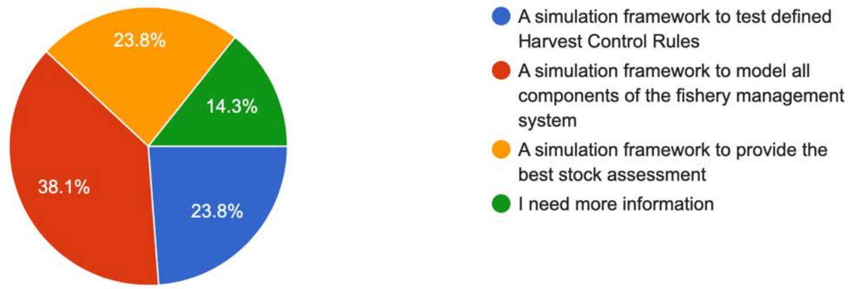


2. How well do you understand what Management Procedures (MPs) are and how they work?
21 responses



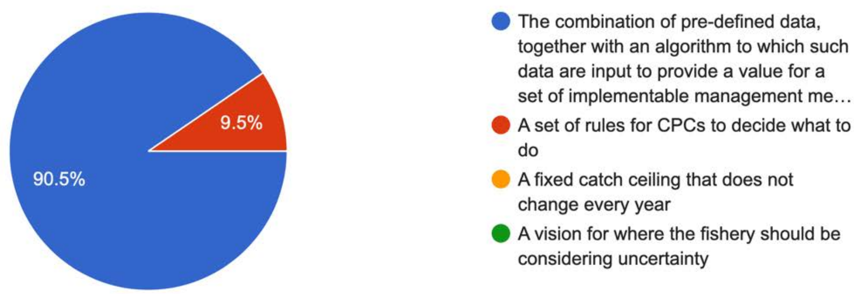
3. What does Management Strategy Evaluation mean to you?

21 responses



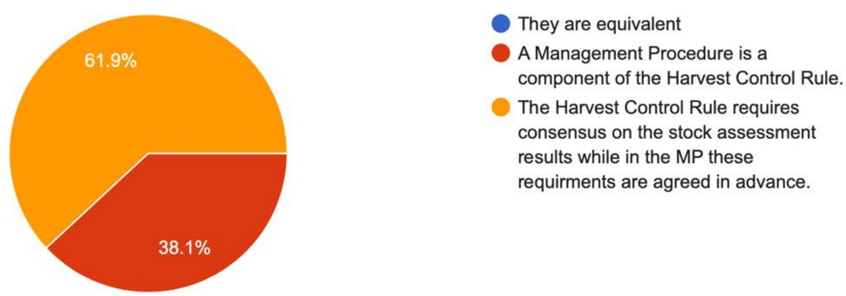
4. Which one of these definitions better explains to you what a Management Procedure is?

21 responses



5. What is the difference between the IOTC skipjack Harvest Control Rule and a Management Procedure?

21 responses

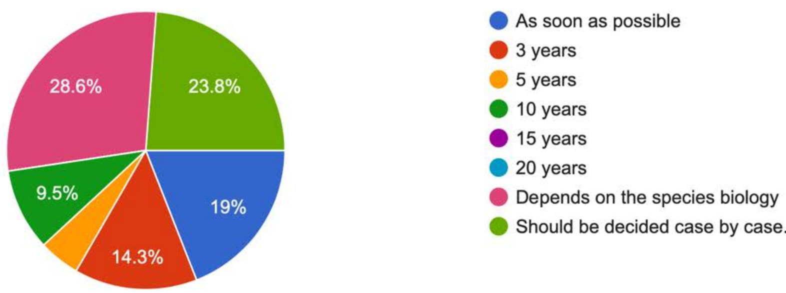


6. Please select your highest priority management objective.

21 responses

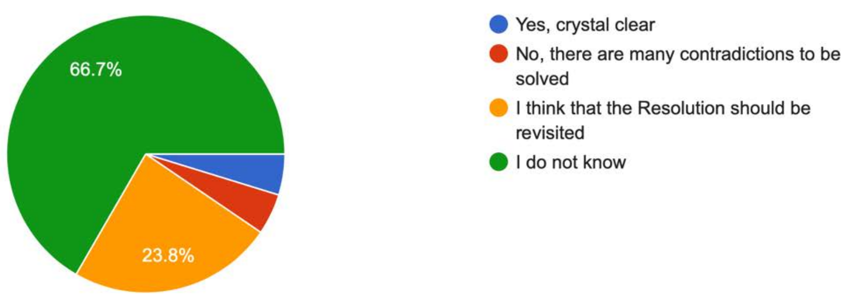
7. What would you consider to be an appropriate timeframe for recovery for an overexploited/overfishing stock

21 responses

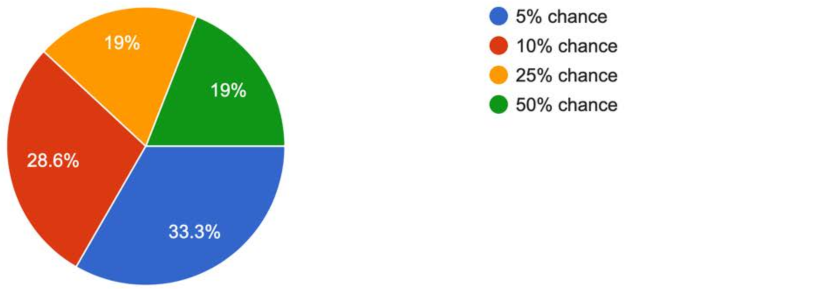


8. Do you consider that the management framework and operational objectives established in Resolution 15/10 are clear

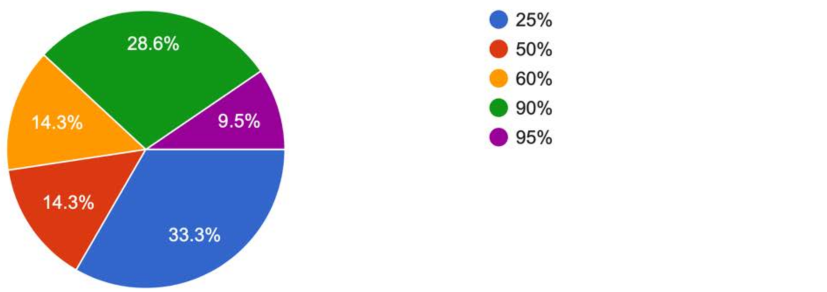
21 responses



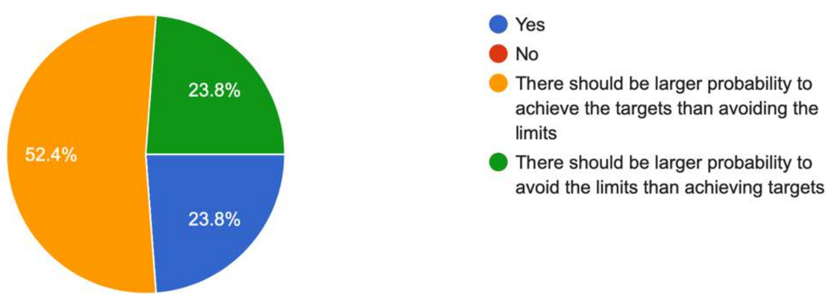
9. How would you define low probability" ?
21 responses



10. What is your interpretation of high probability in this case from Resolution 15/10: “For a stock where the assessed status places it within the lowe...tock with a high probability within this quadrant”?
21 responses

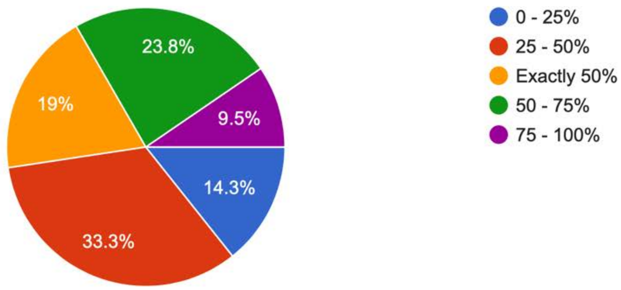


11. Do you think that the “high probability” is the same when related to achieving the targets or avoiding falling below the limits?
21 responses



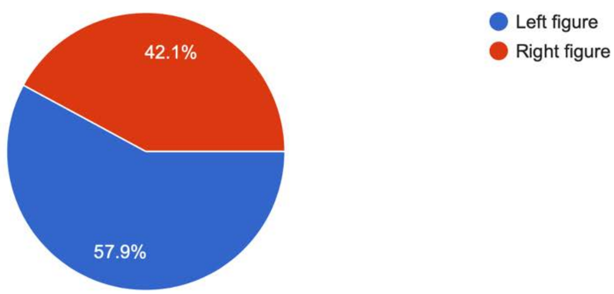
12. On average, the stock should be above B/BMSY and below F/FMSY what proportion of the time?

21 responses



13. Which of the stock below would require more stringent management measures (stock status marked by the circle)?

19 responses



ANNEX 2

Report of the "Furthering Capacity Building for Harvest Control Rules and Management Strategy Evaluation: Indian Ocean Tuna Management Workshop"
National Institute of Fisheries Science, Busan, Republic of Korea, 19th – 21st February 2020

Hilario Murua
International Seafood Sustainability Foundation

8th March 2020

The workshop was part of the "Sustainable Management of Tuna Fisheries and Biodiversity Conservation in Areas Beyond National Jurisdiction" (ABNJ Tuna Project). The overarching project focuses on three component areas:

1) Supporting implementation of sustainable and efficient fisheries management and fishing practices,
2) Reducing illegal, unreported and unregulated (IUU) fishing through strengthened and harmonized monitoring, control and surveillance,
3) Reducing ecosystem impacts from tuna fishing, including bycatch and associated species.

Under Component 1, Capacity Building Workshops for Management Procedures (MPs) and Management Strategy Evaluation (MSE) directed outreach to specific countries are organized. Under a Letter of Agreement with FAO, these workshops are implemented by the International

Seafood Sustainability Foundation (ISSF) with contributions from in-country institutions and regional tuna RFMOs.

Moreover, the IOTC Technical Committee on Management Procedures at its 2019 meeting, considered that MP/MSE involves complex concepts and agreed there is need to capacity building in support of the next TCMP to clarify key issues in Management Strategy Evaluations for IOTC stocks. Furthermore, the TCMP requested that Intersessional capacity building on MSE be conducted to increase understanding of the MSE process and to increase the engagement in the process of adoption of IOTC MPs by all CPCs. The IOTC Secretariat is collaborating with ISSF and FAO in organizing and implementing of CPC specific WSs planned for the region.

Workshop Aims

The goal of this workshop was to create a better understanding among Indian Ocean States regarding Management Strategy Evaluation (MSE) and Management Procedures (MP, also called Harvest Strategies) to ensure sustainable management of tunas. Specifically, in this workshop, to leverage the understanding of IOTC process, in general, but of the IOTC MP discussions, in particular, of Republic of Korea.

Ultimately, the objective of this workshop was to leverage the participation of Republic of Korea in the process of development of tuna MPs within the Indian Ocean. Participation in this workshop will empower Republic of Korea's administration, scientist and industry to meaningfully engage in the process of MP development already occurring at the Indian Ocean Tuna Commission (IOTC).

The Event

The workshop program included revision of the Management Procedure framework and the principles of sound fisheries management. The workshop provided a platform and background knowledge for engagement in the Indian Ocean regional level MP development and adoption of robust MPs which best achieve the objectives of IOTC members and stakeholders.

The workshop provided an introduction to the process of MP development; the elements of a MP, for example management objectives, timeframes and risk; how to interpret the trade-offs between different objectives and the use of MSE to evaluate performance of alternative MPs. But for setting the context and increase the understanding of those complex concepts, the workshop firstly focused on the IOTC Management Framework with the introduction of the provision of fisheries management advice; including the description of the Kobe plots, Target and Limit Reference Points and IOTC Decision Framework as per Resolution 15/10. Although the agenda was comprehensive, the objective was to have an open and lengthy discussion on the various elements that require more attention from participants. The goal was to discuss relevant needs and issues for Republic of Korea specific to Indian Ocean tunas and allow for more in-depth understanding of how the concepts and tools presented in the workshop may assist in increasing

Republic of Korea participation in the process of the IOTC Technical Committee on Management Procedures.

The Workshop was one of capacity building on MPs targeted at decision-makers, scientists, industry and NGO from Republic of Korea. The Workshop was organized by Hilario Murua (ISSF) with the collaboration of Dr. Doo Nam Kim (National Institute of Fisheries Science) and Paul de Bruyn (IOTC) and it was given by Toshihide Kitakado (IOTC Scientific Committee Chair) and Hilario Murua (ISSF). Janne Fogelgren (FAO) also participated in the workshop. The list of participants is included in **Appendix 1**. And the agenda for the workshop is in **Appendix 2**. Unfortunately, several participants from Korean fishery administration and industry, as well as IOTC Secretariat, cancelled their participation in the last minute due to the coronavirus outbreak following Republic of Korean Government advise to avoid large meetings. In any case, the workshop was attended by around 25 participants including fishery administration, scientist, industry and NGOs.

The Workshop was opened by Dr. Doo Hae An, director of Distant-water Fisheries Resources Division of National Institute of Fisheries Science, who emphasizes the importance of this type of Workshop to increase the capacity of Republic of Korea delegation in IOTC discussions on MPs and, hence, to leverage the participation of Republic of Korea in the process of development of tuna MPs within the Indian Ocean. But he underlined that this was not only for IOTC but for all tunaRFMOs as Republic of Korea is an important fishery CPC to all tunaRFMOs (CCSBT, IATTC, ICCAT, and WCPFC). He welcomed participants and he was very supportive of MP development at IOTC.

The workshop was guided by various presentations, but it was planned in a way that presentations would not be the main capacity building tool. Instead the presentations were used to foster discussion and engage participants, and presentations were combined with group activities such as developing conceptual maps between the various concepts and components of stock assessment process and MPs so as to understand their differences. Moreover, a question poll was also used to discuss management objective prioritization, timeframes for actions and tolerable risks of failure in achieving objectives as well as the IOTC management decision framework. Finally, a Shiny Application developed by the ABNJ was used to develop and test different alternative harvest control rules and management procedures to review and understand the trade-off between conflicting objectives related to safety, catch stability, yield, etc.

The first morning was focused on an introduction to the IOTC Management Framework and a brief of IOTC stocks status, the IOTC consensus-based process for adoption of Management Procedures, the status of the Republic of Korean fisheries to understand possible contrasting objectives amongst various stakeholders, and to contrast the differences between current stock assessment approach for providing management advice and that used to test performance of alternative Management Procedures. These presentations were followed by rich discussions that allowed the organizers to gauge the level of understanding among participants to adjust the contents of subsequent presentations and discussions (**all presentations are included in**

Appendix 3). As the knowledge and experience of participants were quite diverse, from those that work in data collection to those attending IOTC or other tuna RFMO tuna stock assessments meetings, others attending as advisors at tunaRFMO Commission meetings, as well as industry and NGO participants; the rest of the day was focused on presenting the basic principles of Management Procedure approach, components and concepts, including Kobe plots, target and limit reference points, the IOTC management decision framework in Resolution 15/10, overview of objectives, timeframes, probabilities and risk, trade-offs, performance statistics, the roles and responsibilities of scientists and managers in MP development and the MP process of dialogue and feedback. At this point, the agenda was adjusted to spend more time reinforcing basic, but fundamental concepts to increase audience understanding and engagement for the second day, and, in general, for their participation in IOTC MP process. The first day was finished with the development of conceptual maps of Stock Assessment and Management Procedure processes (**Figure 1**).

The second morning started with a revision of the conceptual maps elaborated in day 1 and the discussion of the responses to the question poll (**Appendix 4**). The rest of the day was focused on a more detailed presentation of the different components of Management Procedures and the Management Strategy Evaluation and on the Shinny App practical exercises for examining MP and various Harvest Control Rule examples with different objectives to discuss performance statistics and the trade-offs between different objectives. There were many discussions related to objectives (economic, social, biological and ecological), and their prioritization. Participants were very engaged in the 3 exercises at all levels: asking questions, presenting their ideas and the conceptual maps developed, participating in the various activities, developing HCRs/MPs to achieve various fishery management objectives. Overall, the level of knowledge about the MP process improved considerably by the end of the workshop (**Figure 2**).

Conclusion

Based on attendees participation in discussions as well their engagement in the activities, where they showed a good understanding of different concepts of the MPs and developing the conceptual maps of Stock Assessment vs. MP; the objective of the workshop to create a better understanding among Republic of Korean stakeholders of the Indian Ocean Management Strategy Evaluation (MSE) and Management Procedure (MP) process was achieved. The feedback received from fishery administration participants, scientist, industry stakeholders and NGOs was very positive, and all of them underlaid that their comprehension of such complex matters of Management Procedure and Management Strategy Evaluation greatly improved.

Participants recognized that their understanding increased and suggested that similar types of workshops should be organized to address IOTC process of management decision, stock assessment, and other themes to increase their capacity to contribute to the process. Participants showed positive feedback in terms of workshop content and format, and comments and recommendations for improvement were received. Moreover, WWF-Korea showed interest about organizing a second round of MSE/MP workshop involving more participants, which demonstrates the usefulness of this exercise and their willingness to participate in the implementation of sound Management Procedures in IOTC particularly and tunaRFMOs more generally.

As MSE/MP involves complex concepts and processes, IOTC Technical Committee on Management Procedures at its 2019 meeting underlined the need to organize capacity building workshops on MSE to increase the engagement in the process of adoption of IOTC MPs by all IOTC CPCs. Considering the success of this workshop, ***the group RECOMMENDED that the next Common Oceans ABNJ FAO Tuna project (phase 2) provides support to more MP/MSE capacity building workshops.***

Figure 1. Example of group activity where groups of participants arrange the different elements of Stock Assessment (C and D) and Management Procedure (E and F) in a conceptual map as they understand the process. A: group 1 discussion, B: group 2 discussion, C: group 1 Stock Assessment

conceptual map, D: group 1 Management Procedure conceptual map, E: group 2 Management Procedure conceptual map, F: group 2 Stock Assessment conceptual map.

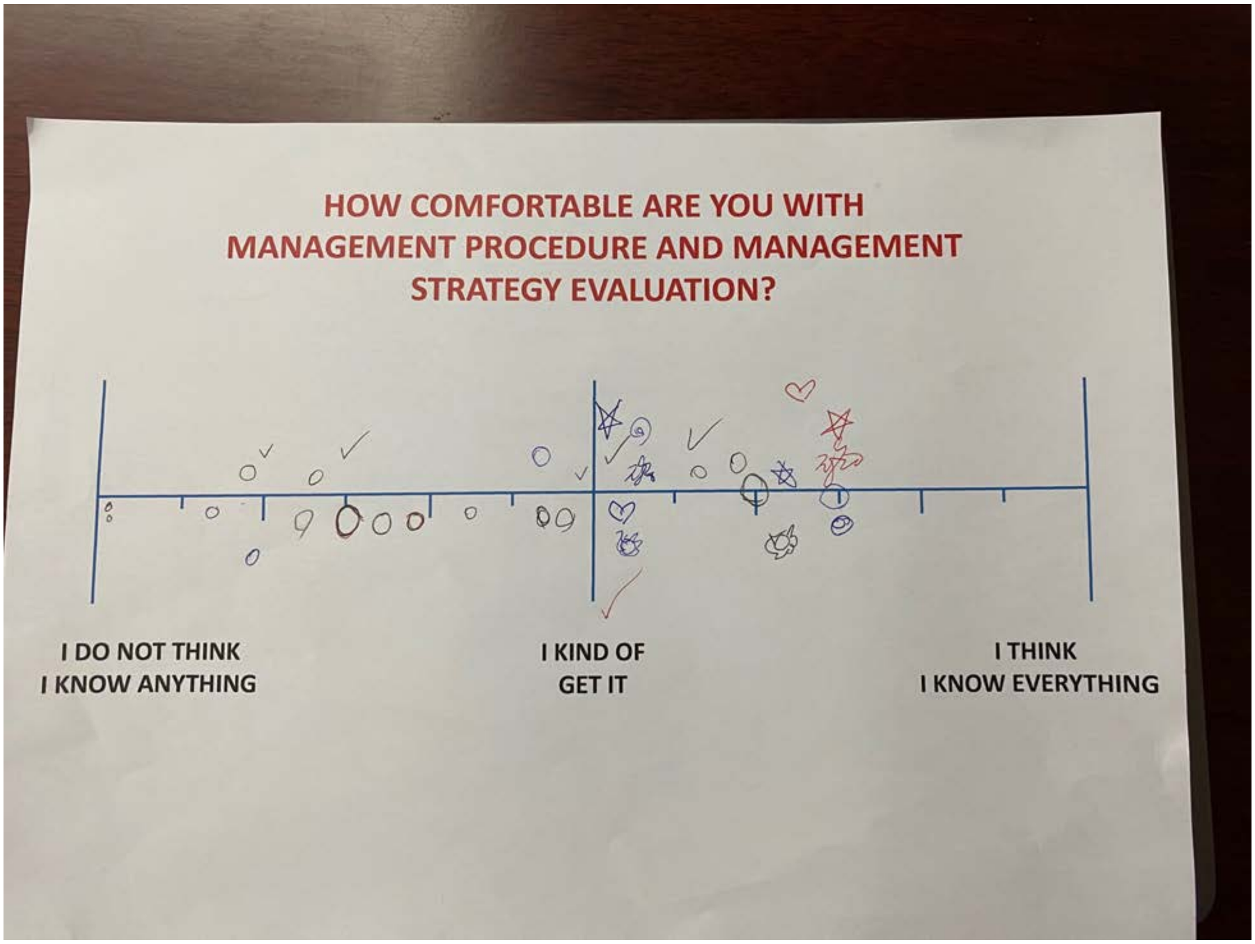


Figure 2. Distribution of participants' own perception of how much they understand Management Procedures at the start of the meeting (black marks) and by the end of the workshop (blue-red marks).

Appendix 1. List of Participants

Furthering Capacity Building for Harvest Control Rules and Management Strategy Evaluation : *Indian Ocean Tuna Management Workshop*

Feb. 19 - 20, 2020 / National Institute of Fisheries Science

Name	Affiliation	e-mail address
김선경	해외수산협력센터	sk.kim@kofci.org
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구연정	동원수산(주)	dwysk@dwsusan.com
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Appendix 2. Workshop Agenda

Furthering Capacity Building for Harvest Control Rules and Management Strategy Evaluation: Indian Ocean Tuna Management Workshop

19-20 February, 2020
National Institute of Fisheries Science, Busan, Replubic of Korea

Workshop Context

The workshop is part of the "Sustainable Management of Tuna Fisheries and Biodiversity Conservation in Areas Beyond National Jurisdiction" (ABNJ Tuna Project). The overarching project focuses on three component areas:

4) Supporting implementation of sustainable and efficient fisheries management and fishing practices
5) Reducing illegal, unreported and unregulated (IUU) fishing through strengthened and harmonized monitoring, control and surveillance
6) Reducing ecosystem impacts from tuna fishing, including bycatch and associated species

Under the Component 1, Capacity Building Workshop for Management Procedures and Management Strategy Evaluation directed to specific countries outreach are organized. These workshops are implemented by the International Seafood Sustainability Foundation (ISSF) with contribution from Indian Ocean Tuna Commission (IOTC) and country institutions.

Workshop Aims

The goal of this workshop is to create a better understanding among Indian Ocean States of the Management Strategy Evaluation (MSE) and Management Procedure (MP, also called Harvest Strategies) to ensure sustainable management of tunas.

Ultimately, the objective of this workshop is to leverage the participation of Republic of Korea in the process of development of tuna MPs within the Indian Ocean. Participation in this workshop will empower Republic of Korea to engage meaningfully in the process of MP development that are occurring in the Indian Ocean Tuna Commission (IOTC).

The Event

The workshop program will include discussion of Management Procedure framework and the principles of sound fisheries management. This workshop will provide the platform and background knowledge for participation in the Indian Ocean regional level MP work, and will contribute to the development of robust Management Procedures that are most likely to meet the objectives of IOTC members and stakeholders.

This workshop will provide introduction to the process of MP development; the elements of a MP, for example management objectives, timeframes and risk; how to interpret the trade-offs between different objectives and the use of MSE to evaluate MPs. Although the agenda is comprehensive, the objective is to have an open and lengthy discussion on the various elements that will require more attention from participants. The goal is to discuss relevant needs and issues for Republic of Korea specific to the Indian Ocean tunas and allow for more in-depth understanding of how the concepts and tools presented in the workshop may assist in increasing Republic of Korea participation in the process of the IOTC Technical Committee on Management Procedures.

The Agenda

DAY ONE – 19TH February 2020

0900 – 0930	**Introduction & Objectives of the workshop**	Hilario Murua (ISSF)
0930 – 1045	**Setting the Context**	
	• Introduction to IOTC Management Framework and stock status	Hilario Murua (ISSF)
	• The IOTC Process on adoption of Management Procedures	Hilario Murua (ISSF)
	• Overview of national tuna fisheries	Doo Nam Kim (NIFS)
	• Moving from a 'best assessment' approach to Management Procedures	Hilario Murua (ISSF)
1045 – 1115	BREAK	
1115 – 1230	**Introduction to the provision of Fisheries Management Advice and Management Procedure approach, components and concepts** ***<u>Fisheries Management Advice</u>*** • Basic Principles, • Kobe plots, • Target and Limit Reference Points, • IOTC Decision Framework	Hilario Murua (ISSF)
1230 – 1330	LUNCH	
1330 – 1500	**Introduction to the provision of Fisheries Management Advice and Management Procedure approach, components and concepts (continue)** ***<u>Management Procedures</u>*** • Basic Principles, • Objectives, • Timeframe & Risk, • Performance Indicators, • Roles and responsibilities, • Dialogue and feedback mechanism, • Discussion	Hilario Murua (ISSF)

1500 – 1530	BREAK	
1530 – 1615	**Going Deeper: MP and Management objectives and performance measures to evaluate MSE results** • Objectives o Types of objectives, scale, time-frame, probabilities, etc. o Reference points and how they related to objectives, o Trade-off between objectives o National vs. Regional objectives o Your objectives?	Hilario Murua (ISSF)
1615 – 1715	Questionnaire discussion Recap: Conceptual Map exercise Wrap up and planning 2nd day	Hilario Murua (ISSF) Hilario Murua (ISSF) Hilario Murua (ISSF)
1730	DAY 1 CLOSE	

DAY TWO – 20TH February 2020

0900 - 0915	OPENING Day 1 reflections & Day 2 overview	 Hilario Murua (ISSF)
0915 - 1030	**Going Deeper: MP and Management objectives and performance measures to evaluate MSE results** • Objectives o Types of objectives, scale, time-frame, probabilities, etc. o Reference points and how they related to objectives, o Trade-off between objectives o National vs. Regional objectives o Your objectives? o How to interpret the results, performance indicators and trade-off figures	Toshihide Kitakado (TUMSAT) /Hilario Murua (ISSF)

1030 - 1100	BREAK	
1100 - 1200	**Going Deeper: Management Strategy Evaluation (MSE) and Exploring Management Procedures** • Type of HCR, • Create and run various HCRs • Comparing results and tradeoffs: a closer look	Toshihide Kitakado (TUMSAT)/Hilario Murua (ISSF)
1200 - 1230	**Going Deeper: discuss an example from IOTC (e.g Bigeye)** • Present various MPs as discussed in 2019 TCMP • Comparing results and tradeoffs • Discussion	Toshihide Kitakado (TUMSAT)/ Hilario Murua (ISSF)
1230 - 1330	LUNCH	
1330 - 1500	**Stakeholder view** • Stakeholder objectives • Trade-offs and performance indicators, how to interpret the results	Hilario Murua (ISSF)
1500 - 1530	BREAK	
1530 - 1600	**Putting all pieces together** • What we learned • How this applies to upcoming IOTC process	All
1600 - 1630	**How did we do?** • Workshop evaluation	All
1630 - 1700	Closing	

Appendix 3. Presentations

Appendix 4. Results of the Question Poll

Furthering Capacity Building for Harvest Control Rules and Management Strategy Evaluation: Indian Ocean Tuna Management Workshop

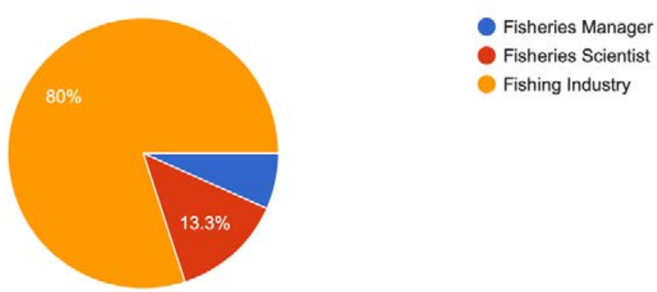
19-20 February, 2020
National Institute of Fisheries Science, Busan, Republic of Korea

Busan Workshop Questionnaire (MSE)

17 responses

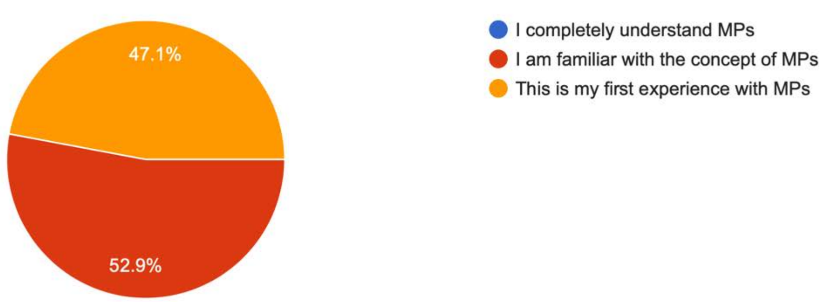
1. What is your position?

15 responses



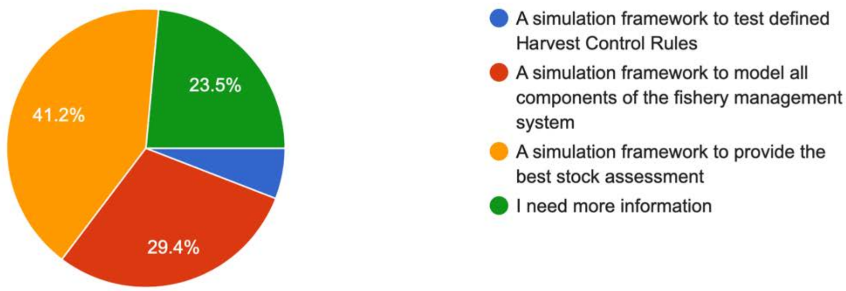
2. How well do you understand what Management Procedures (MPs) are and how they work?

17 responses



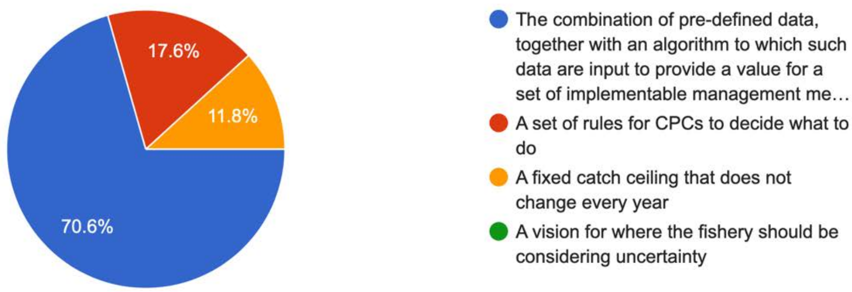
3. What does Management Strategy Evaluation mean to you?

17 responses



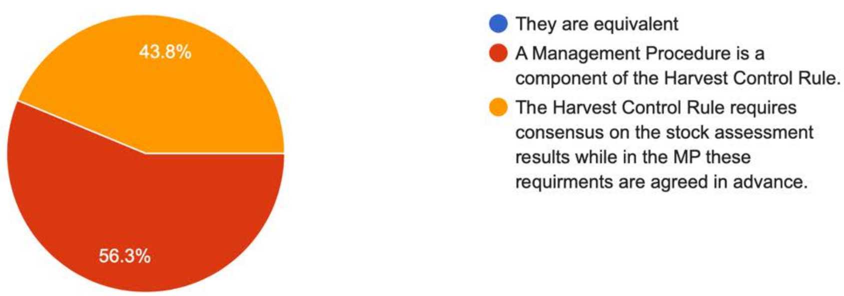
4. Which one of these definitions better explains to you what a Management Procedure is?

17 responses



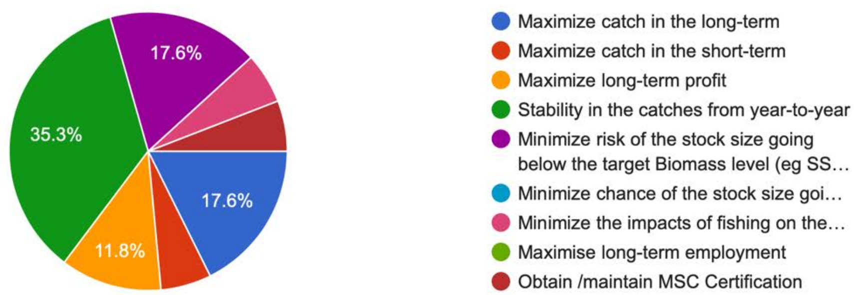
5. What is the difference between the IOTC skipjack Harvest Control Rule and a Management Procedure?

16 responses



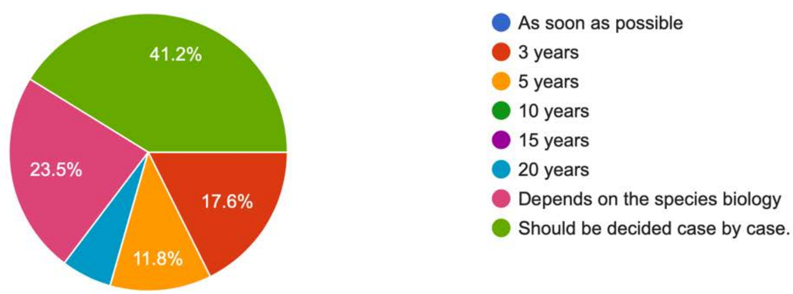
6. Please select your highest priority management objective.

17 responses



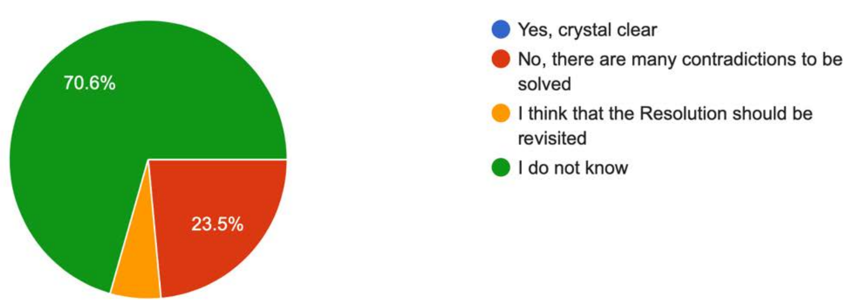
7. What would you consider to be an appropriate timeframe for recovery for an overexploited/overfishing stock

17 responses



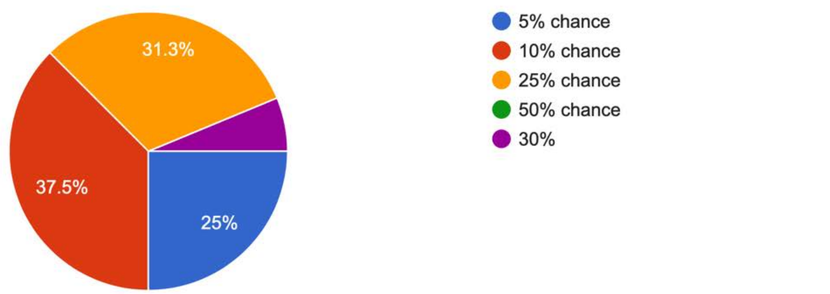
8. Do you consider that the management framework and operational objectives established in Resolution 15/10 are clear

17 responses



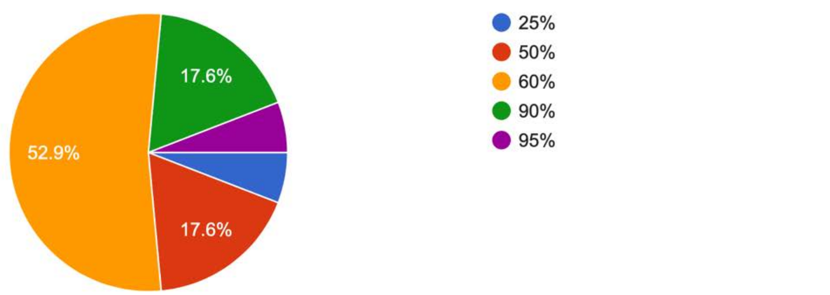
9. How would you define low probability" ?

16 responses



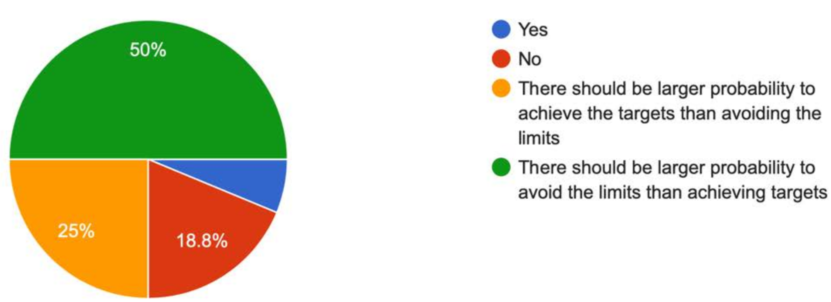
10. What is your interpretation of high probability in this case from Resolution 15/10: "For a stock where the assessed status places it within the lowe...tock with a high probability within this quadrant"?

17 responses



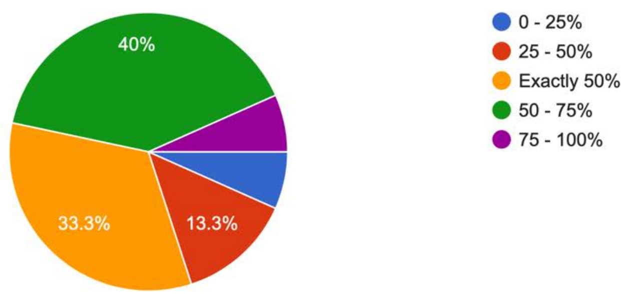
11. Do you think that the "high probability" is the same when related to achieving the targets or avoiding falling below the limits?

16 responses



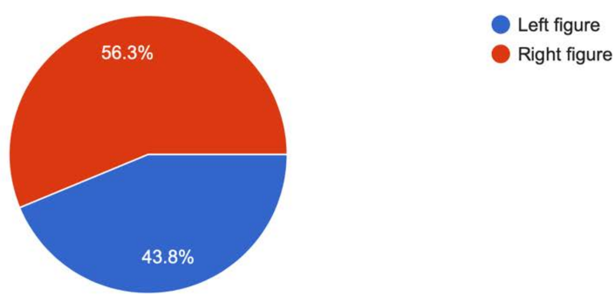
12. On average, the stock should be above B/BMSY and below F/FMSY what proportion of the time?

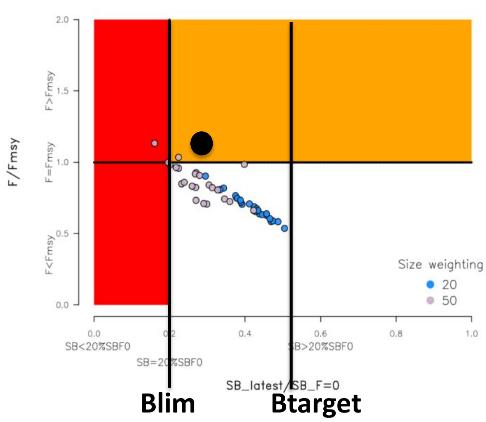
15 responses

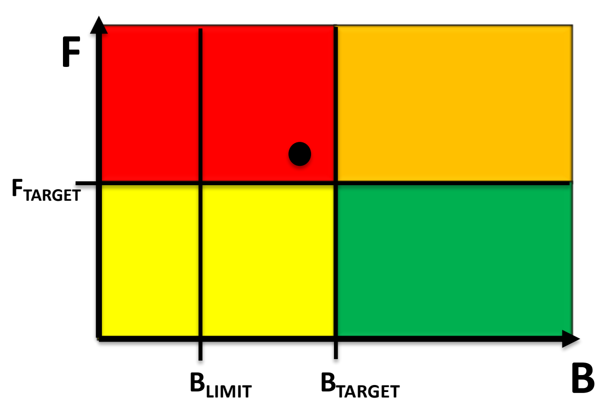


13. Which of the stock below would require more stringent management measures (stock status marked by the circle)?

16 responses







Food and Agriculture Organization of the United Nations

COMMON OCEANS

iotc ctoi

ISSF INTERNATIONAL SEAFOOD SUSTAINABILITY FOUNDATION

Furthering Capacity Building for Harvest Control Rules and Management Strategy Evaluation: Indian Ocean Tuna Management Workshop

Hilario Murua (ISSF)
Toshi Kitakado (TUMSAT)
Dan Fu (IOTC)

Busan, Republic of Korea, 19-20 February 2020

Furthering Capacity Building for Harvest Control Rules and Management Strategy Evaluation: Indian Ocean Tuna Management Workshop

The workshop is part of the ABNJ Tuna Project "Sustainable Management of Tuna Fisheries and Biodiversity Conservation in Areas Beyond National Jurisdiction"

The project is focused on three component areas:

1. ***<u>Promotion of sustainable management,</u>***
2. Strengthening and harmonizing Monitoring Control and Surveillance,
3. Reducing ecosystem impacts.

COMMON OCEANS

Furthering Capacity Building for Harvest Control Rules and Management Strategy Evaluation: Indian Ocean Tuna Management Workshop

- The goal of this workshop is to create a better understanding among Indian Ocean States of the Management Strategy Evaluation (MSE) and Management Procedure (MP, also called Harvest Strategies) to ensure sustainable management of tunas
- Ultimately, the objective of this workshop is to leverage the participation of Republic of Korea in the process of development of tuna MPs within the Indian Ocean.

COMMON OCEANS

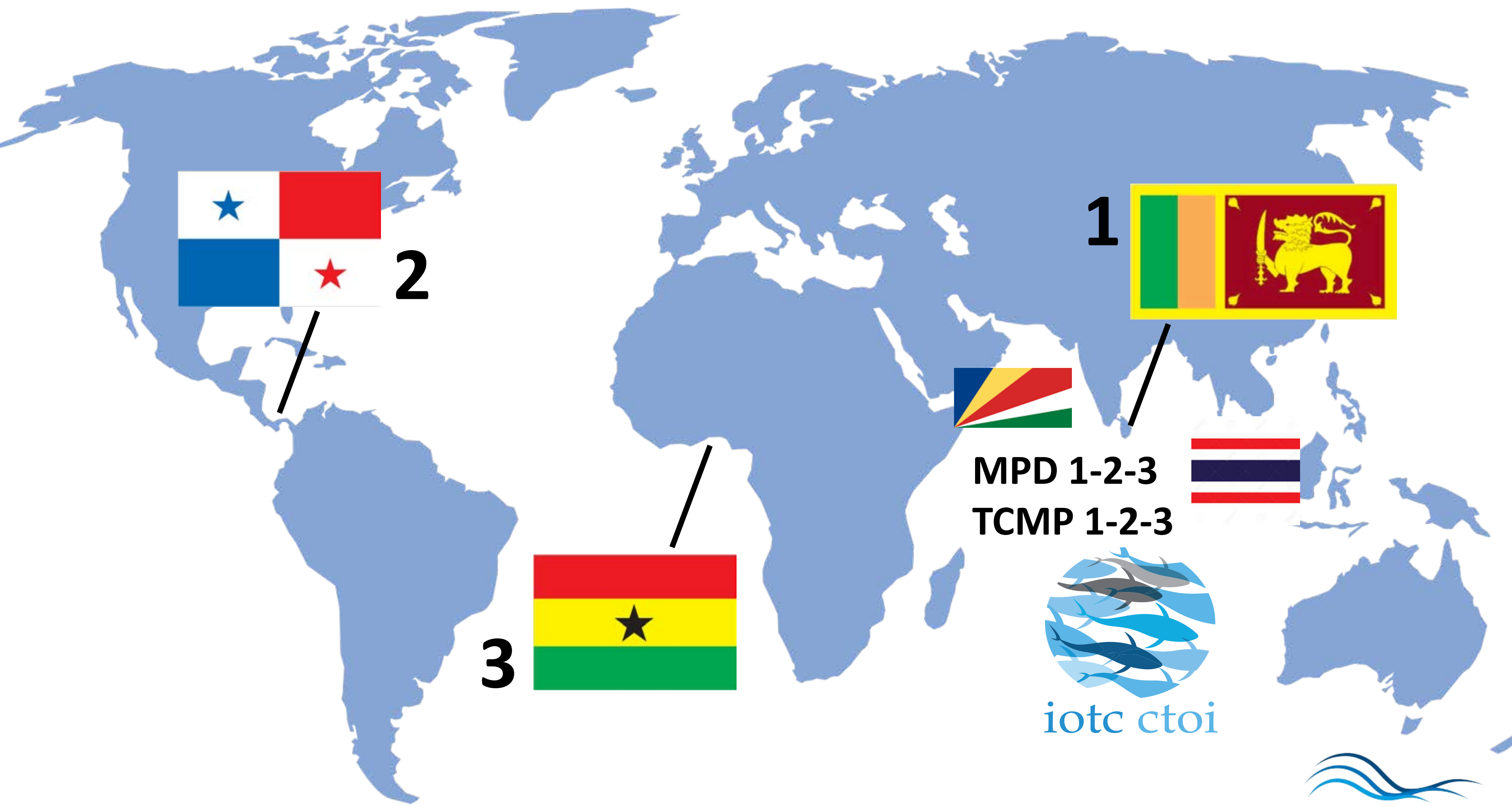
Furthering Capacity Building for Harvest Control Rules and Management Strategy Evaluation: Indian Ocean Tuna Management Workshop

This workshop builds on previous WSs to consider key elements of fisheries management issues currently relevant to IOTC members.

Participation will empower you to engage meaningfully in the ongoing discussions on Management Procedures for Indian Ocean tuna stocks over the coming years

COMMON OCEANS

Furthering Capacity Building for Harvest Control Rules and Management Strategy Evaluation: Indian Ocean Tuna Management Workshop



COMMON OCEANS

Workshop objectives

- Interpretation of IOTC tuna stock status indicators including Kobe plots and other forms of presentation,
- Understanding of Management Procedures (MPs) and the process of of MP development,
- Their components and application,
  - Management objectives,
  - Timeframes
  - Risk

COMMON OCEANS

Workshop objectives

- Open and lengthy discussion on various elements requiring more attention,
- Preparation for discussions about trade-offs between management options,
- **Understanding of roles (scientists, fisheries managers, Secretariat, NGOs, industry),**
- Increase meaningful participation in TCMP/Commission discussions/decisions
- **Gain understanding/confidence to speak in support of management options (including MPs) to meet national/IOTC Goals**

COMMON OCEANS

Workshop Format

- Presentations as a guide, but a lot to understand – an ambitious agenda,
- Informal set up, if something is not clear or we move quickly, please request to STOP!!
- Engagement/questions essential,
- Your WS so please free feel to change the course of actions (presentation),
- Hands on during the second day,
- Working in plenary but interaction is key,
- Flexible; if something is not working, we can change it

COMMON OCEANS

Workshop Format

- THIS IS A ITERATIVE PROCESS
  - Not be afraid to interrupt,
  - Questions help everybody,
  - Your ideas enrich everybody,
  - We are here to listen, also during coffee.
- THIS IS NOT A LECTURE OR TECHNICAL EXERCISE
  - No strange acronyms,
  - No equations (maybe just one…),
  - No modelling code,
  - No complicate figures/tables

COMMON OCEANS

Workshop Format

IN SHORT,

THE WORKSHOP IS YOURS AND FOR YOU!!!!

COMMON OCEANS

Agenda Day 1 (Morning)

Setting the Context

- Introduction to IOTC Management and stock status– *H. Murua & T. Kitakado*
- IOTC MP process – *H. Murua & T. Kitakado*
- Overview of Republic of Korea tuna fisheries – Dr. *Doo Nam Kim*
- From best assessment to MP– *D. Fu*

COFFEE BREAK

COMMON OCEANS

Agenda Day 1 (Morning - continue)

Introduction to the Provision of Management Advice and Management Procedure approach, components and concepts – *H. Murua/T. Kitakado/D. Fu*

Fishery Management Advice

- Basic principles,
- Kobe plot,
- Target and Limit Reference Points,
- IOTC Decision Framework

LUNCH BREAK

COMMON OCEANS

Agenda Day 1 (Afternoon)

Introduction to the Provision of Management Advice and Management Procedure approach, components and concepts – *H. Murua/T. Kitakado/D. Fu (Continue)*

Management Procedure

- Basic principles,
- Objectives,
- Timeframes and risk,
- Performance Indicators,
- Roles and responsabilities,
- Dialogue and feedback mechanism,
- Discussion

LUNCH BREAK

COMMON OCEANS

Agenda Day 1 (Afternoon - cont.)

- *Exercise 1: Conceptual Maps of Stock Assessment vs Management Procedure.*
- *Questionnaire discussion*
  https://forms.gle/qfMysHzz5VqPPqYJA

CLOSE

COMMON OCEANS

Agenda Day 2 (Morning)

Going Deeper: MP and Management objectives and performance measures to evaluate MSE results. ***H. Murua/T. Kitakado/D. Fu***

- Objectives
- Types of objectives, scale, time-frame, probabilities, etc.
- Reference points and how they related to objectives,
- Trade-off between objectives
- National vs. Regional objectives
- Your objectives?
- How to interpret the results, performance indicators and trade-off figures

COFFEE BREAK

COMMON OCEANS

Agenda Day 2 (Morning continue)

Going Deeper: Management Strategy Evaluation (MSE) and Exploring Management Procedures. ***H. Murua/T. Kitakado/D. Fu***

- Types of Harvest Control Rules (HCR)
- Create and run various HCRs
- Comparing results and tradeoffs: a closer look

Going Deeper: Discuss and example from IOTC (e.g Bigeye). ***H. Murua/T. Kitakado/D. Fu***

- Present various MPs as discussed in 2019 TCMP
- Comparing results and tradeoffs
- Discussion

COMMON OCEANS

LUNCH BREAK

Agenda Day 2 (Afternoon)

Stakeholder view– *H. Murua/T. Kitakado/D. Fu*

- Stakeholder objectives,
- Comparing results and tradeoffs: a closer look.

Putting all pieces together – *All*

- What we learned,
- How this applies to upcoming IOTC process

Workshop Evaluation

CLOSING

COMMON OCEANS

Furthering Capacity Building for Harvest Control Rules and Management Strategy Evaluation: Indian Ocean Tuna Management Workshop

GAMSA HAMIN DA!

COMMON OCEANS

iotc ctoi

ISSF INTERNATIONAL SEAFOOD SUSTAINABILITY FOUNDATION

Sustainable Management of Tuna Fisheries and Biodiversity Conservation in the Areas Beyond National Jurisdiction

Introduction to IOTC Management Framework and stock status

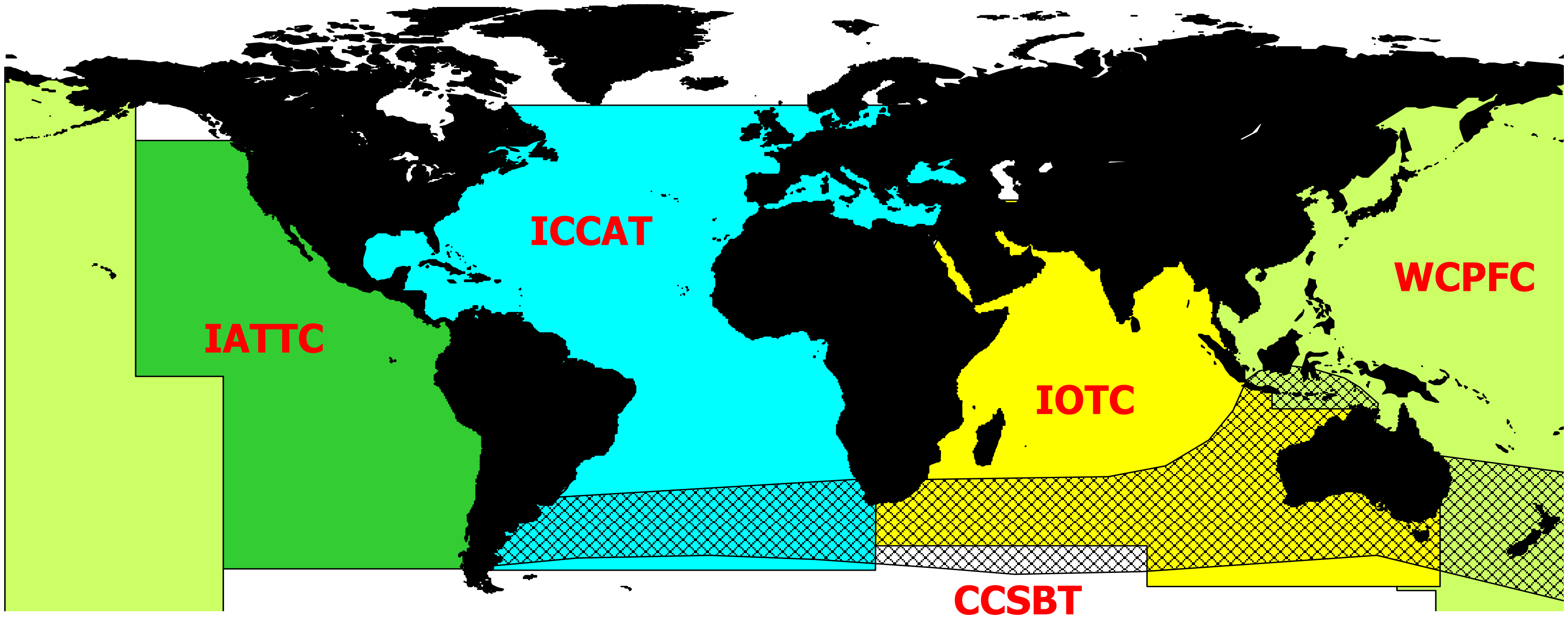
Furthering Capacity Building for Harvest Control Rules and Management Strategy Evaluation: Indian Ocean Tuna Management Workshop

Busan, Republic of Korea, 19-20 February 2020

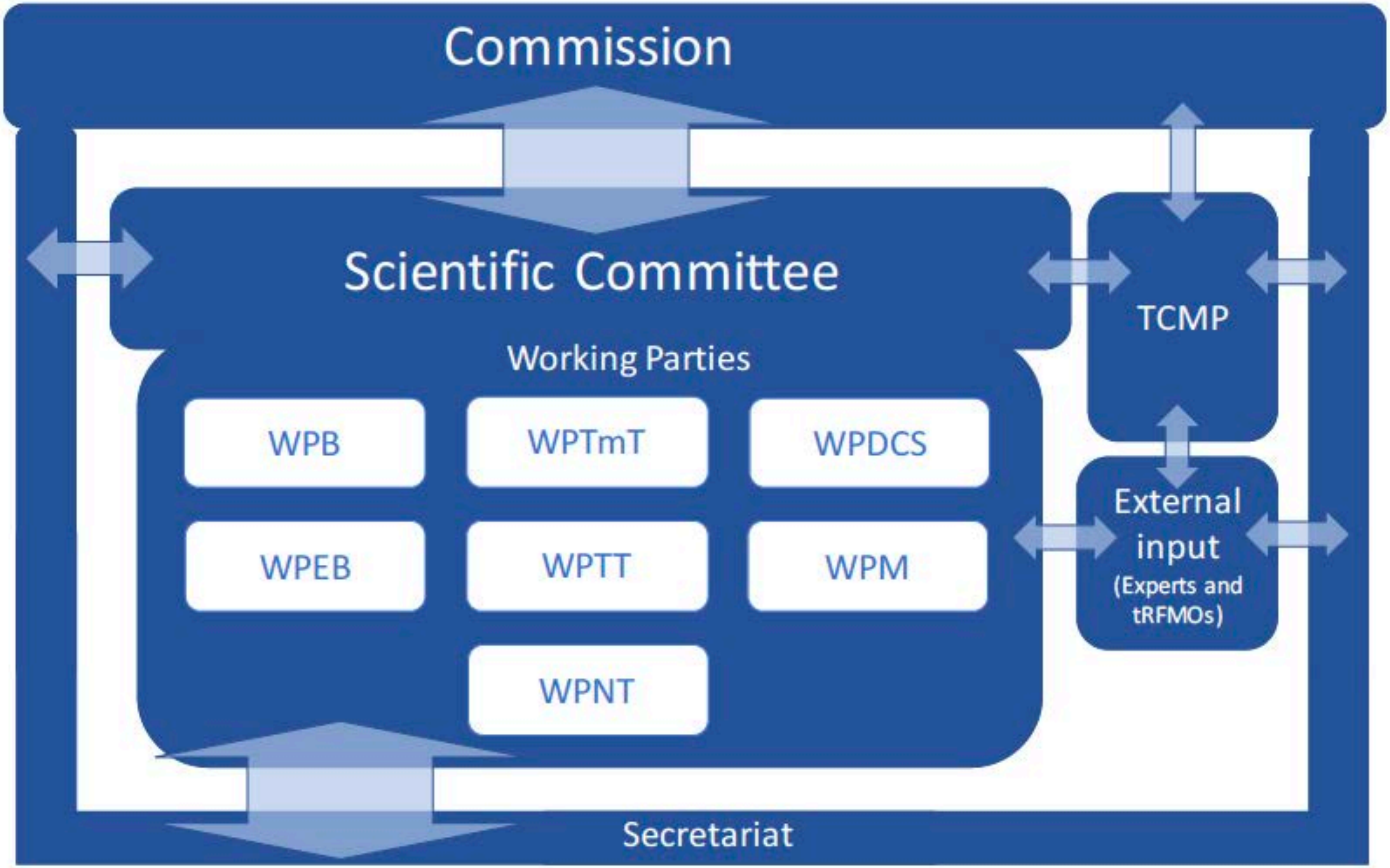
Dr. Hilario Murua
ISSF

IOTC MANAGEMENT PROCECURE HISTORY

5 tuna RFMOs



IATTC: Inter-American Tropical Tuna Commission (La Jolla, USA – 1949)
ICCAT: International Comission for the Conservation of Atlantic Tunas (Madrid, España – 1969)
CCSBT: Commission for the Conservation of Southern Bluefin Tuna (Canberra, Australia – 1994)
IOTC: Indian Ocean Tuna Commission (Mahé, Seychelles – 1996)
WCPFC: Western and Central Pacific Fisheries Commission (Kolonia, Micronesia - 2004)


Commission
Scientific Committee
Working Parties
WPB
WPTmT
WPDCS
WPEB
WPTT
WPM
WPNT
TCMP
External input
(Experts and tRFMOs)
Secretariat

SOME HISTORY

- 2002: First discussion of MSE was in the WPM in 2002, recommending the development of an operating model
- 2009: PRIOTC01 Recommendation 38 to implement Precautionary Approach and uncertainty in the advice as UNFSA; which also calls for an MSE process.
- 2010 COM supported the development of a MSE by the SC as a tool to evaluate conservation and management measures
- 2010 SC Recommended to organize a meeting on MSE between scientist, managers and representatives of the industry
- 2011 COM endorsed the development of a road map for MSE
- 2012
  - Resolution 12/01 on the implementation of the Precautionary Approach
  - Resolution 12/14 on Interim Target and Limit Reference Points
  - Resolution 12/15 on the Best Available Science
- 2013 Resolution 13/10 on Interim Target and Limit Reference Points and a Decision Framework

SOME HISTORY

- 2014
  - 1st Management Dialogue Meeting
  - Resolution 14/03 on Enhancing the Dialogue between Scientist and Managers
- 2015
  - 2nd Management Dialogue Meeting
  - Resolution 15/10 on Target and Limit Reference Points and a Decision Framework
- 2016
  - 3rd Management Dialogue Meeting
  - Resolution 16/02 on HCR for Skipjack
  - Resolution 16/09 on establishing a TCMP
  - MP/MSE Workplan developed by WPM/SC.
- 2017-2018-2019
  - 1st, 2nd and 3rd Technical Committee on Management Procedure
  - MP/MSE Workplan adopted by Commission

2020	ALB/YFT/BET	SKJ	SWO
TCMP	Provide advice to Commission on elements of candidate MPs that require a decision by the Commission, including the performance of candidate MPs against Commission objectives.	Provide advice to the Commission on any outstanding issues resulting from the application of the HCR if required	Provide advice to Commission on elements of candidate MPs that require a decision by the Commission, including the performance of candidate MPs against Commission objectives
COM	Consider work and advice from subsidiary bodies. Decision and adoption of an MP or provide direction to the WPs/SC on the need to undertake further MSE of candidate or alternative MPs	Consider work and advice from subsidiary bodies and review Resolution 16/02.	Consider work and advice from subsidiary bodies and provide direction to the WPs/SC on the need to undertake further MSE of candidate or alternative MPs
WPs/ SC	Undertake MSE to provide advice on the performance of candidate MPs		Consider recommendations from the Commission and undertake MSE to provide advice on the performance of candidate MPs

RESOLUTION 16/09
ON ESTABLISHING A TECHNICAL COMMITTEE ON MANAGEMENT PROCEDURES

2. The objectives of the TCMP shall be to:
   a) Enhance the decision making response of the Commission in relation to management procedures, including recommendations made by the Scientific Committee;
   b) Enhance communication and foster dialogue and mutual understanding between the Scientific Committee and the Commission on matters relating to management procedures; and
   c) Assist the Commission to obtain and promote the effective use of scientific resources and information.
3. The TCMP shall meet prior to and in conjunction with the annual Commission Session, to facilitate full attendance by CPCs.
4. The outcomes of the TCMP will be considered by the annual Commission Session under a standing agenda item for that purpose, as well as through the Commission's consideration of proposals relating to management procedures.
5. The TCMP shall focus on the presentation of results and exchange of information necessary for the Commission to consider possible adoption of Management Procedures. Standard formats for the presentation of results should be used, to facilitate understanding of the material by a non-technical audience.

RESOLUTION 16/09
ON ESTABLISHING A TECHNICAL COMMITTEE ON MANAGEMENT PROCEDURES

6. The agenda of the TCMP shall place emphasis on the elements of each Management Procedure that require a decision by the Commission. The adoption of Management Procedures is an iterative process that allows for adjustments as the work, and the understanding of the elements involved, progresses.

7. The TCMP should undertake the following:

   a) Identifying, evaluating, and discussing management procedures for the IOTC fisheries, which help meet the objectives of the IOTC Agreement, including socioeconomics, food security, etc., identified by the Commission, the ecosystem-based approach to fisheries and the precautionary approach for the consideration of the Commission. Specifically, consideration of the following:

      i. Overarching management objectives to guide the development of management procedures for the IOTC fisheries;

      ii. Target and Limit Reference Points with reference to Resolution 15/10 on interim target and limit reference points and a decision framework (or any subsequent revision);

      iii. Harvest Control Rules (HCRs), including: the extent to which HCRs meet management objectives; the probabilities of achieving target reference points, avoiding limit reference points, or rebuilding; the risks to the fishery and the resource at these limit and target reference points; and allowing, in particular, the implementation of a precautionary approach as required by Resolution 15/10 on interim target and limit reference points and a decision framework (or any subsequent revision);

TCMP 03

MSE basic principles

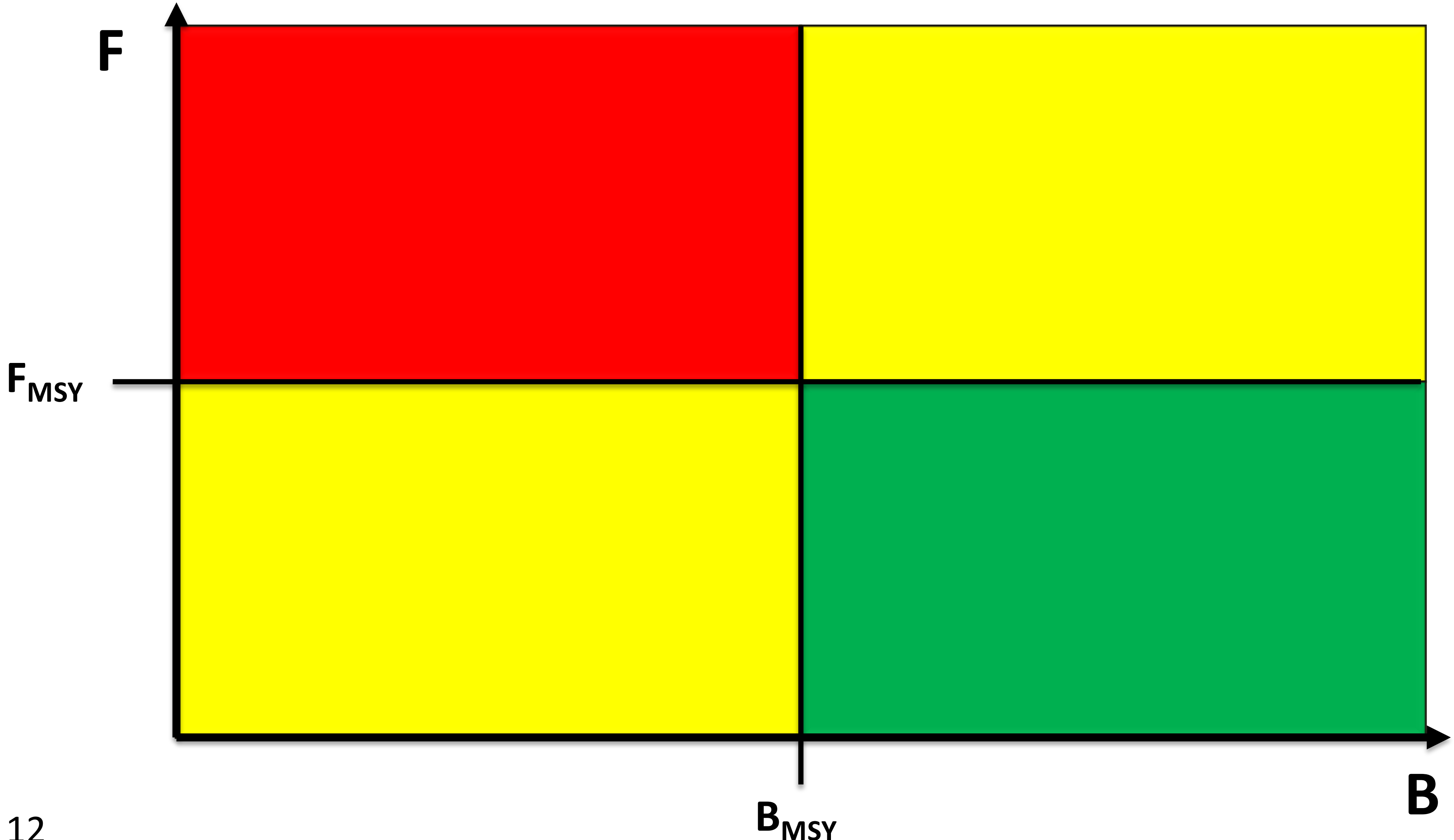
- **Complex issues presented and AGREED to maintain the science related capacity building in the next TCMP to clarify key issues in the Management Strategy Evaluation (MSE).**

- **The TCMP REQUESTED that Intersessional capacity building on MSE be conducted to increase understanding of the MSE process by all CPCs.**

IOTC MANAGEMENT FRAMEWORK

IOTC Convention Objective (Strategic or Conceptual)

The Commission shall *promote cooperation among its Members* with a view to ensuring, through appropriate management, the conservation and *optimum utilization of stocks* covered by this Agreement and *encouraging sustainable development of fisheries* based on such stocks.



Resolution 15/10: Reference Points

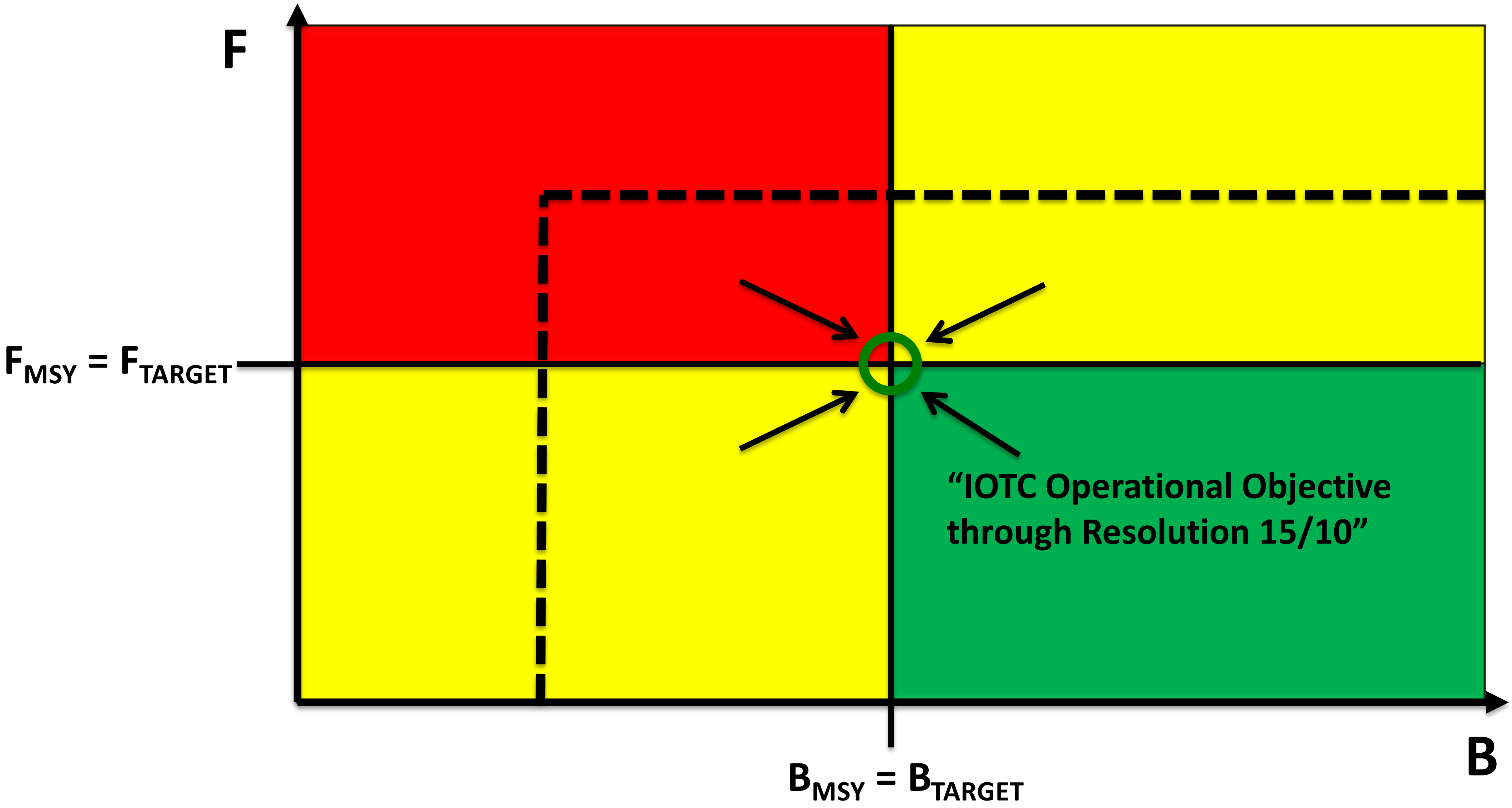
- **Interim Target and Limit Reference Points (TRPs and LRPs)**

When assessing stock status and providing recommendations to the Commission, the **IOTC Scientific Committee should, where possible, apply MSY-based target and limit reference points for tuna and tuna-like species**.

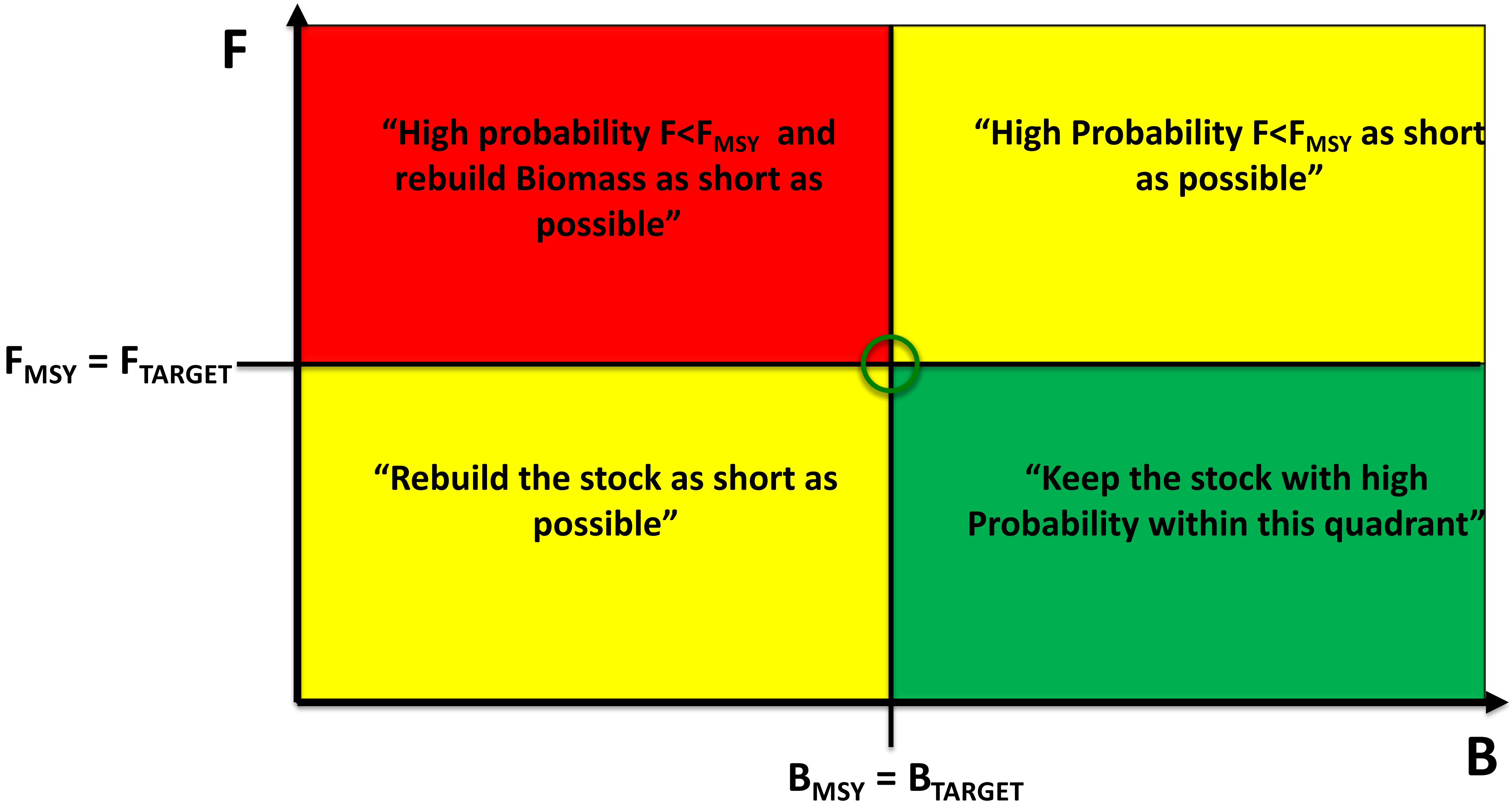
Stock	Target Ref. Point	Limit Ref. Point
Albacore Yellowfin Swordfish	$Btarget = B_{MSY}$ $Ftarget = F_{MSY}$	$Blim = 0.4 * B_{MSY}$ $F = 1.40 * F_{MSY}$
Bigeye		$Blim = 0.5 * B_{MSY}$ $F = 1.30 * F_{MSY}$
Skipjack* (based on B0)		$Blim = 0.4 * B_{MSY}$ $F = 1.50 * F_{MSY}$

* when MSY-based reference points cannot be reliably estimated RPs relative to B0.

Resolution 15/10: Reference Points (Operational Objectives)



Resolution 15/10: Reference Points (Operational Objectives)



IOTC STOCK STATUS

TROPICALS & ALBACORE

Species	Last SA	Status		MSY	Catch 2018	Catch 2014-2018	Catch Trend	Management Advice
		Prev	Last					
Albacore	2019	16	19	35,700	41,603	38,030		**Catch reduction**
Bigeye	2019	16	19	87,000	81,413	89,720		**10 % Catch reduction**
Skipjack	2017	14	17	510,100	606,197	484,993		HCR 16/02 – **Catch limit = 470,029 t.**
Yellowfin	2019	18	19	403,000	437,422	407,377		**Res. 19/01**

NERITICS

Species	Last SA	STAT US	MSY	Catch 2017	Catch 2013-2017	Catch Trend	Management Advice
Kawakawa	2015		152,000	159,881	157,326		Catches reduce ~10 % ~136,000
Longtail	2017		140,000	138,403	139,856		Catches = 2016 levels 138,403
IP King-mackerel	2016		Unknown	52,455	46,814		Catches < 46,787 (2009-2011)
Narrow-based SP mackerel	2017		130,720	159,370	160,812		Catches reduce 30 % ~ 110,000
Bullet	NO SA		Unknown	11,094	**9,959**		Catches < 8,870 (2009-2011 average)
Frigate	NO SA		Unknown	74,886	**86,157**		Catches < 94,921 (2009-2011 average)

BILLFISHES

Species	Last SA	Status	MSY	Catch 2017	Catch 2013-17	Catch Trend	Management Advice
Swordfish	2017		**31,590**	34,782	31,405	↗	**Catch < MSY**
Black marlin	2018		**12,930**	21,250	18,673	↗	**Res. 18/05**
Blue marlin	2019		**9,980**	9,969	**11,382**	→	**7,800 t.**
Striped marlin	2018		**4,730**	3,082	3,587	→	**Catch 1,500 and 2,200**
Indo-Pacific Sailfish	2015		**23,900**	36,911	31,267	↗	**Res. 18/05**

Korean tuna fisheries in the Indian Ocean

Sung Il Lee

National Institute of Fisheries Science

Background

- Korean tuna longline fishery first commenced in the Indian Ocean in 1957.

  - targeted YFT, BET along with ALB, SBT

- Korean tuna purse seine fishery started in 2012.

  - targeted SKJ and YFT

- Korea has implemented Electronic Reporting system since 2015.

Changes in data reporting and collection system

❖ Legal basis : the Distant Water Fisheries Development Act

Paper logbook

(~ 2012. 11)

- Time for data submission
  - (home-based) within 30 days after completion of operations
  - (foreign-based) within 60 days

Elec. logbook

(2012. 12 ~ 2015. 8)

- The Act strengthened
  - fishers report every month (achieved 100% coverage)
  - to collect information on discard/release
  - to collect bycatch information on Ecologically Related Species

Elec. Reporting

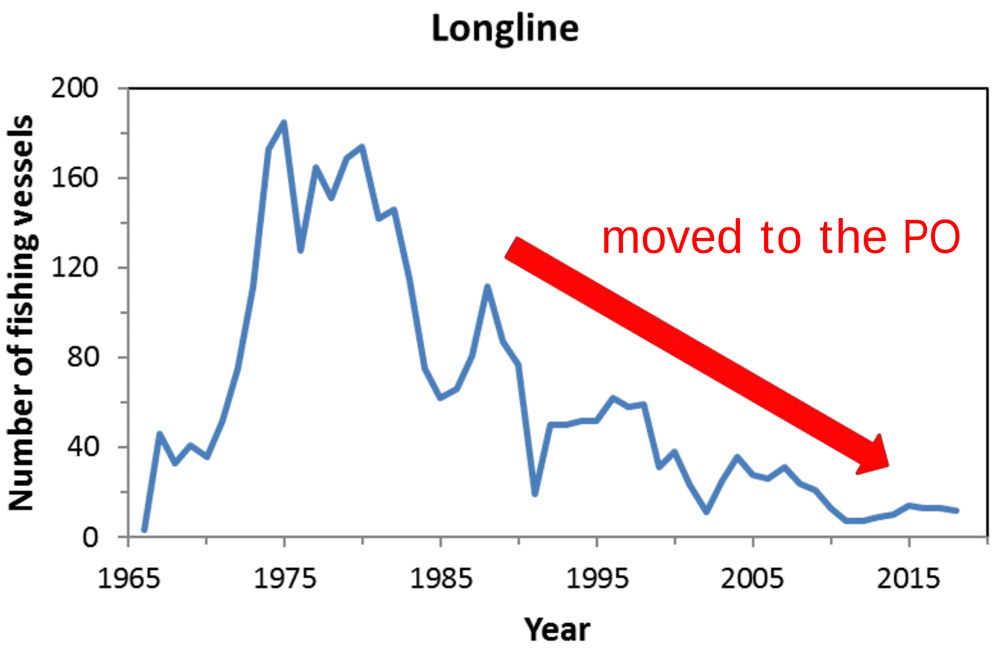
(2015. 9 ~)

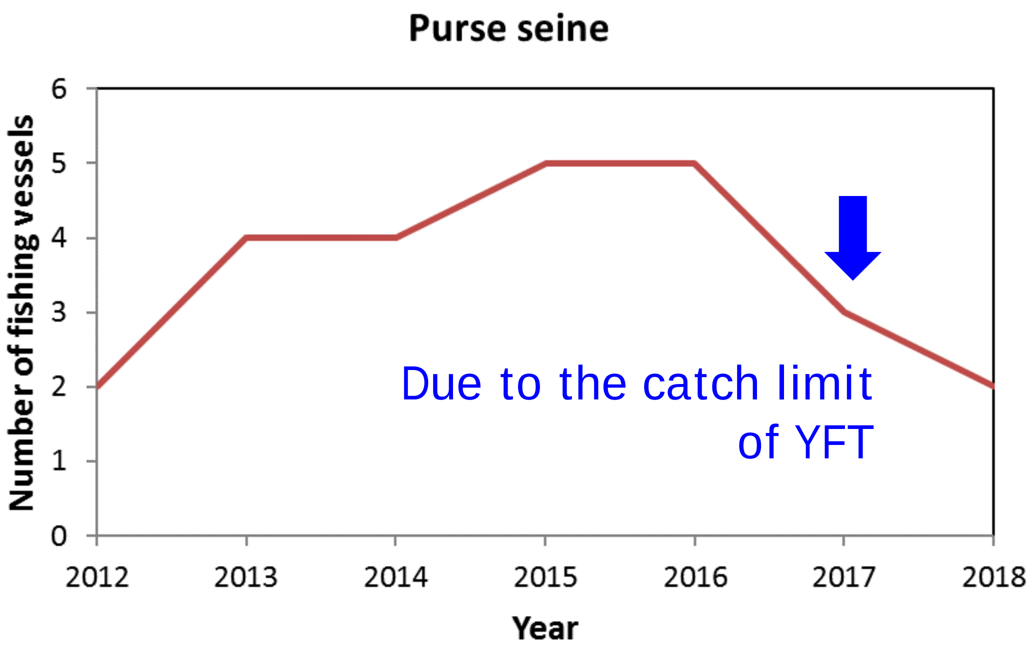
- The reporting system changed
  - fishermen report every day to the NIFS
  - cross-checked with data of VMS and CDS

Data contents collected from logbooks through changes of the reporting system

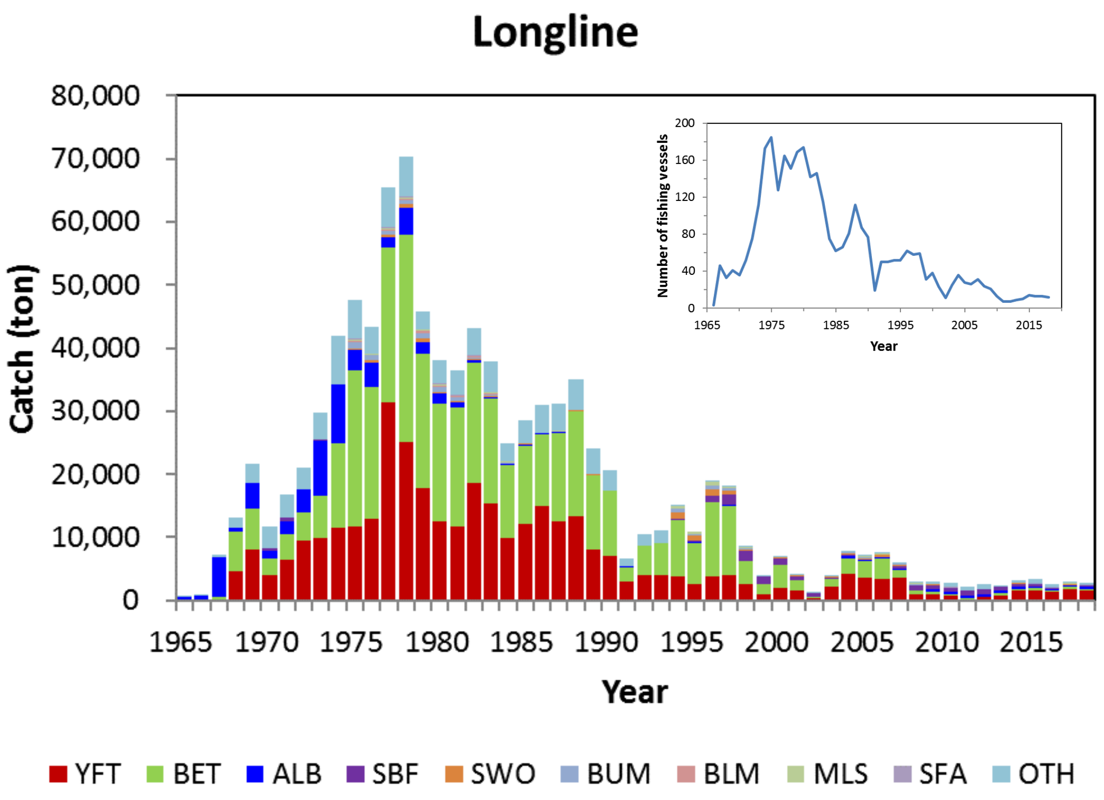
Paper logbook	Elec. logbook	Elec. reporting
• Species reported - tuna : ALB, YFT, BET, PBF, SKJ, SBT - billfish : BUM, MLS, SWO, BLM, WHM, SFA - others : not identified - sharks : not identified	• Species reported - tuna : same - billfish : same - others : same - sharks : BSH, MAK, POR, FAL, OCS, HMS and OSH - sea bird/sea turtle (added)	• Species reported ※ not only key species but also bycatch species
• Set details and catch - fishing date and position - fishing effort(hooks, floats) - retained catch(No/kg)	• Set details and catch - fishing date and position - fishing effort(hooks, floats) - retained catch(No/kg) - activity code - No. of discard(live/dead) - set start time	• Set details and catch - fishing date and position - fishing effort(hooks, floats) - retained catch(No/kg) - activity code - No/kg of discard(live/dead) - set start/end time

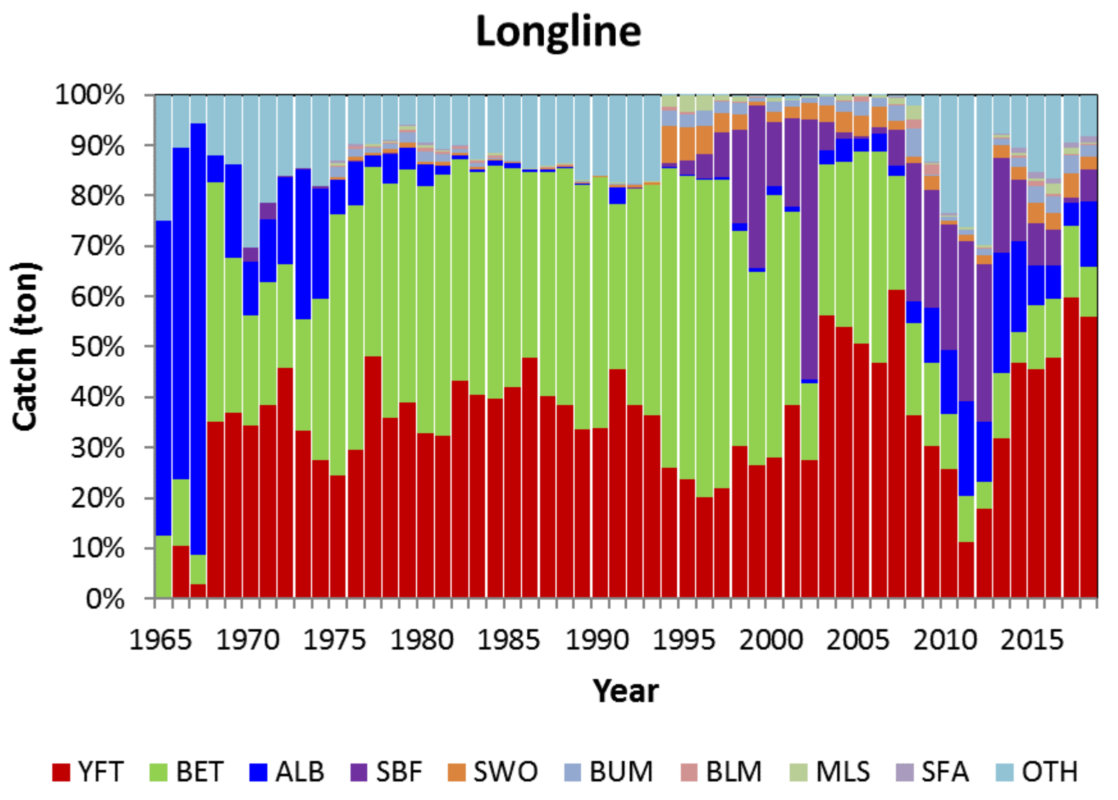
Changes in the number of longline and purse seine fishing vessels



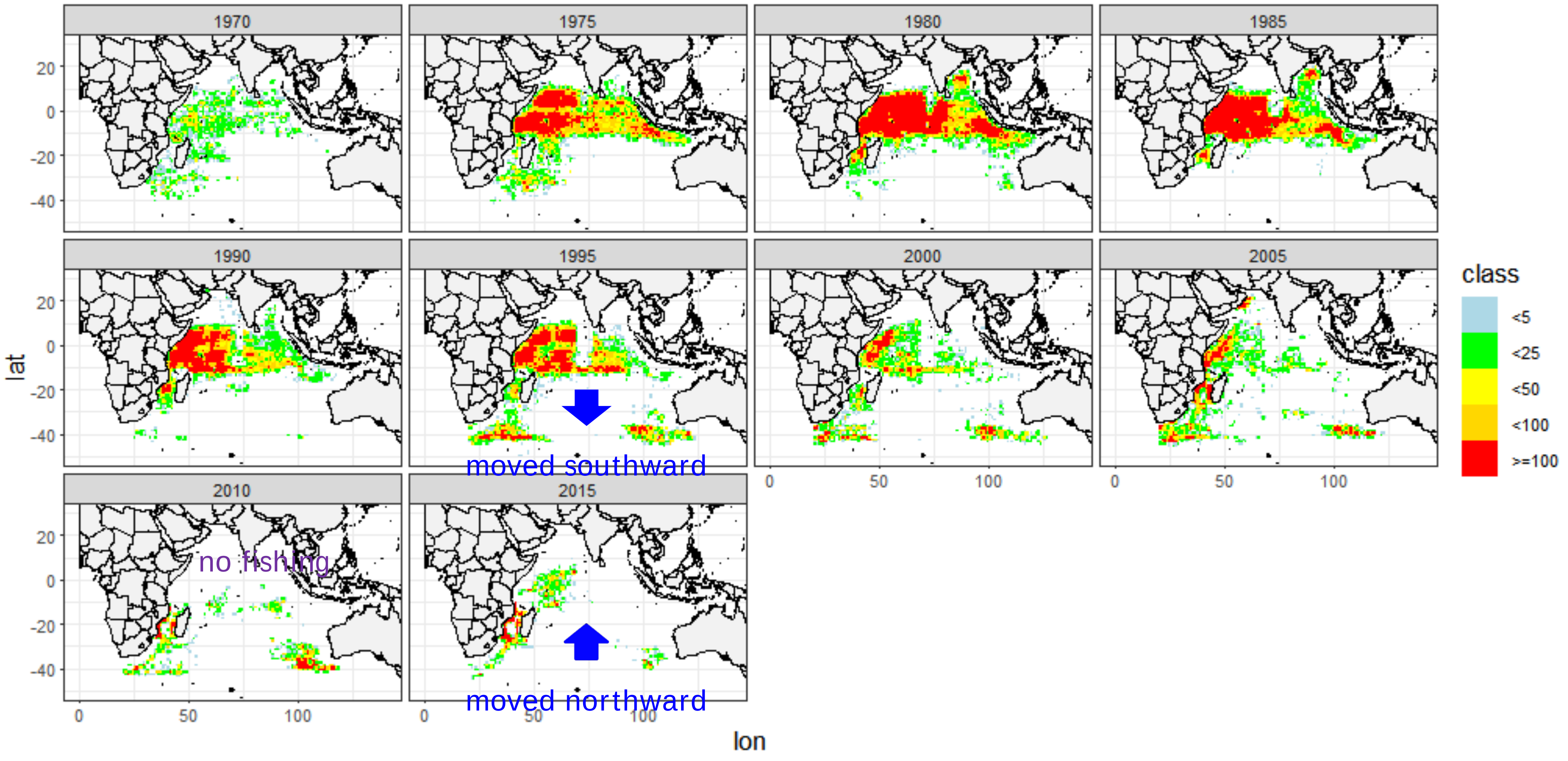


Catch trend of major species of longline fishery

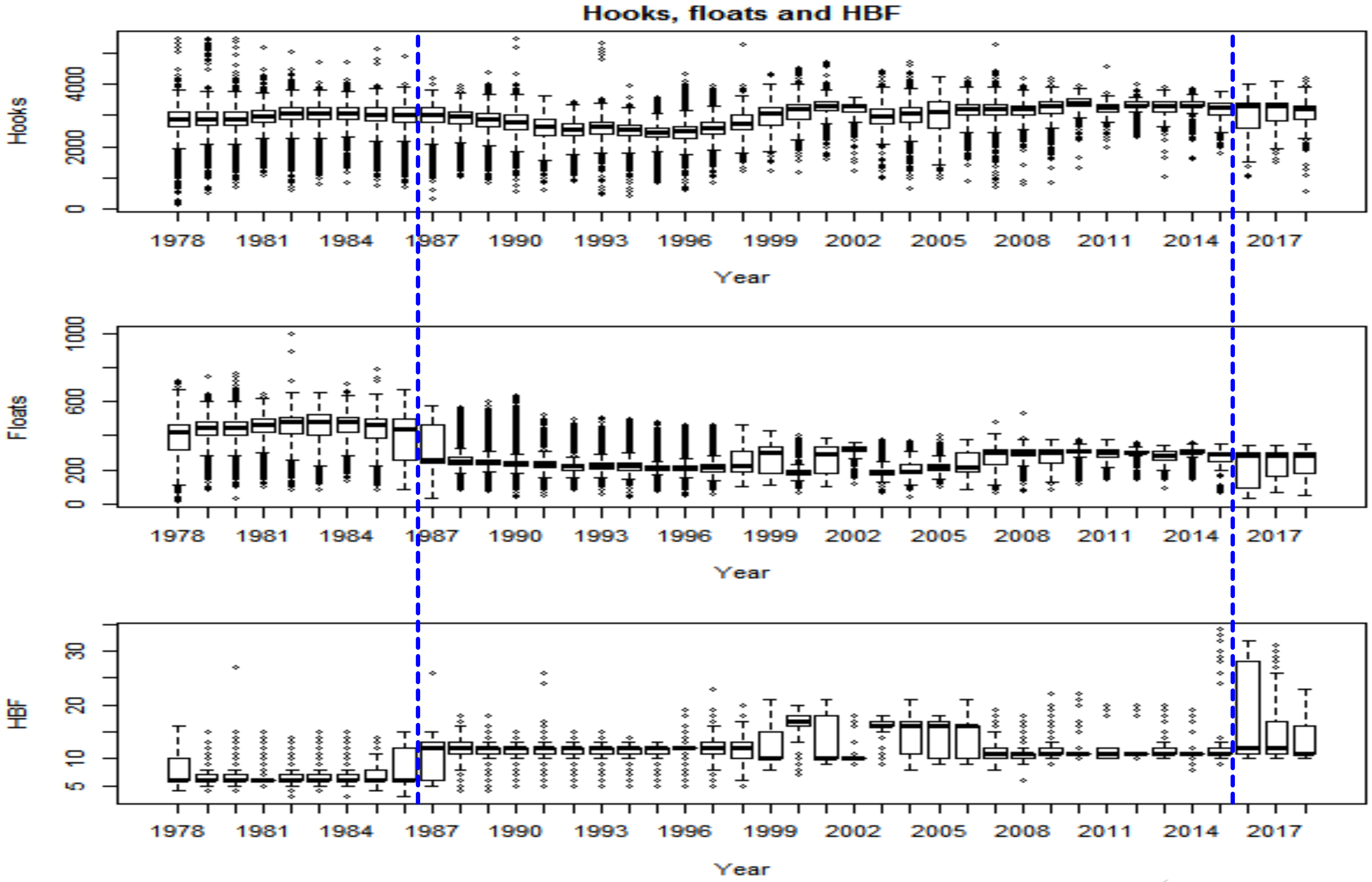




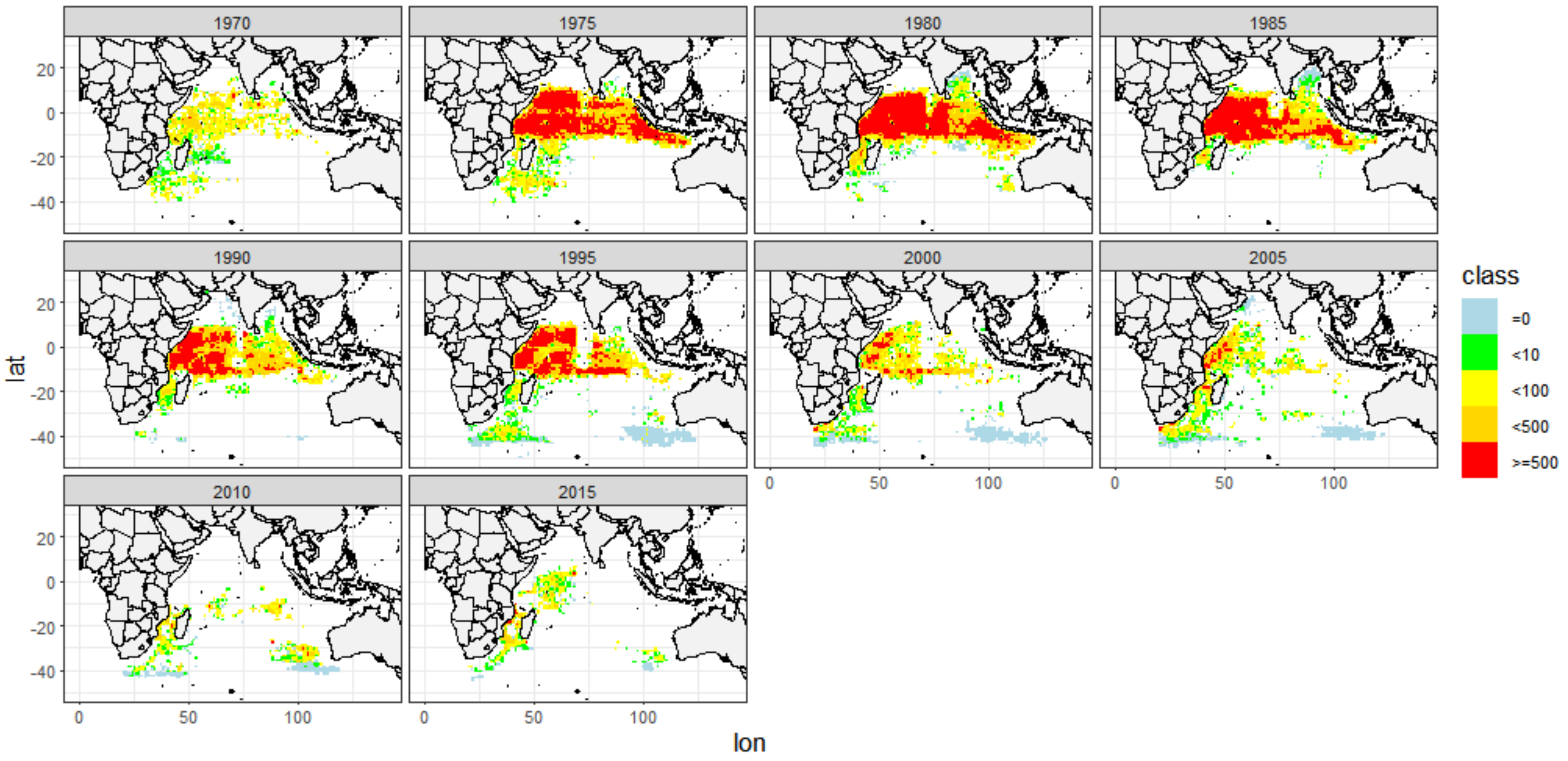
Effort (hooks) distributions of longline fishery



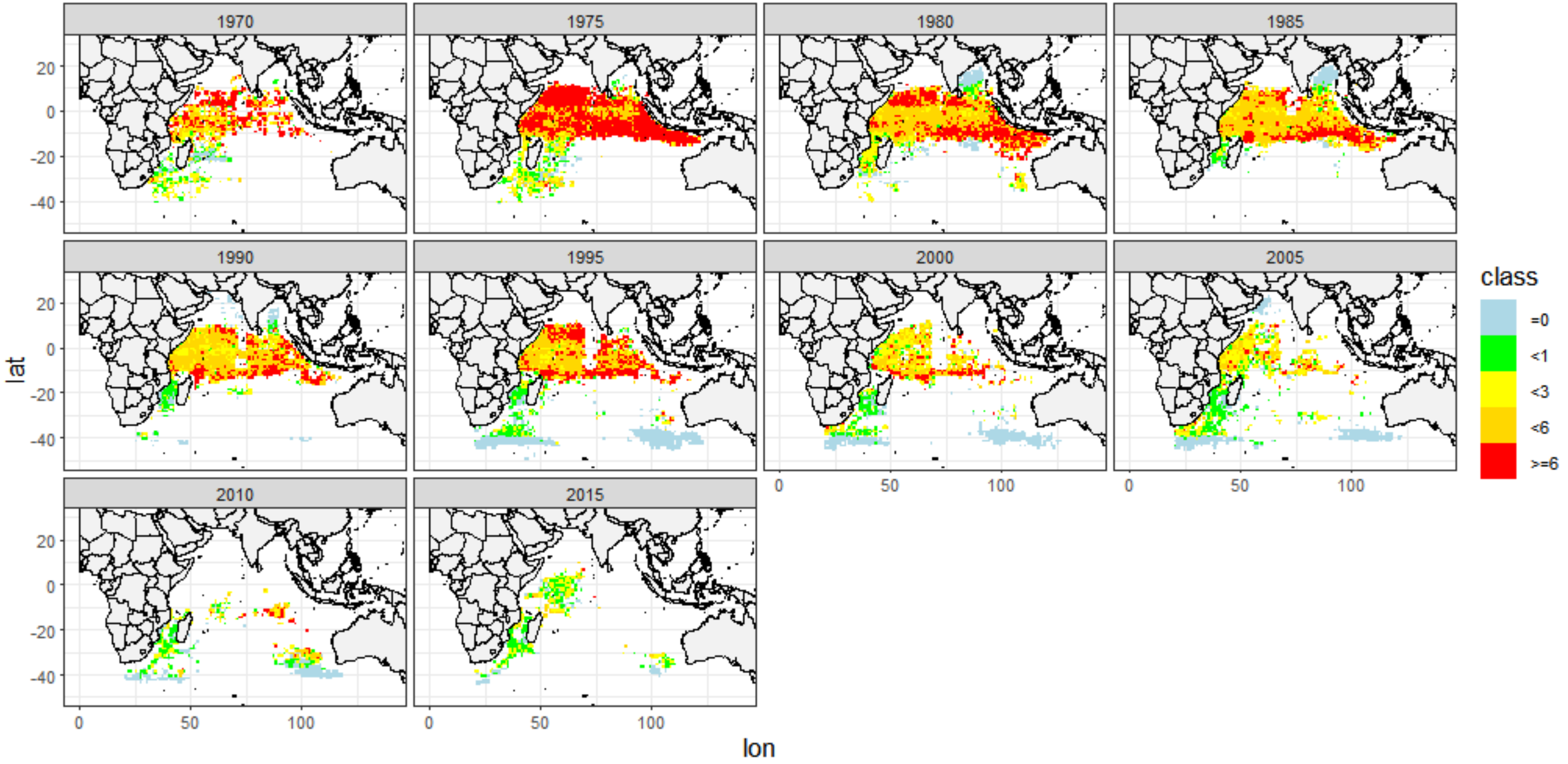
Longline gear configuration



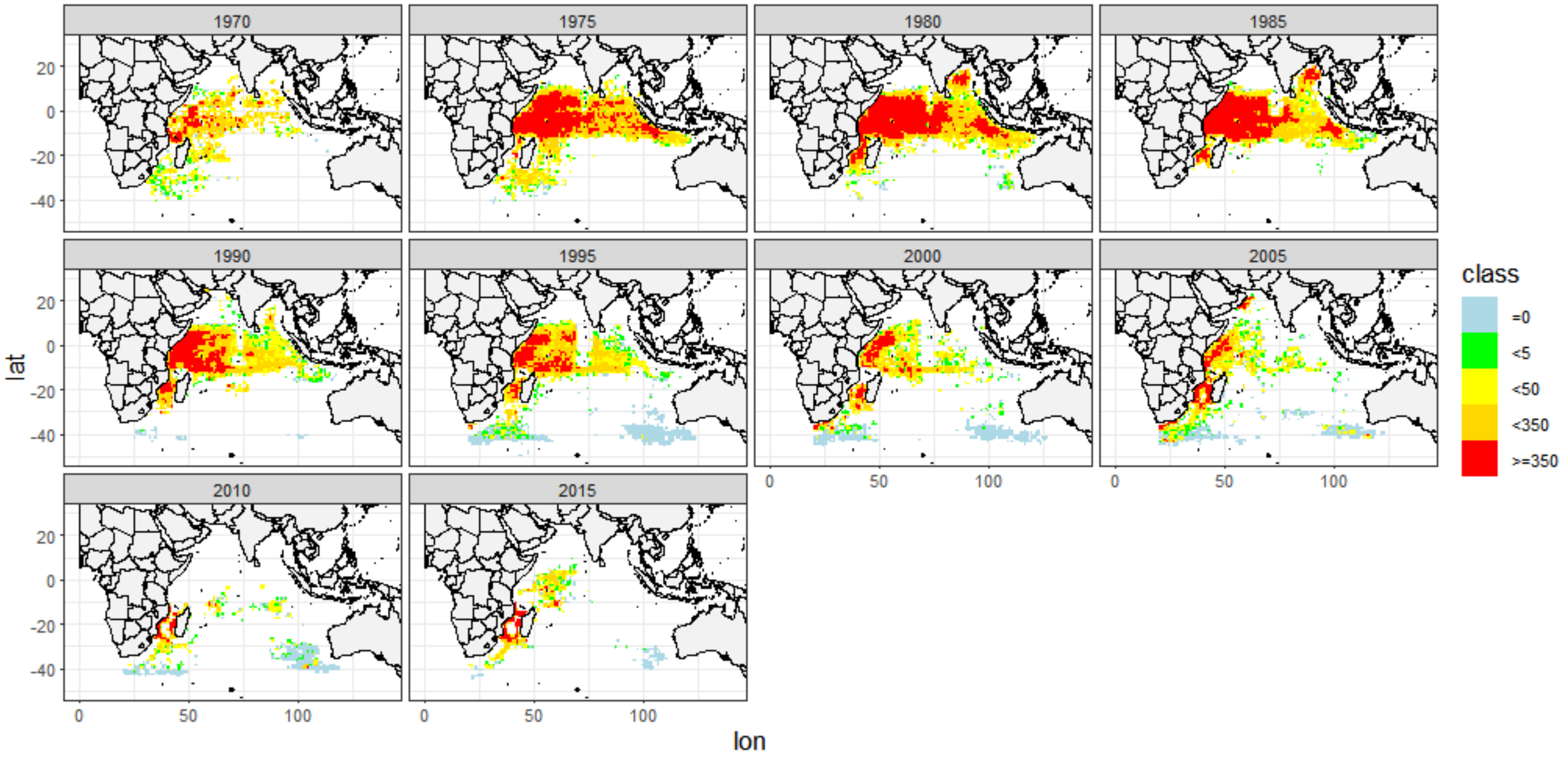
Catch distributions of longline fishery for bigeye



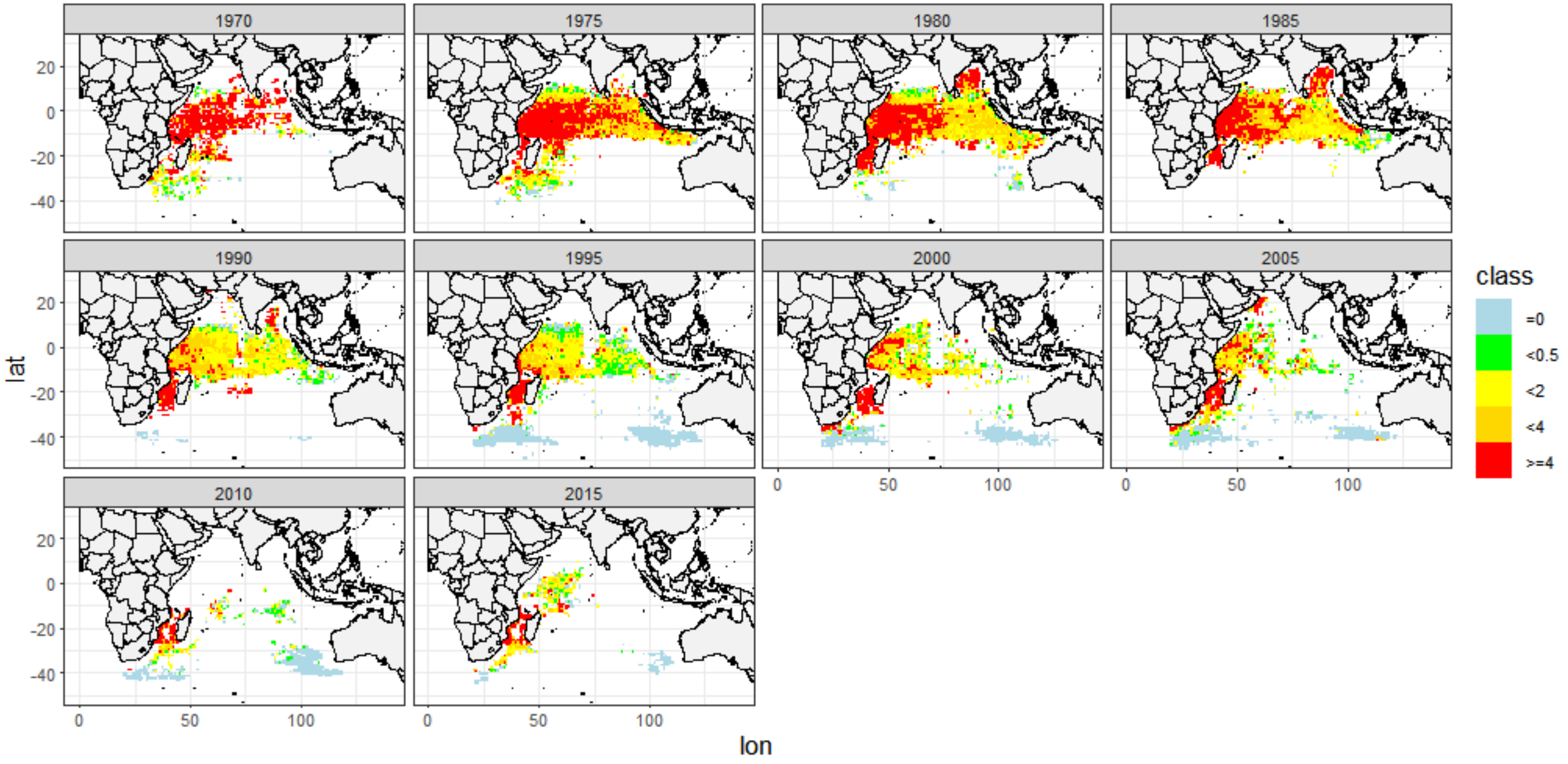
CPUE distributions of longline fishery for bigeye



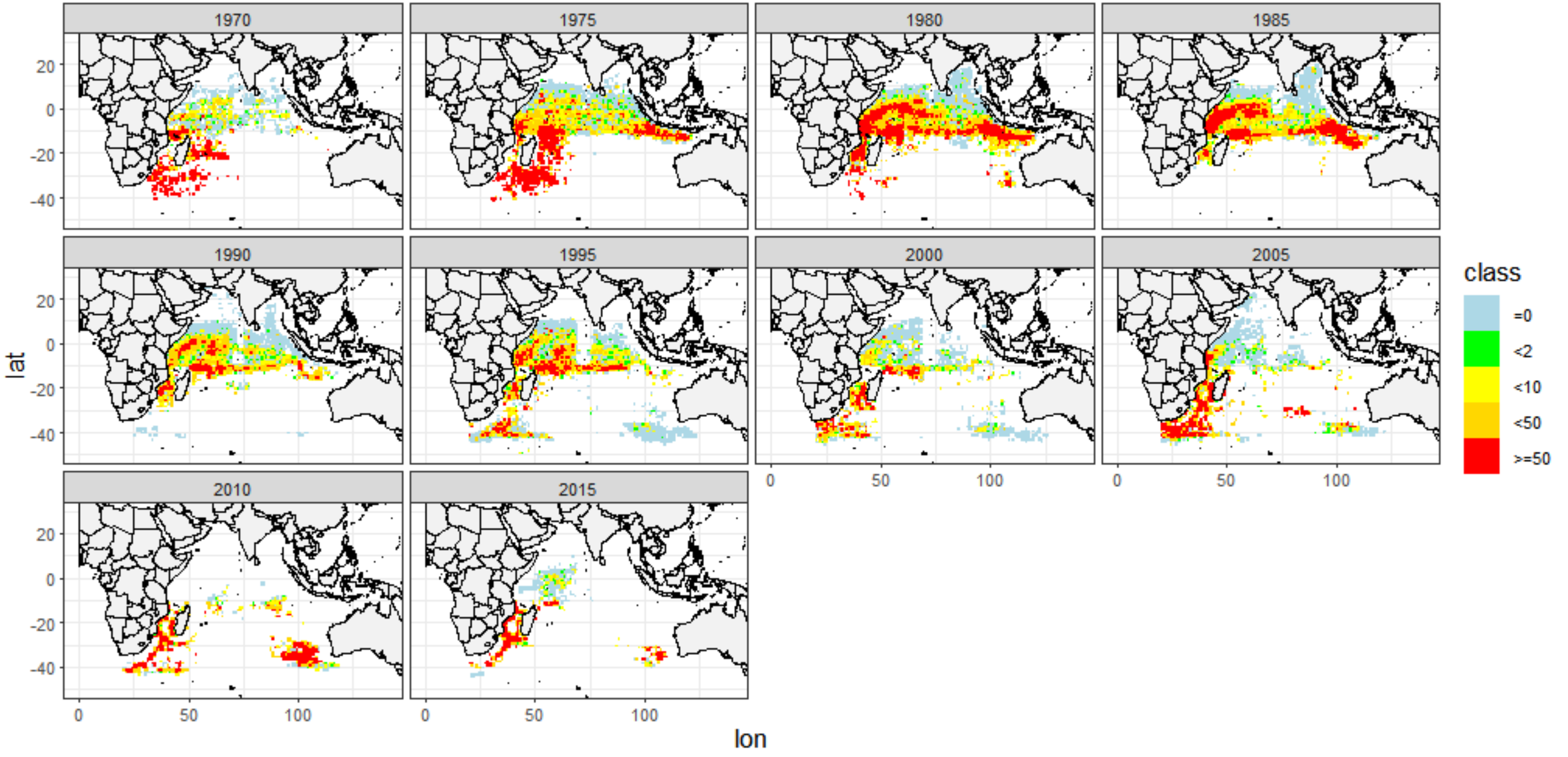
Catch distributions of longline fishery for yellowfin



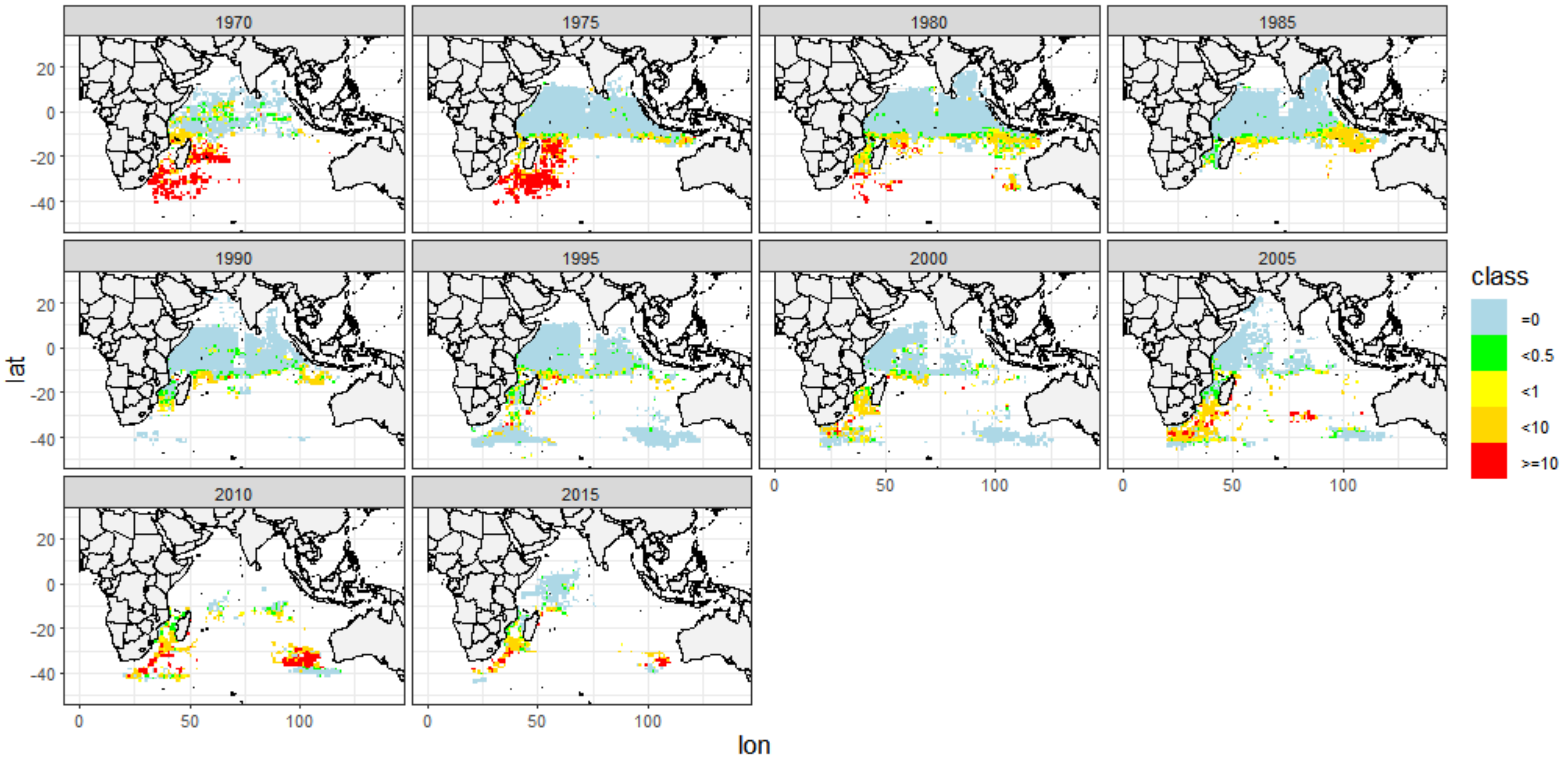
CPUE distributions of longline fishery for yellowfin



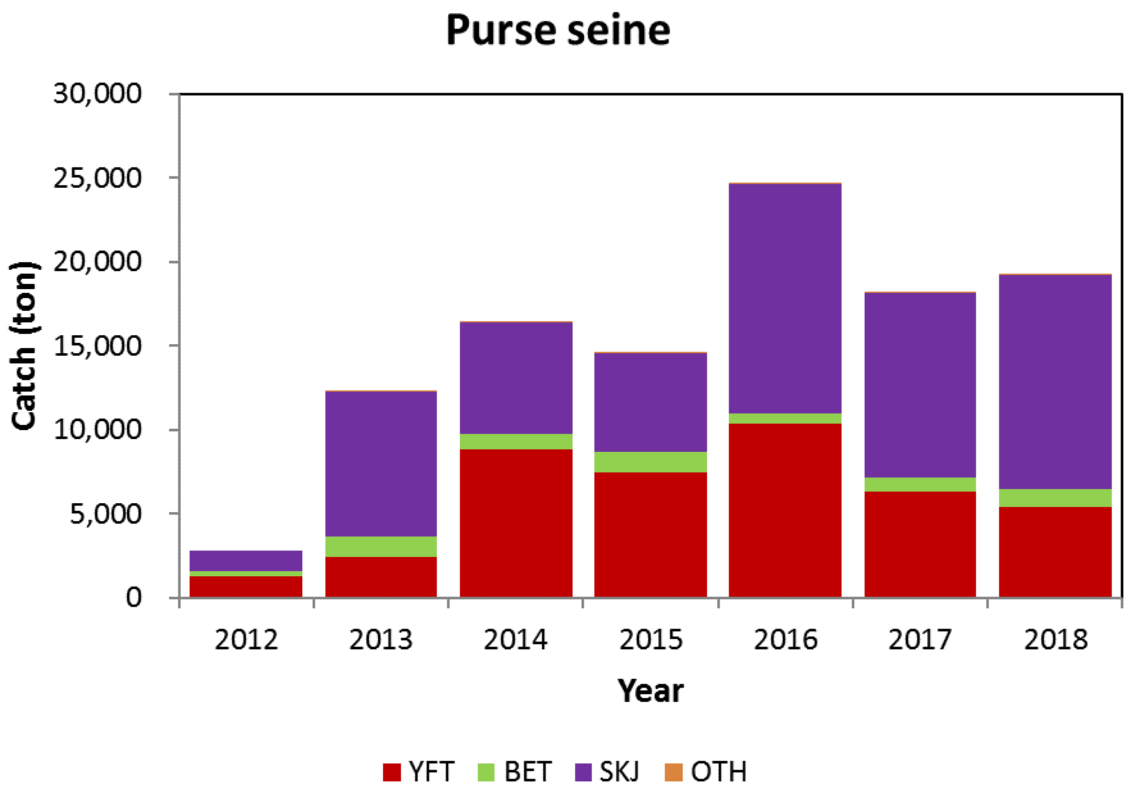
Catch distributions of longline fishery for albacore

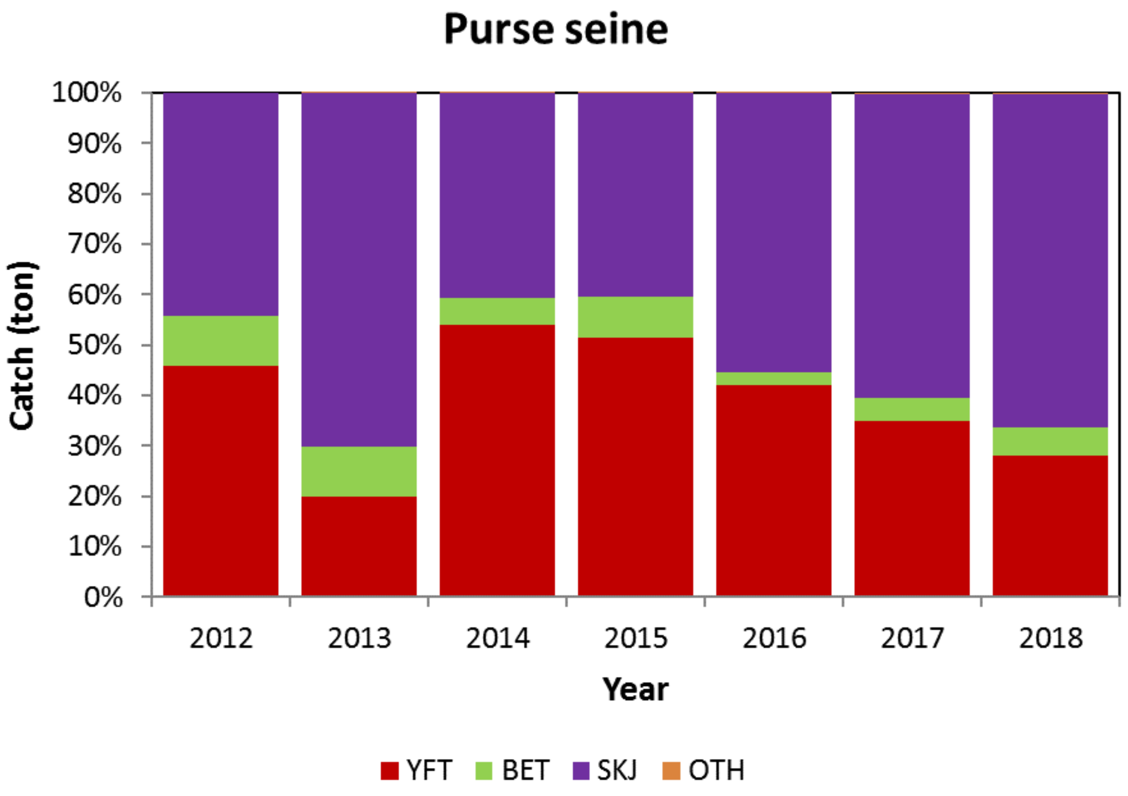


CPUE distributions of longline fishery for albacore

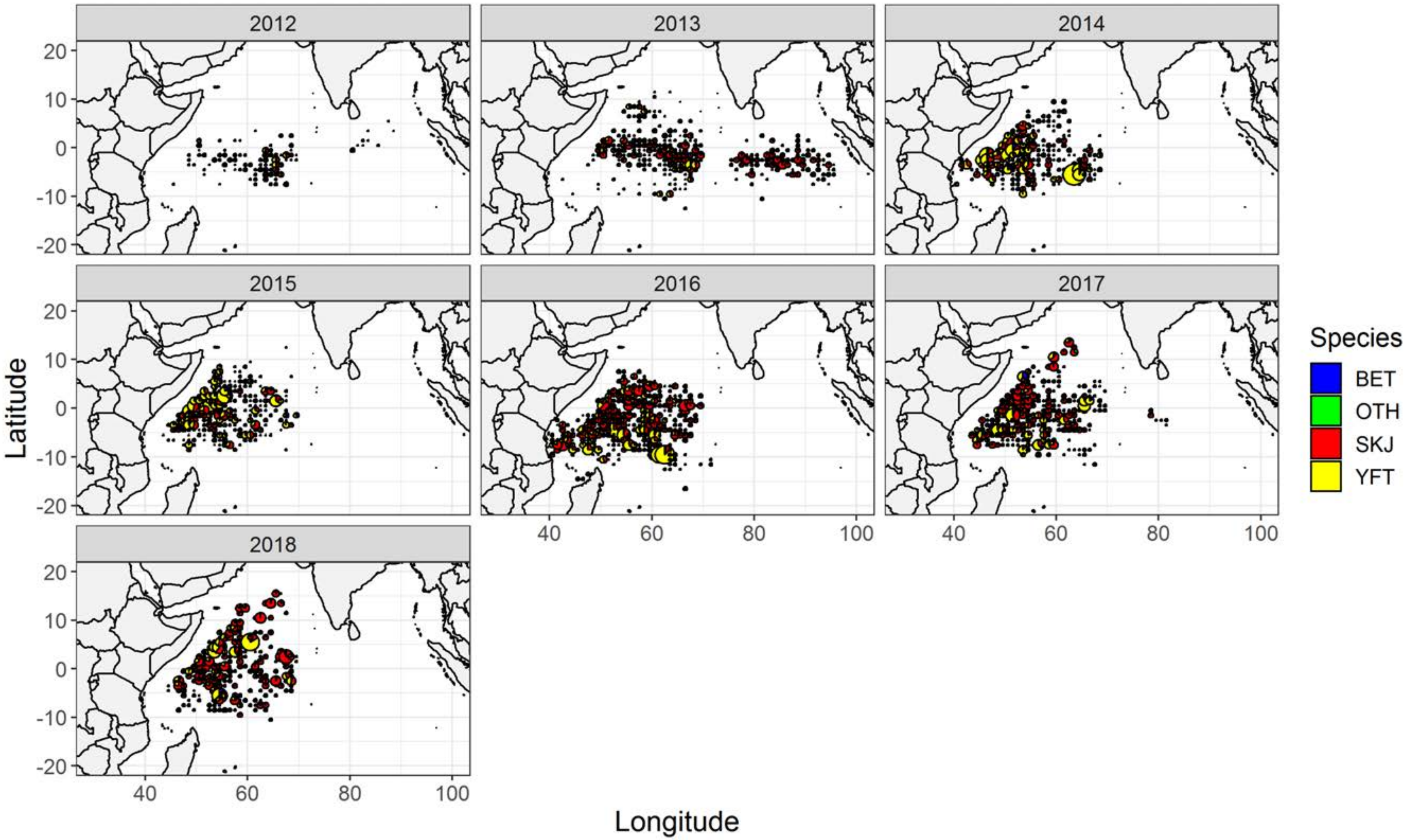


Catch trend of major species of purse seine fishery

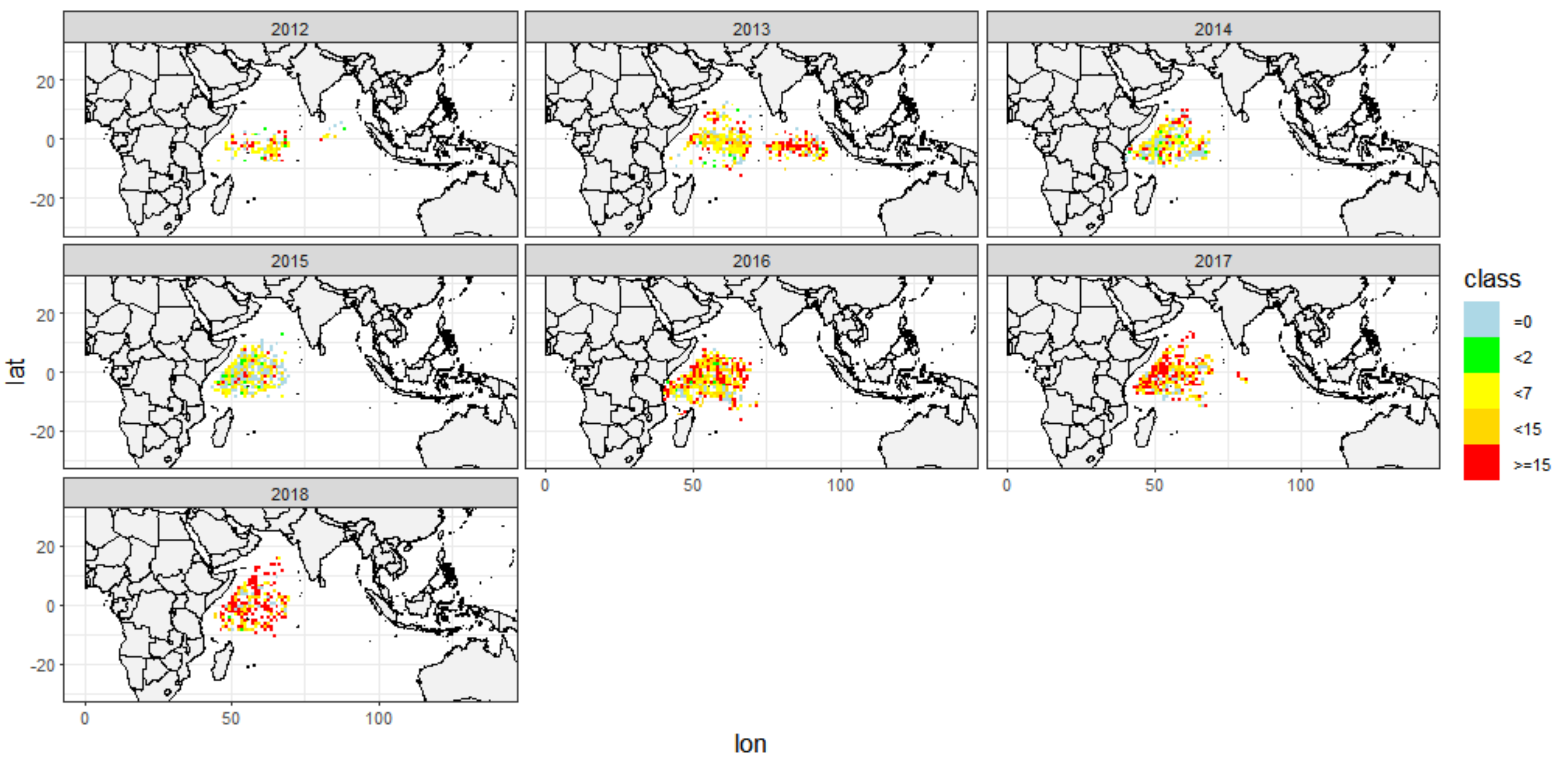




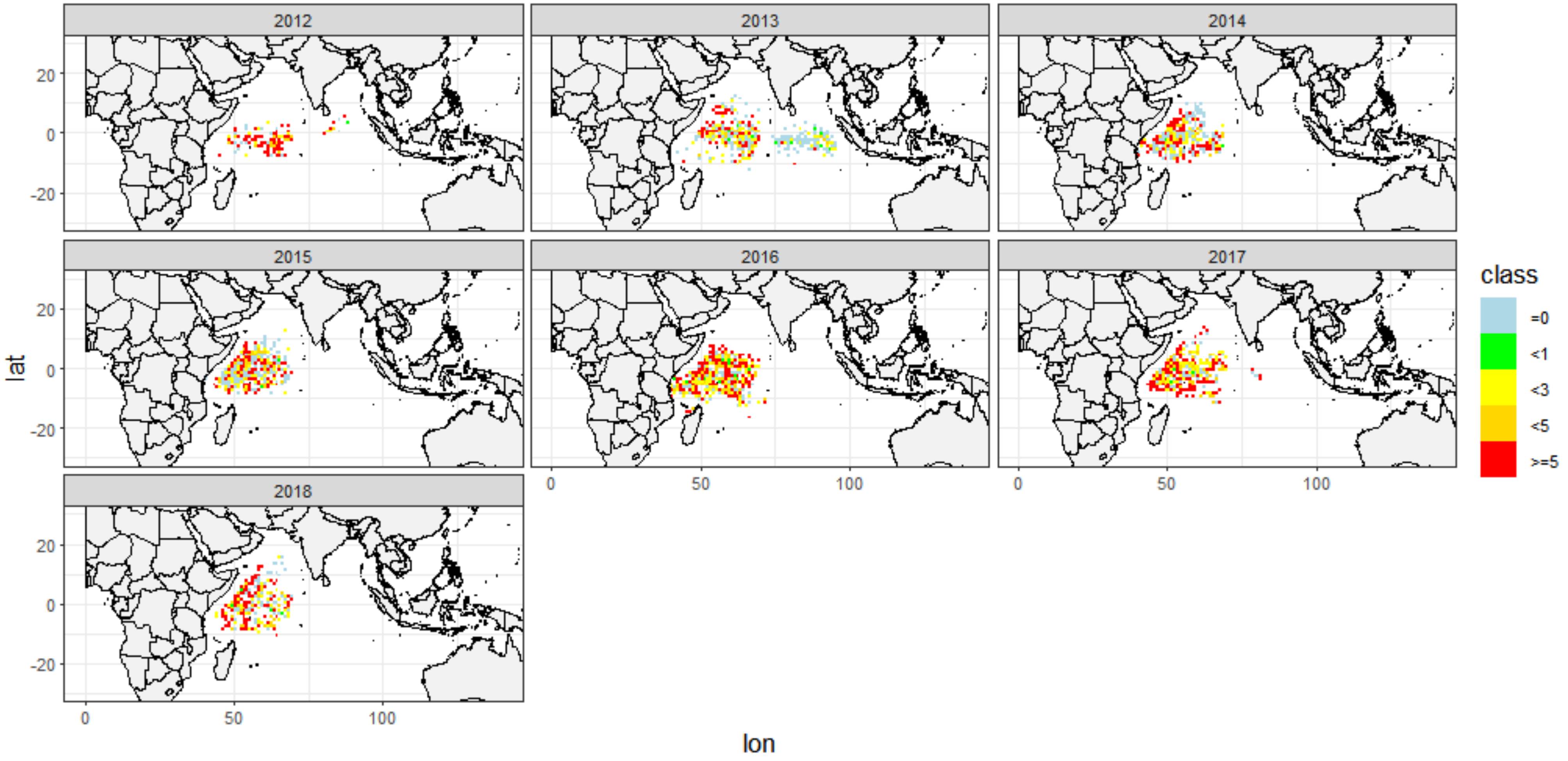
Distributions of catch by species of purse seine fishery



CPUE distributions of longline fishery for skipjack



CPUE distributions of longline fishery for yellowfin



Thank you !

Introduction to Management Strategy Evaluation with TunaMSE: Stock assessment vs MPs

Dan Fu (IOTC)

Busan, Republic of Korea, 19-20 February 2020

Fishery management

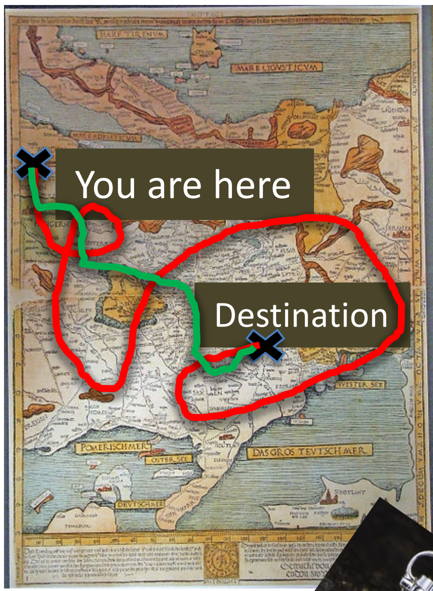
Goals

- Generate sustainable economic and social benefit
- Conserving productivity of the fish stock
- Minimizing direct and indirect impact on wider ecosystem

Requires

- Assessment of stock status ad sustainable level of harvest
- Management measures to control fishing in response to changes in the resource

Fishery management challenges



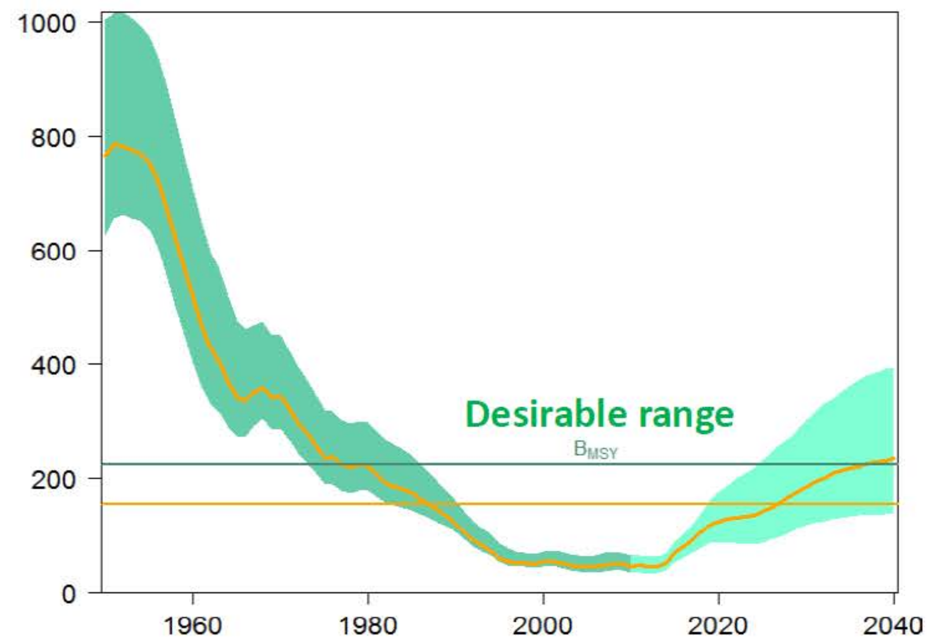
- Assessing the status of the stock and predicting future catch levels
- Monitoring and predicting impacts of the fishery on the recourses
- Setting reasonable harvest levels and providing catch advice
    - Making decisions under large uncertainty
    - Making trade-offs between short and long-term objectives

Fishery management elements

- Availability of information on resource status and trends relative to desirable levels
- Capacity to adjust harvest controls in response to changes in stock abundance
- Ability to implement and enforce harvest regulations

Information on resource status relative to desirable levels

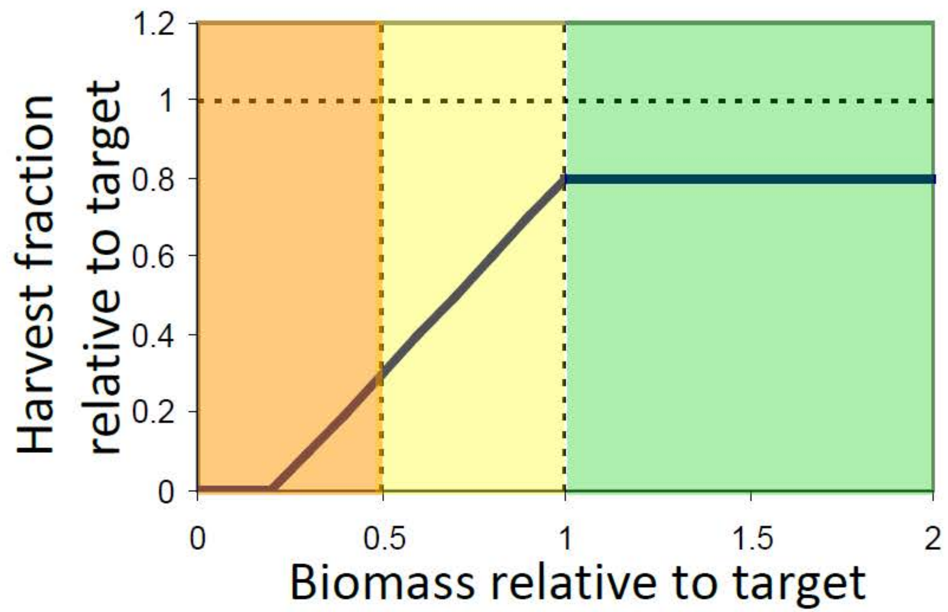
- Analyze data collected using population models
- Estimate historical and current stock status
- Estimate desirable levels of stock size



Anna Parma (2019) International Symposium on Fisheries Sustainability: Strengthening the Policy-Science Nexus

Adjust harvest controls in response to stock abundance

- Set annual catch limit using harvest control rules or management procedures

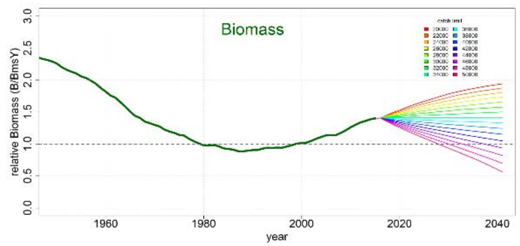


Catch advice

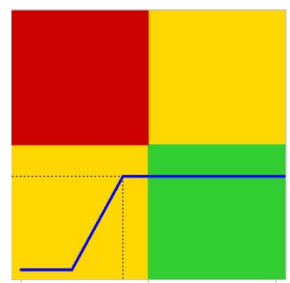
Fishing

Data collection

Stock Assessment



Agreed management procedure



Stock assessment

- Mathematic representation of population processes
- Provide “best fit” to observations
- Reconstruct population history
- Estimate stock size and reference quantities

Population dynamics

A (very) simple summary:

$$B_{current} = B_0 - F - M + Y$$

Current state

“Initial” state

Fishing mortality

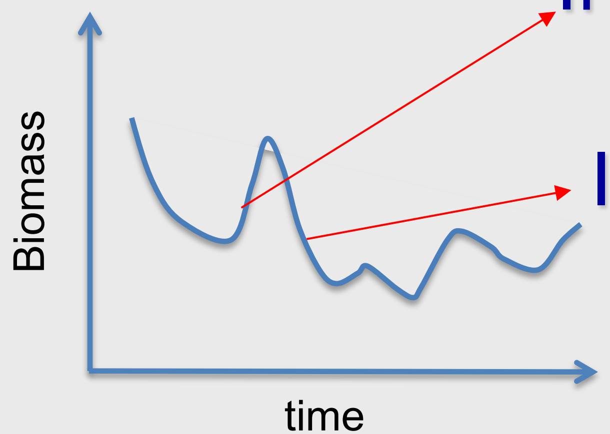
Natural mortality

Recruitment (Births)+Growth

Stock assessment – Reconstruct population history

If F + M < Y, population increases

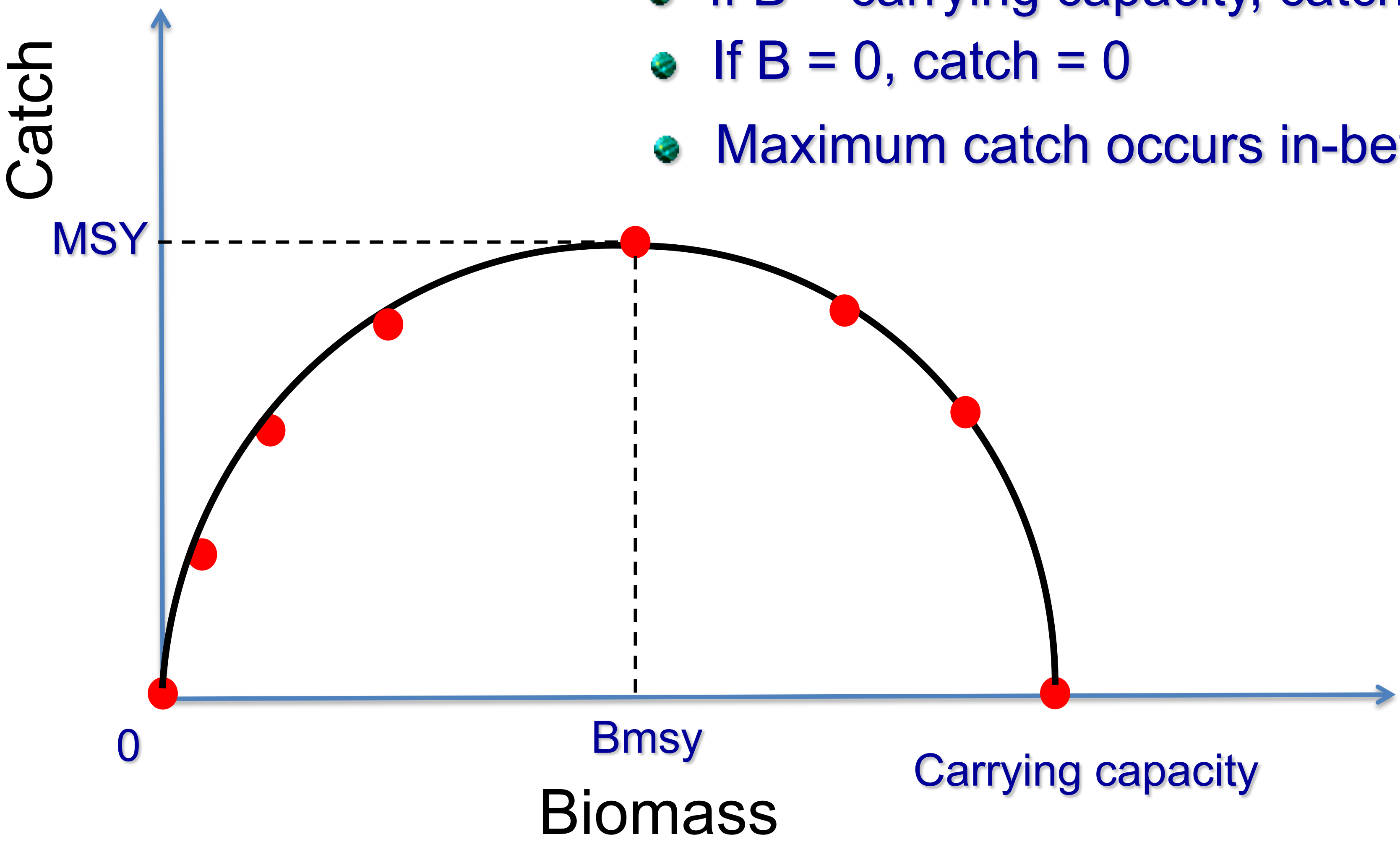
If F + M > Y, population decreases



- MSY – maximum catch that can be taken sustainably
- Bmsy – biomass level that support MSY
- Fmsy – MSY / Bmsy

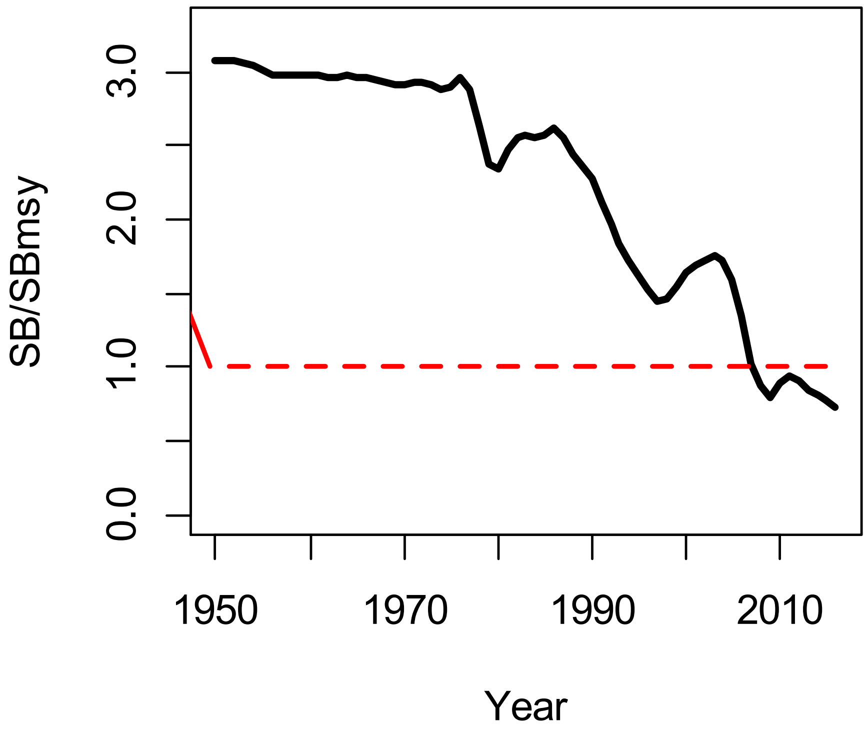
Maximum sustainable yield (MSY)

- If B = carrying capacity, catch = 0
- If B = 0, catch = 0
- Maximum catch occurs in-between

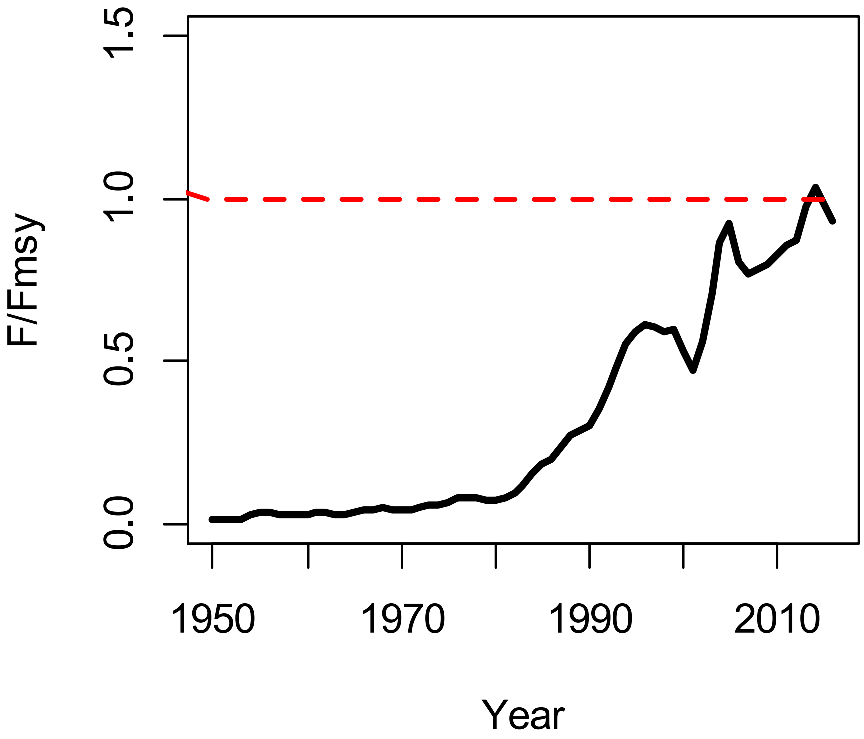


Stock assessment (Yellowfin example*)

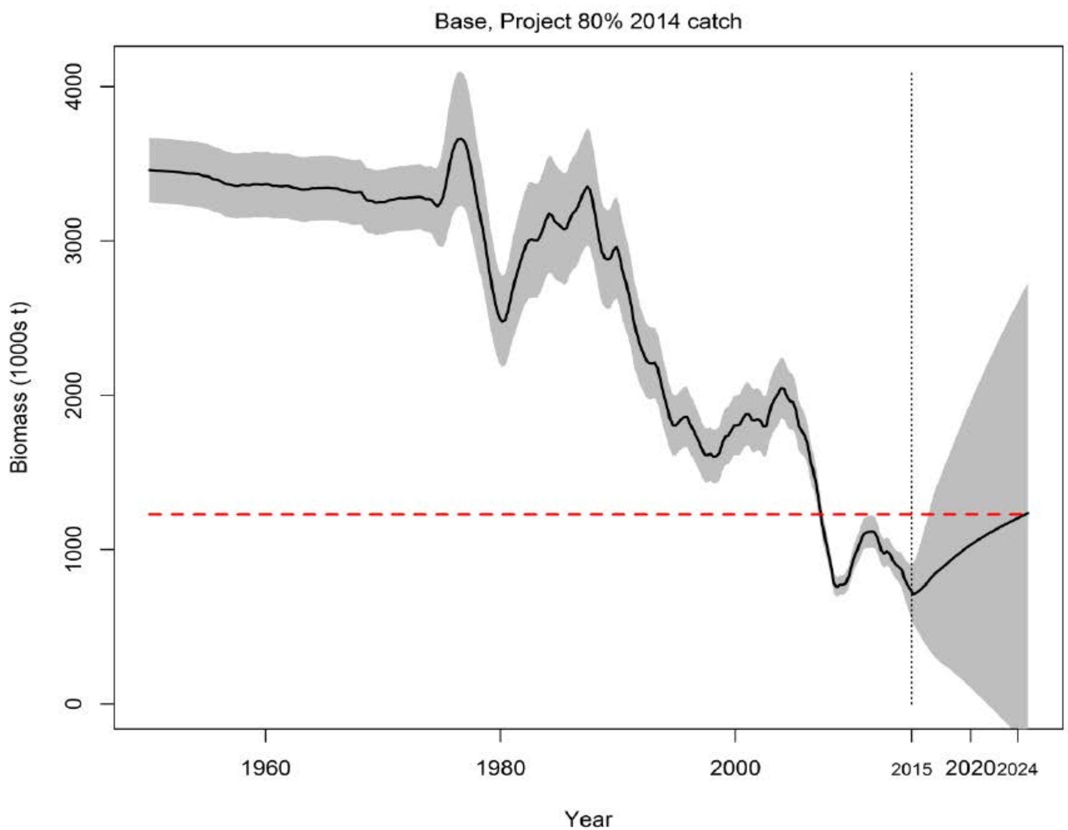
Biomass



Exploitation rates



Stock assessment – Projection



YFT assessment

At 20% catch reduction, biomass rebuilds to Bmsy after 10 years (50% probability)

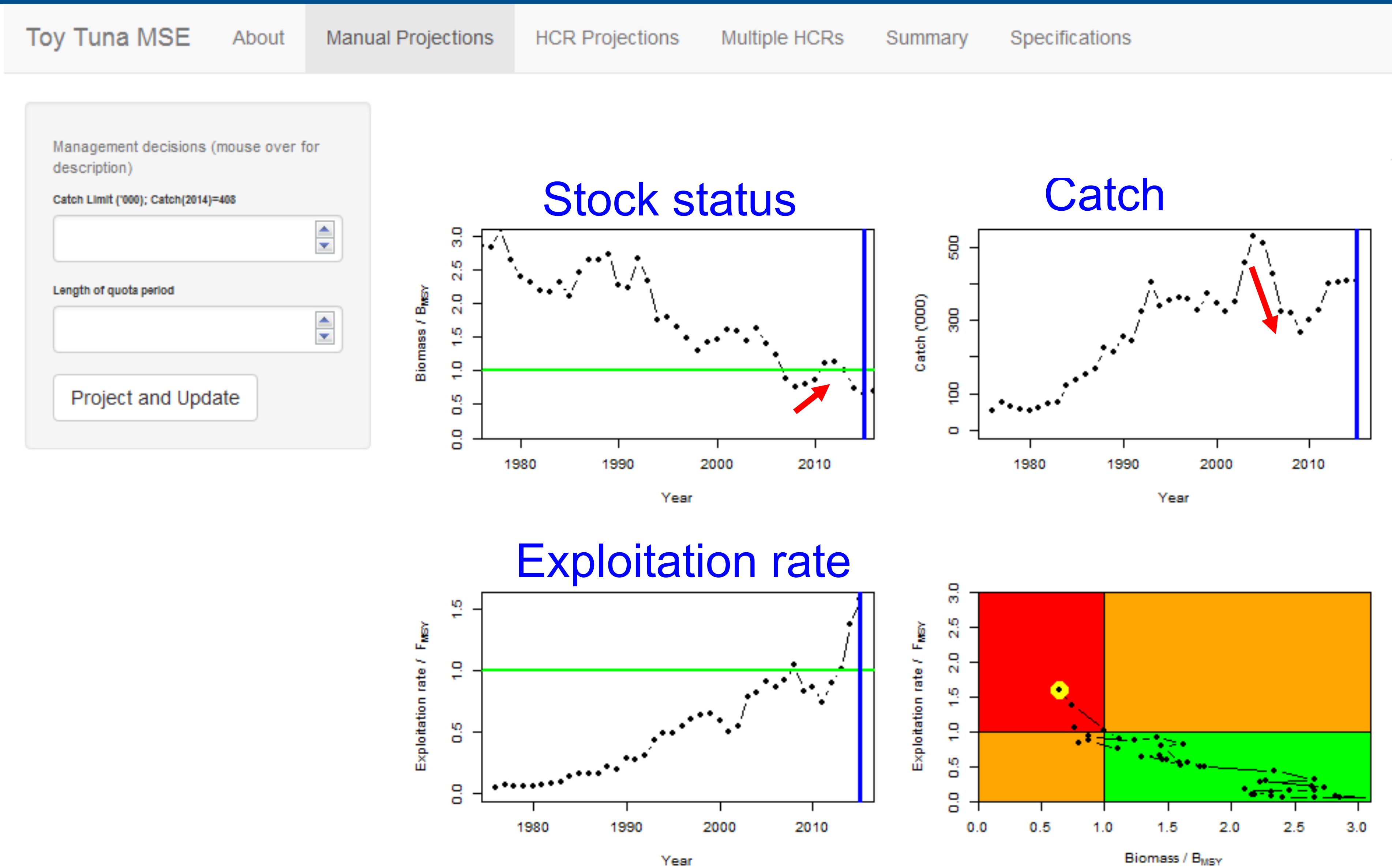
Kobe II Strategy Matrix

TAC	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
0	38%	56%	74%	86%	91%	94%	96%	97%	98%	98%	99%	99%	99%	99%	100%	100%	100%	100%
20000	29%	38%	45%	54%	63%	69%	75%	79%	83%	85%	87%	89%	90%	92%	93%	93%	94%	95%
22000	28%	36%	43%	50%	58%	64%	70%	75%	78%	81%	84%	85%	87%	89%	89%	91%	92%	92%
24000	27%	35%	40%	46%	53%	59%	64%	69%	73%	76%	79%	81%	83%	84%	86%	87%	88%	89%
26000	26%	33%	38%	43%	49%	54%	59%	63%	67%	70%	73%	76%	78%	79%	81%	83%	84%	84%
28000	25%	31%	36%	39%	44%	49%	53%	57%	61%	63%	66%	69%	71%	73%	75%	76%	77%	79%
30000	24%	29%	34%	37%	39%	43%	47%	50%	54%	57%	59%	61%	63%	65%	66%	68%	69%	71%
32000	23%	27%	31%	34%	36%	39%	41%	44%	47%	49%	51%	53%	55%	57%	58%	59%	61%	62%
34000	22%	24%	27%	30%	32%	34%	36%	38%	40%	41%	43%	45%	47%	48%	49%	50%	52%	52%
36000	21%	22%	23%	25%	27%	29%	31%	32%	33%	34%	35%	36%	38%	39%	40%	40%	41%	42%

Stock assessment summary

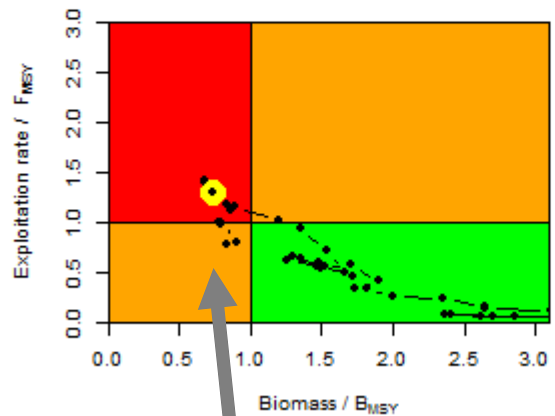
- Reconstruct population history
- Estimates of current stock status
  - Overfished ? (Biomass < Bmsy)
  - Overfishing? (F > Fmsy)
- Forecast of future stock status

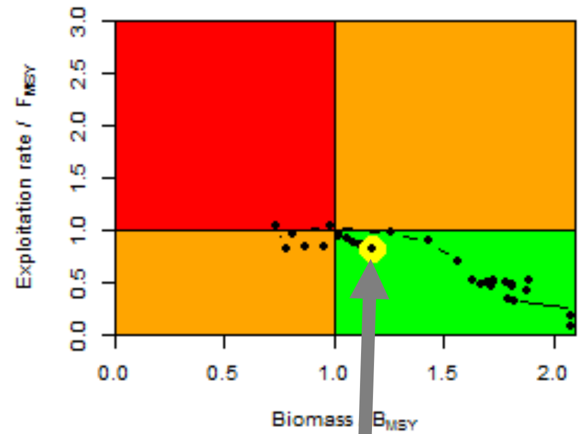
‘Tuna MSE’ – Stock assessment



‘Tuna MSE’ – Underlying Truth

We are not always lucky !



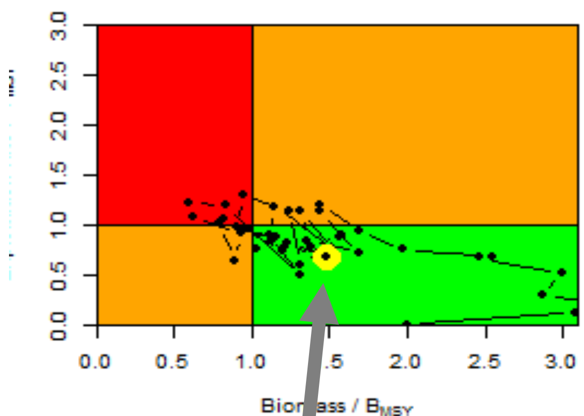


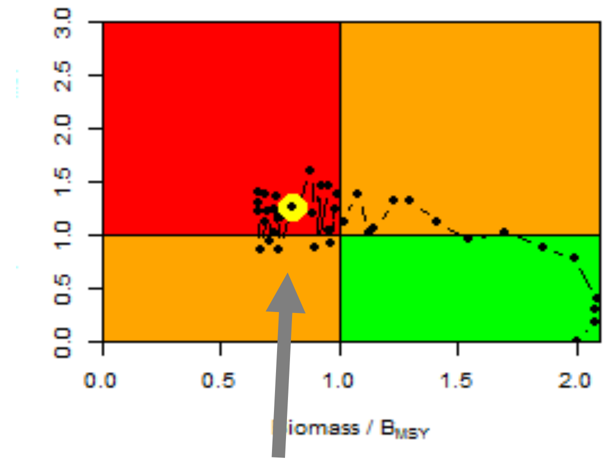
Assessment: the stock is in red

The truth: the stock is in green

‘Tuna MSE’– Underlying Reality

We are not always lucky !





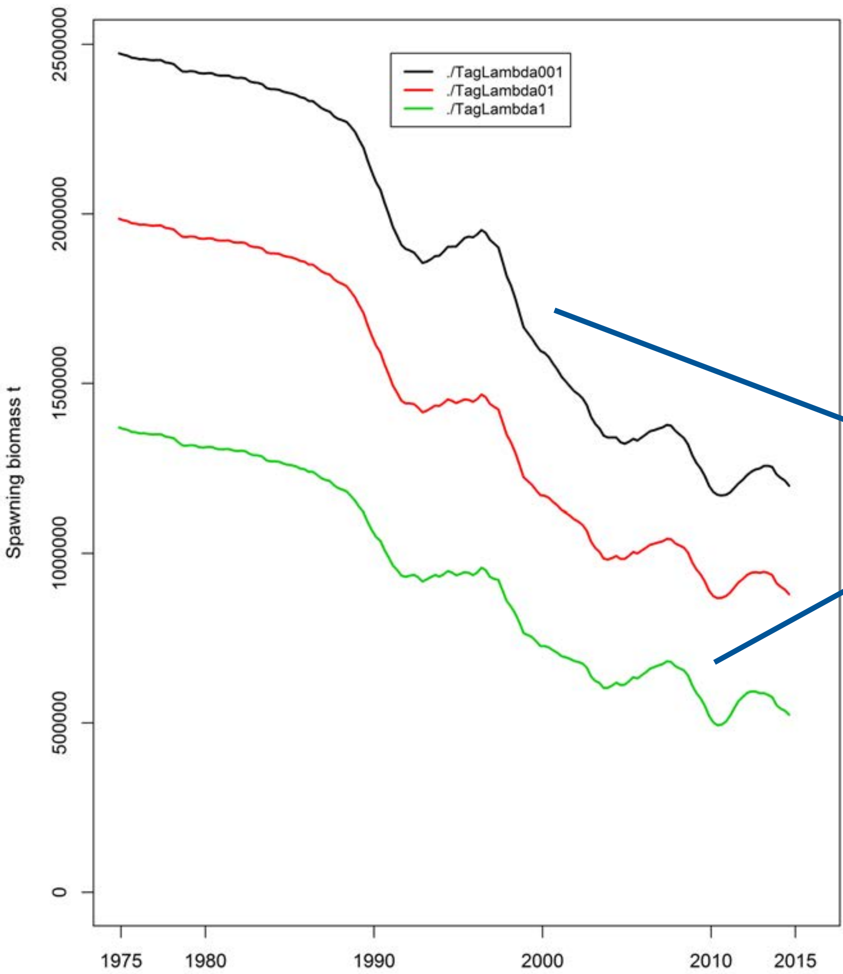
Assessment : the stock is in green

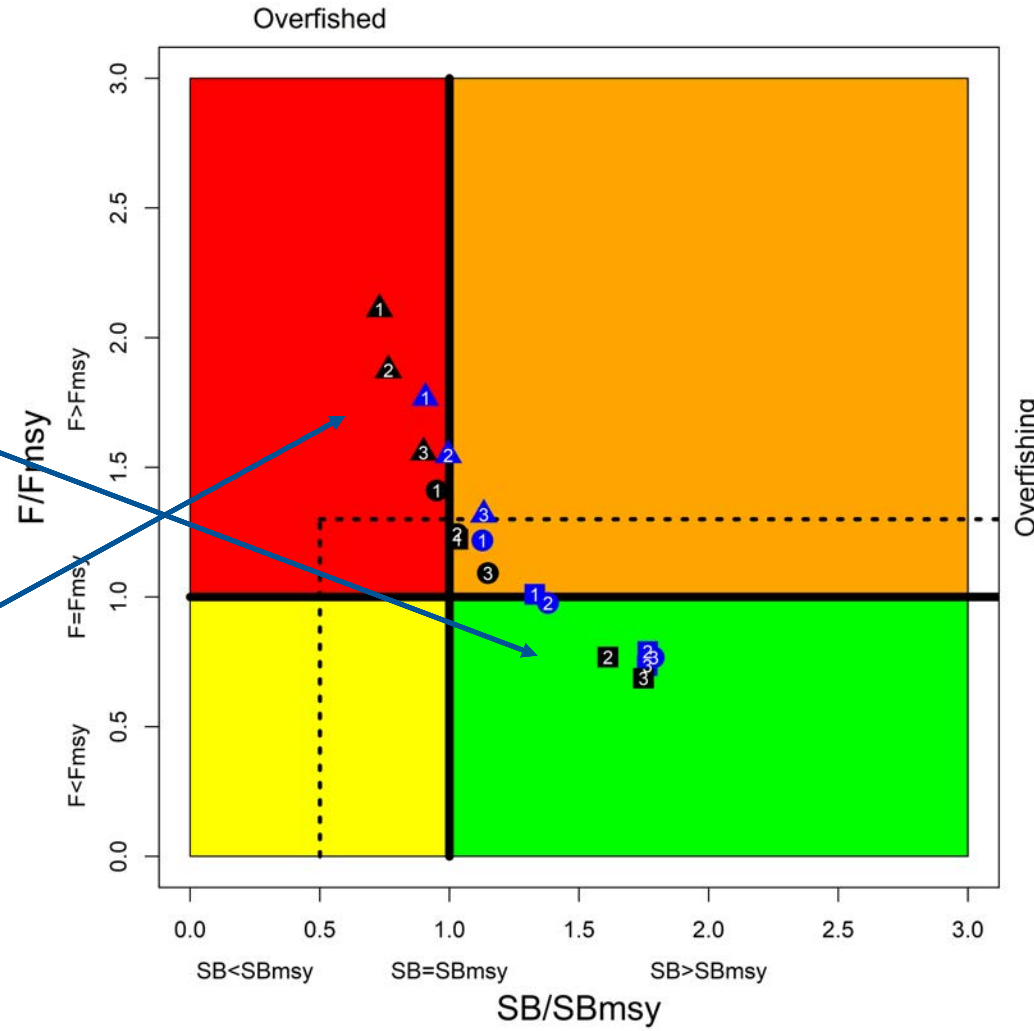
Reality: the stock is in red

Stock assessment issues

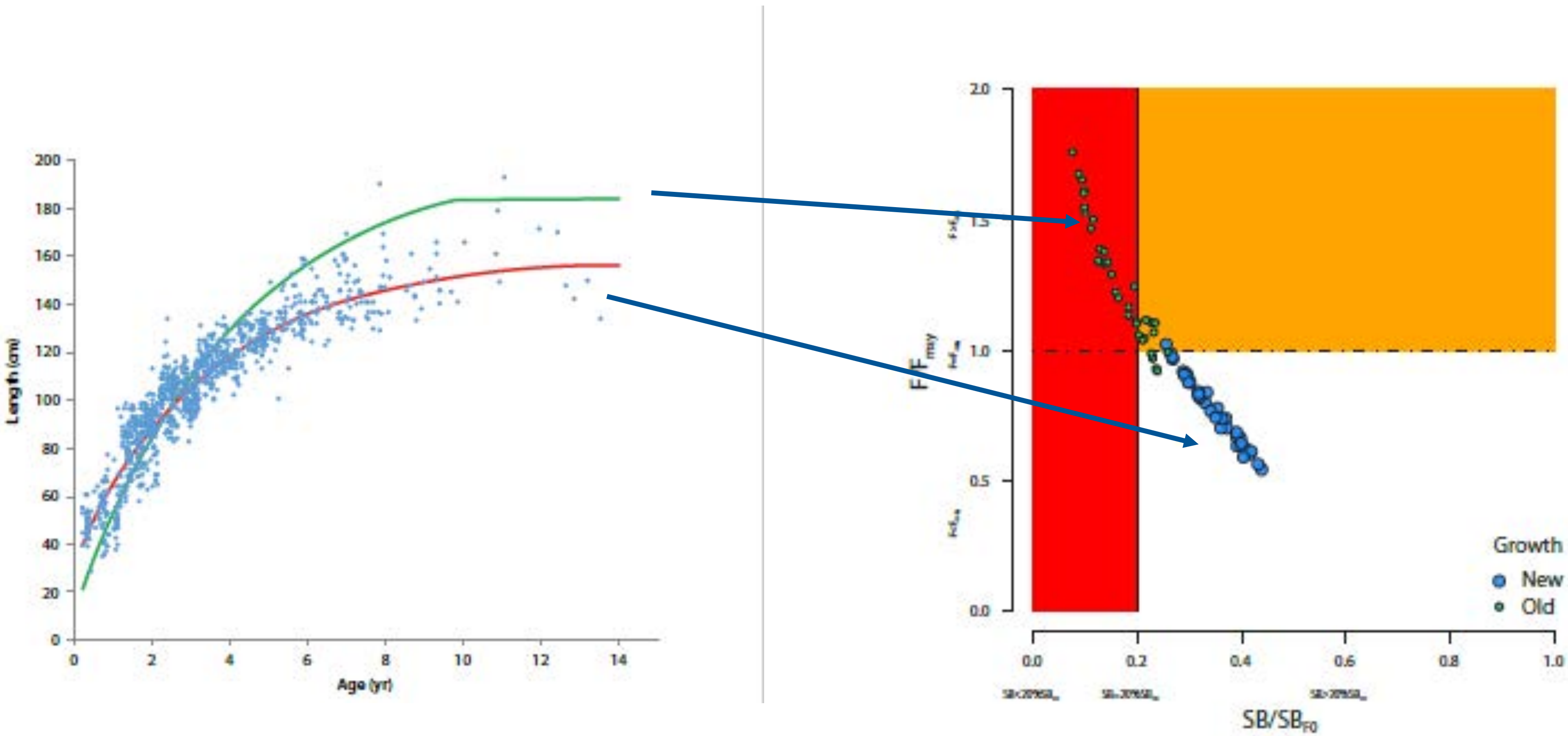
- Uncertainty in the status of the Stock
- Uncertainty in future levels of recruitment
- Uncertainty in the impact of future catches on the Stocks
- Overall uncertainty in state of stock and impacts of future catches makes consensus decision making difficult

IOTC bigeye tuna assessment





WCPFC bigeye tuna assessment



Disadvantages of stock assessment

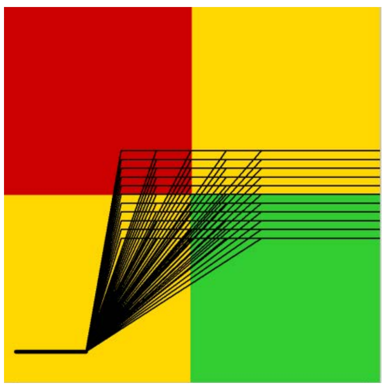
- Results depended on quality of the data, and may be sensitive to method used
- Stock status is uncertain, and can easily change with new interpretation of data or change of models
- Often consider the most probable scenario, not covering a wide range of possibilities
- not characterize the full uncertainty in the long-term
- Not considering management response
- No rules about how quotas will be set and thus no transparency and understanding of what will happen

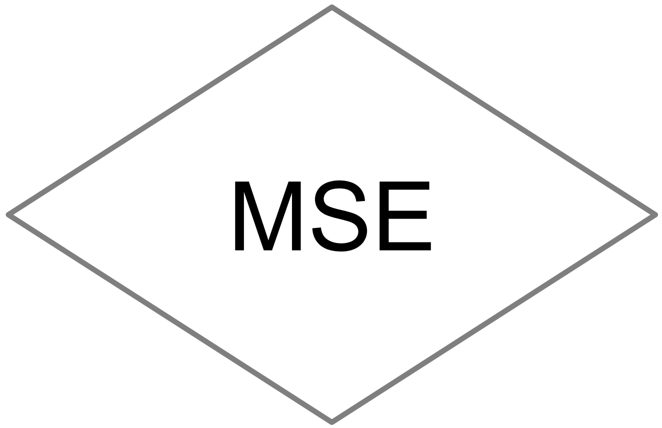
Being there is everything

- Stock assessment – where we are now
- Management procedure – How to get there
- MSE – What's the best way

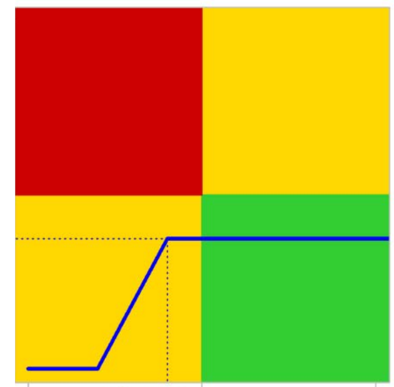
Management strategy evaluation

Candidate management procedures





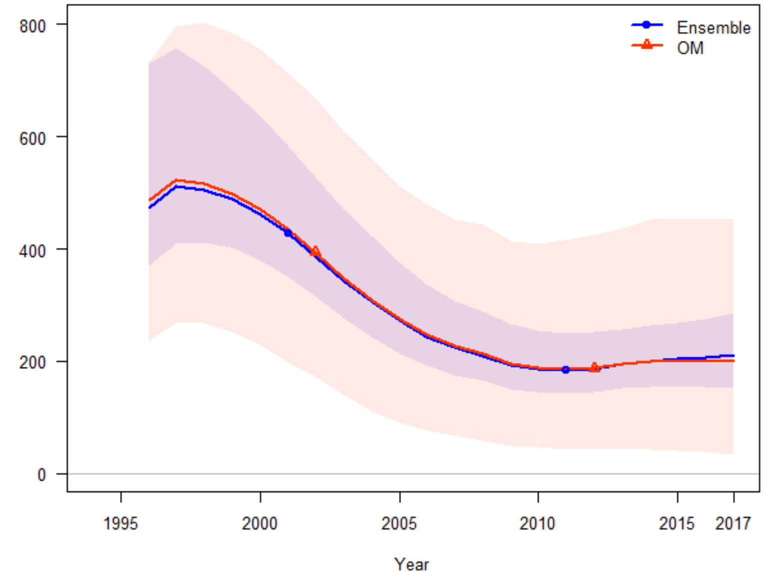
Agreed management procedures



- Management objectives
- Operating models
- Simulation testing
- Performance measures

Advantages of Management Procedure

- Incorporates greater uncertainty than the assessment
- The goal is to develops a management procedure robust to uncertainty and variability in the long-term



Allan Hicks, IPHC (2018)

Advantages of Management Procedure

- Provides greater certainty for all stakeholders (agreed rules for decision making).
- Designed to achieve an agreed balance between competing management objectives.
- Provides a better chance of achieving management objectives (pre-testing to identify robust strategies).
- Designed to be robust to current scientific uncertainty.
- Demonstrates to the community that you are managing responsibly.

Challenges with Implementing a Management Procedure

- Technical challenges in developing and testing an MSE.
- Scientists and Commissioners are required to make a number of decisions and choices related to:
  - The management objective.
  - Choice of Harvest control rules
- Each decision involves trade-offs between catch and risk to the stock.

Introduction to Management Procedure approach, components and concepts

Furthering Capacity Building for Harvest Control Rules and Management Strategy Evaluation: Indian Ocean Tuna Management Workshop

Busan, Republic of Korea, 19-20 February

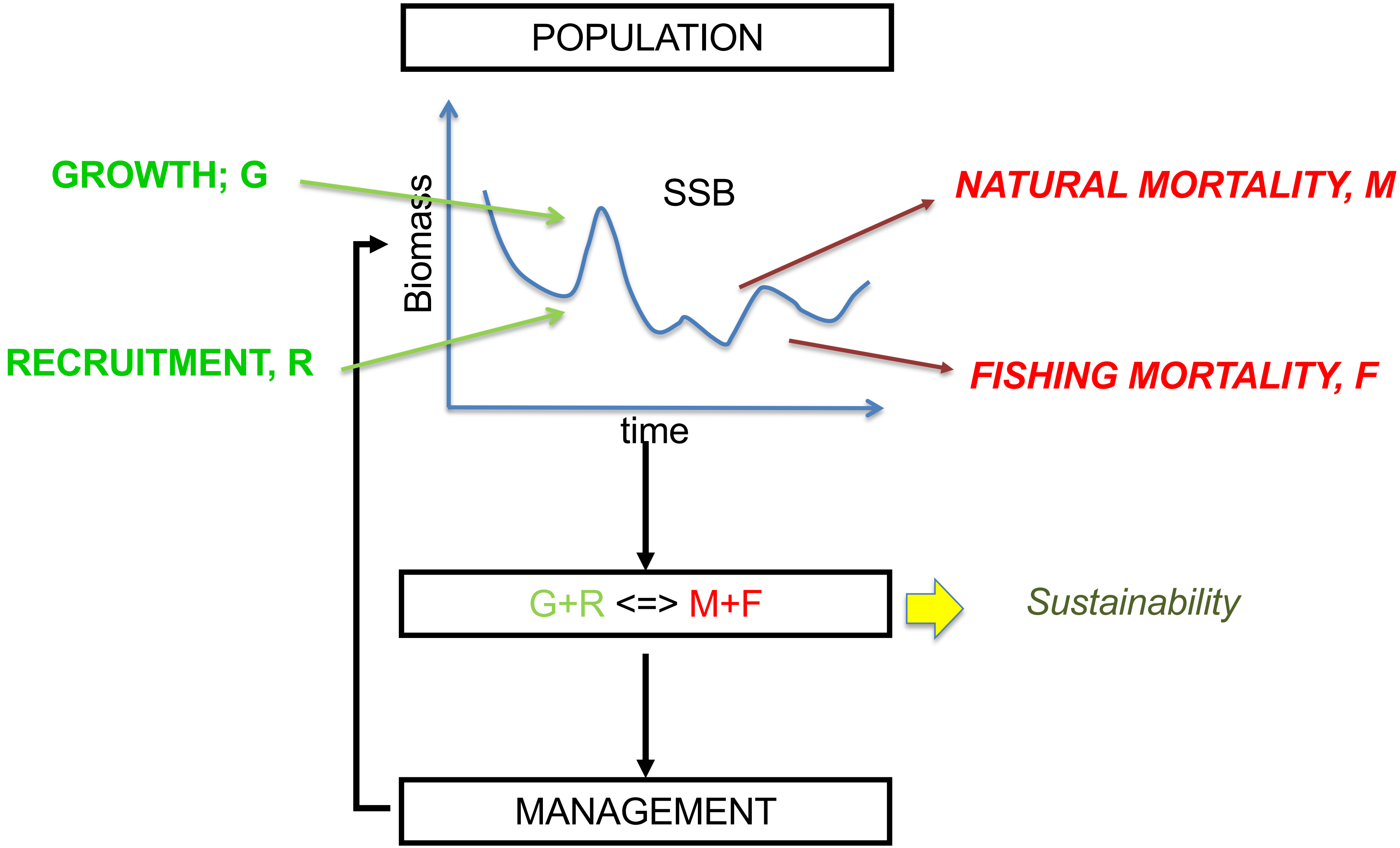
Dr. Hilario Murua (ISSF)
Dr. Dan fu & Dr. Toshihide Kitakado
(TUMSAT)

Outline

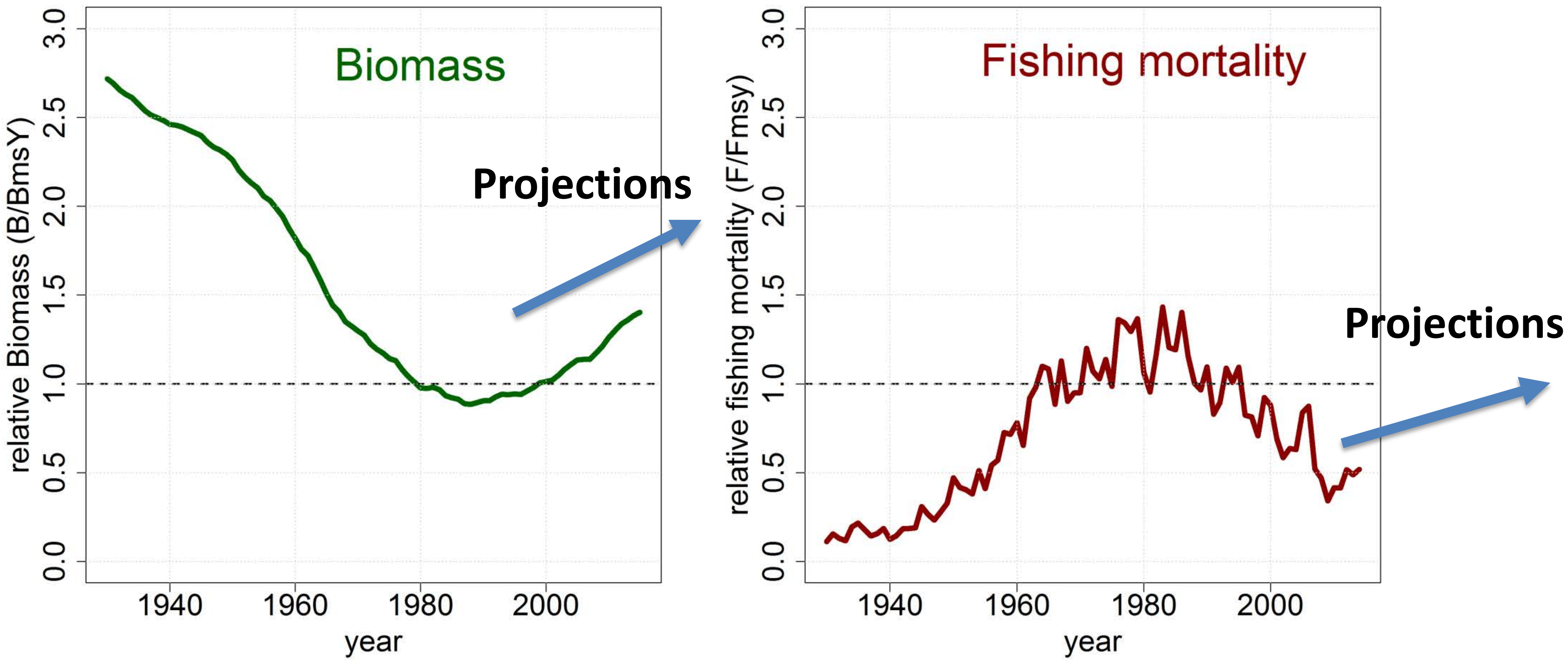
- Provision of Management Advice (***H. Murua***)
  - Target and Limit Reference Points,
  - Kobe Plot,
  - Decision framework.
- MP and MSE basic principles (***T. Kitakado***)
  - Objectives,
  - Timeframes & risk,
  - Trade-off between objectives,
  - MSE Process
  - Feedback from managers,
- Presentation of MSE Results (***T. Kitakado***)
  - Performance Indicators
- Roles and responsabilities and feedback mechanism

PROVISION OF MANAGEMENT ADVICE

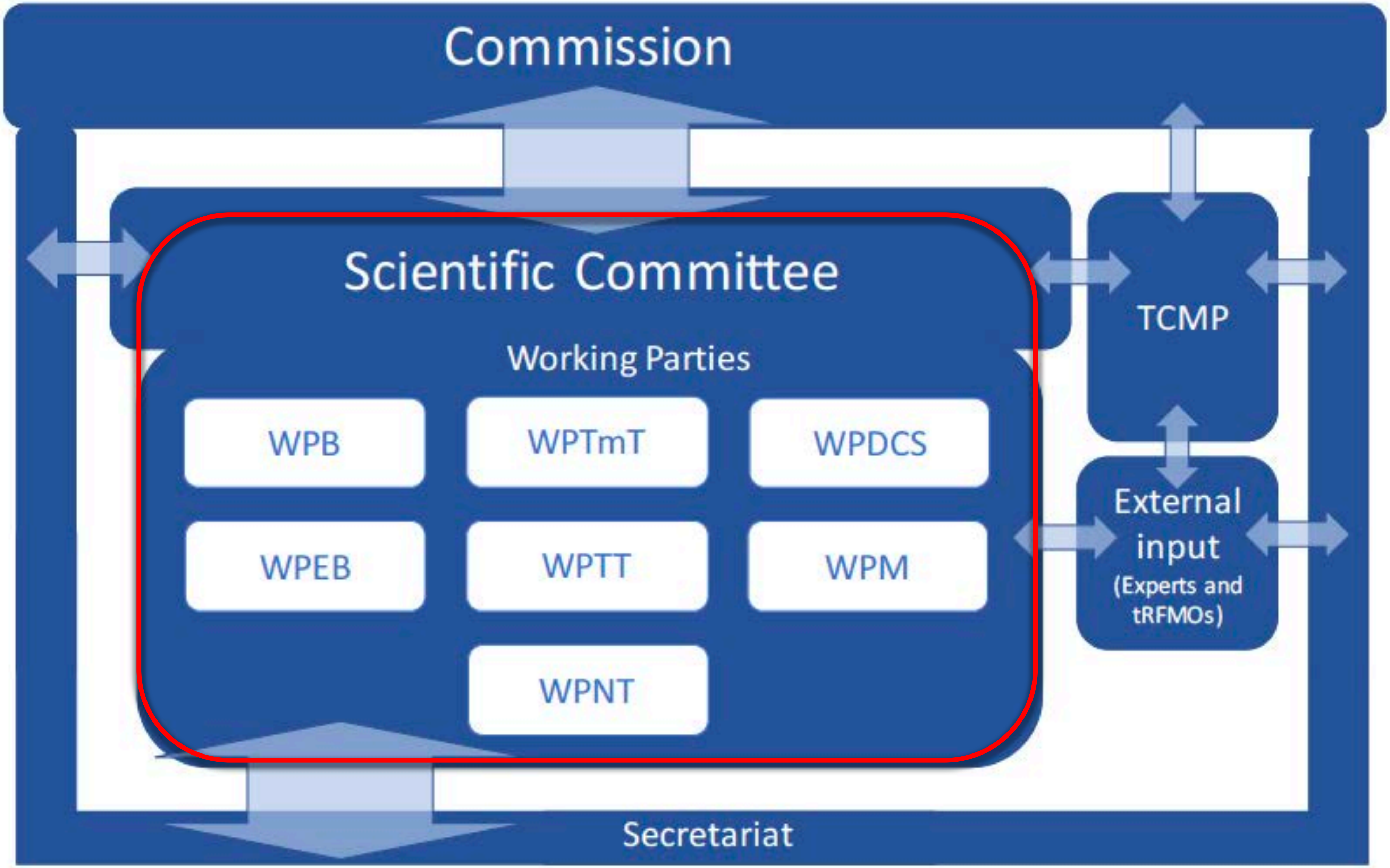
Stock Assessment: Reconstruct population history



Stock Assessment: Reconstruct population history

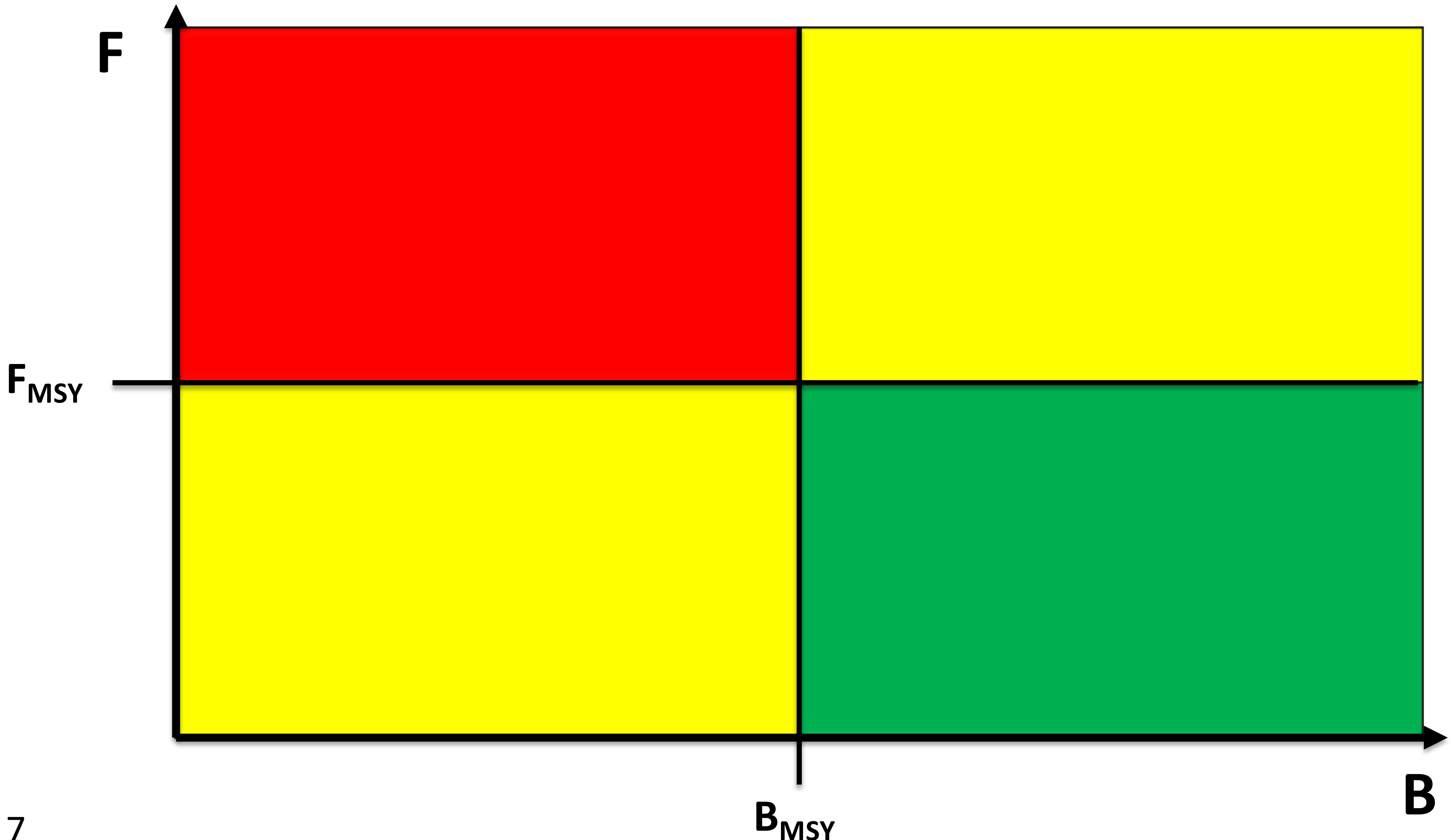


Prediction is very difficult, especially if it's about the future - *Niels Bohr, Physicist*


Commission
Scientific Committee
Working Parties
WPB
WPTmT
WPDCS
WPEB
WPTT
WPM
WPNT
TCMP
External input
(Experts and tRFMOs)
Secretariat

IOTC Convention Objective (Strategic or Conceptual)

The Commission shall *promote cooperation among its Members* with a view to ensuring, through appropriate management, the conservation and *optimum utilization of stocks* covered by this Agreement and *encouraging sustainable development of fisheries* based on such stocks.



Provision of Management Advice

Resolution 15/10: Reference Points (Operational Objectives)

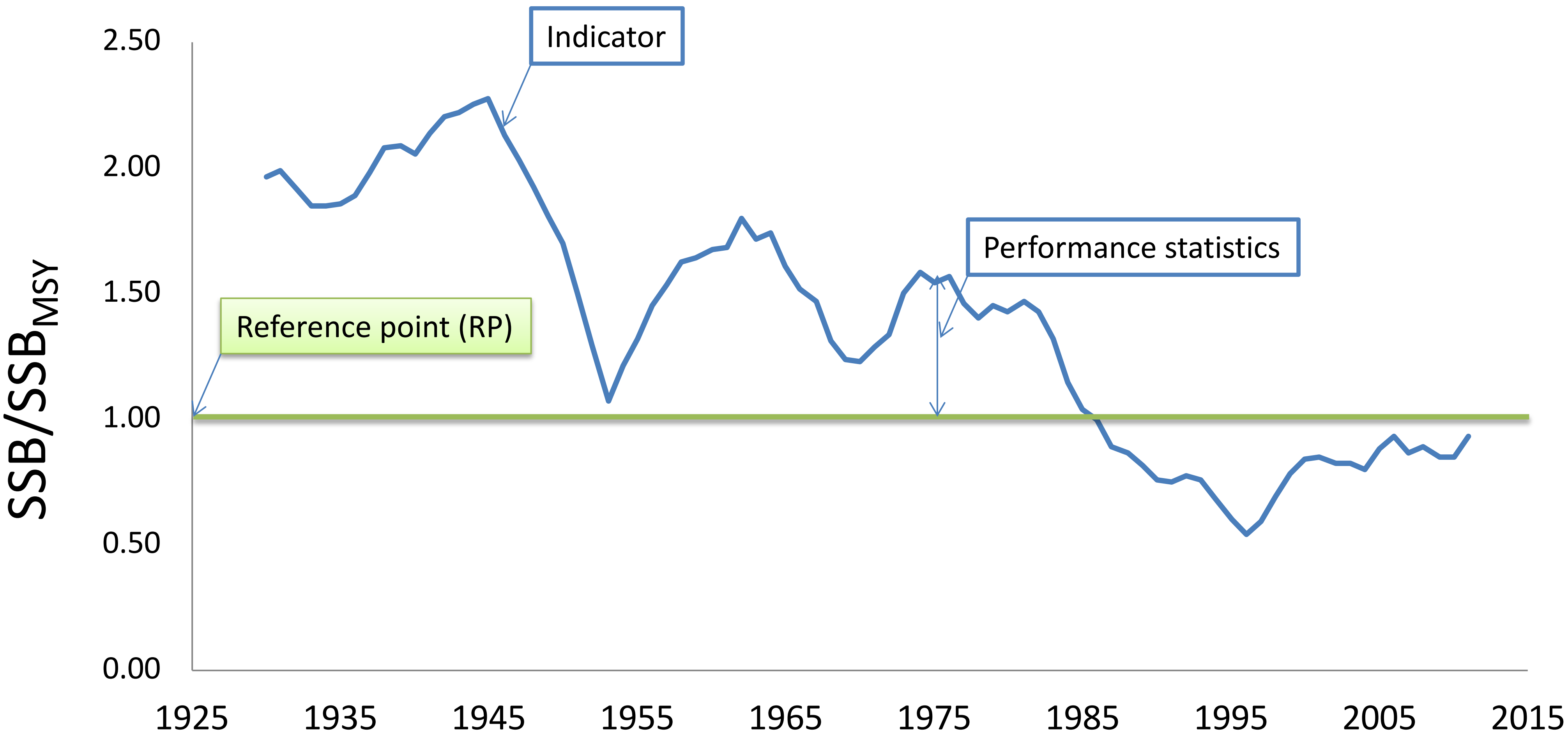
Interim Target and Limit Reference Points (TRPs and LRPs)

When assessing stock status and providing recommendations to the Commission, the **IOTC Scientific Committee should, where possible, apply MSY-based target and limit reference points for tuna and tuna-like species**.

Stock	Target Ref. Point	Limit Ref. Point
Albacore	Btarget = B_{MSY} Ftarget = F_{MSY}	Blim = 0.4 * B_{MSY} F = 1.40 * F_{MSY}
Yellowfin		
Swordfish		
Bigeye		Blim = 0.5 * B_{MSY} F = 1.30 * F_{MSY}
Skipjack* (based on B0)		Blim = 0.4 * B_{MSY} F = 1.50 * F_{MSY}

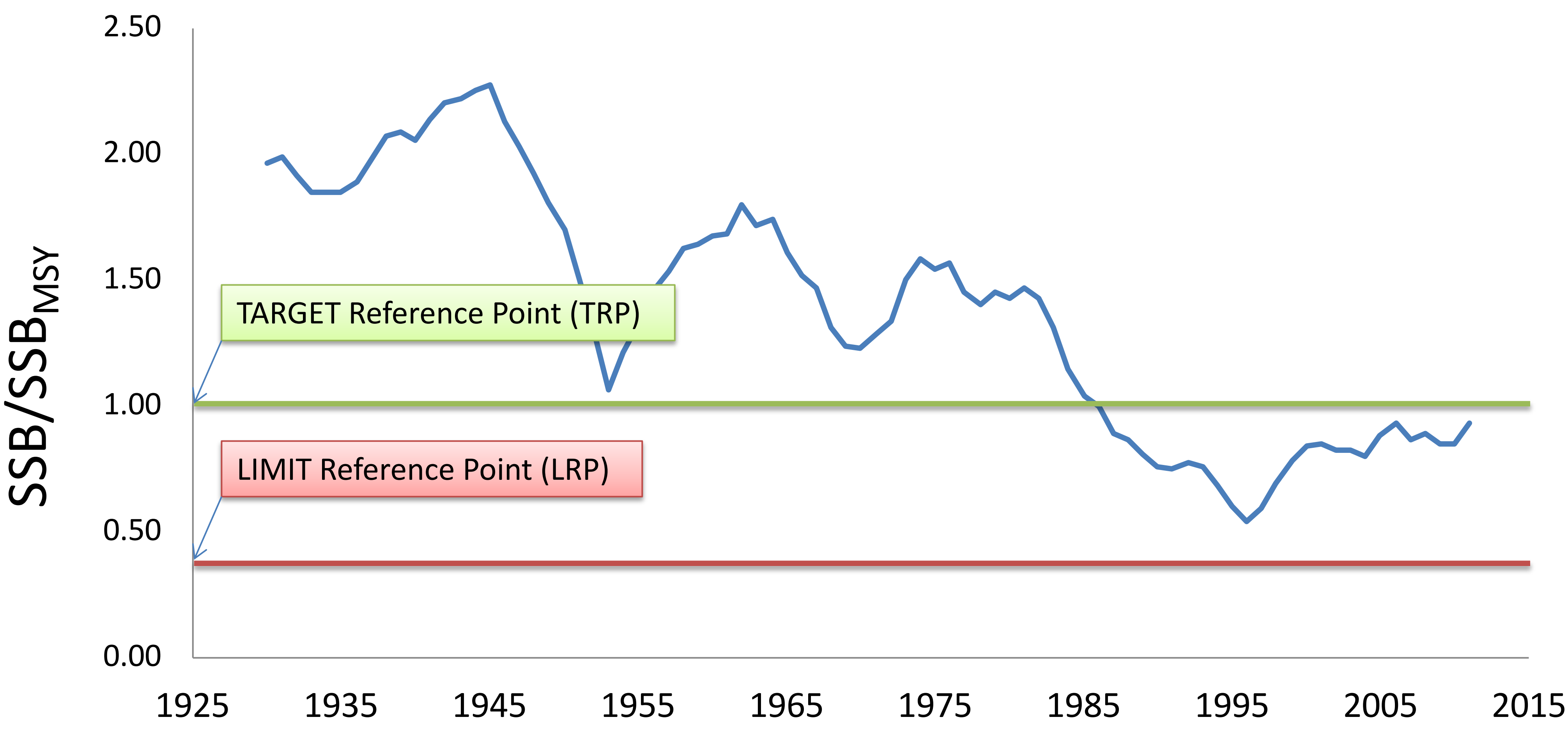
* when MSY-based reference points cannot be reliably estimated RPs relative to B0.

Resolution 15/10: Reference Points



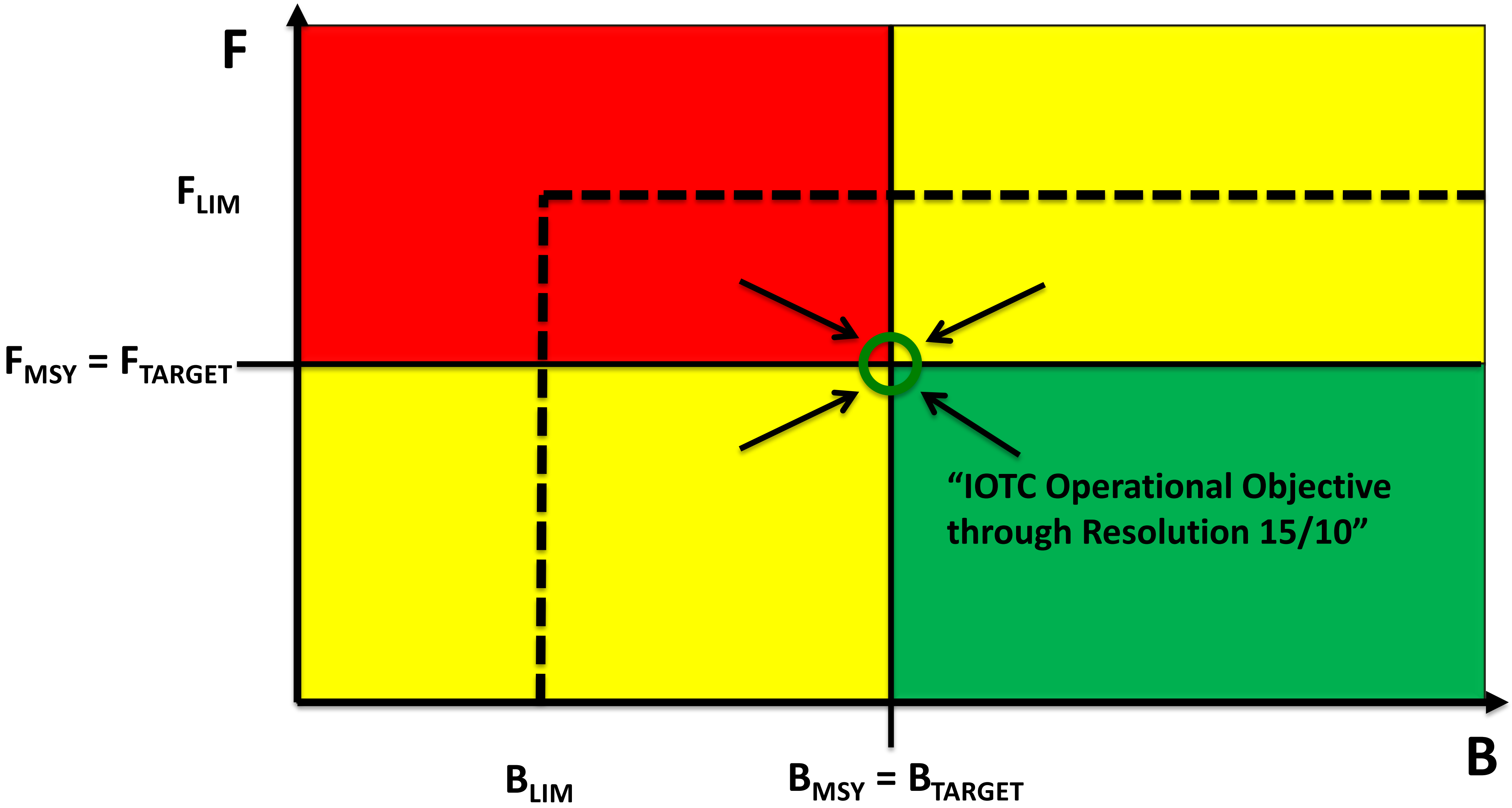
Reference Point is a **pre-determined** level of a given indicator that corresponds to a particular state of the stock

Resolution 15/10: Reference Points

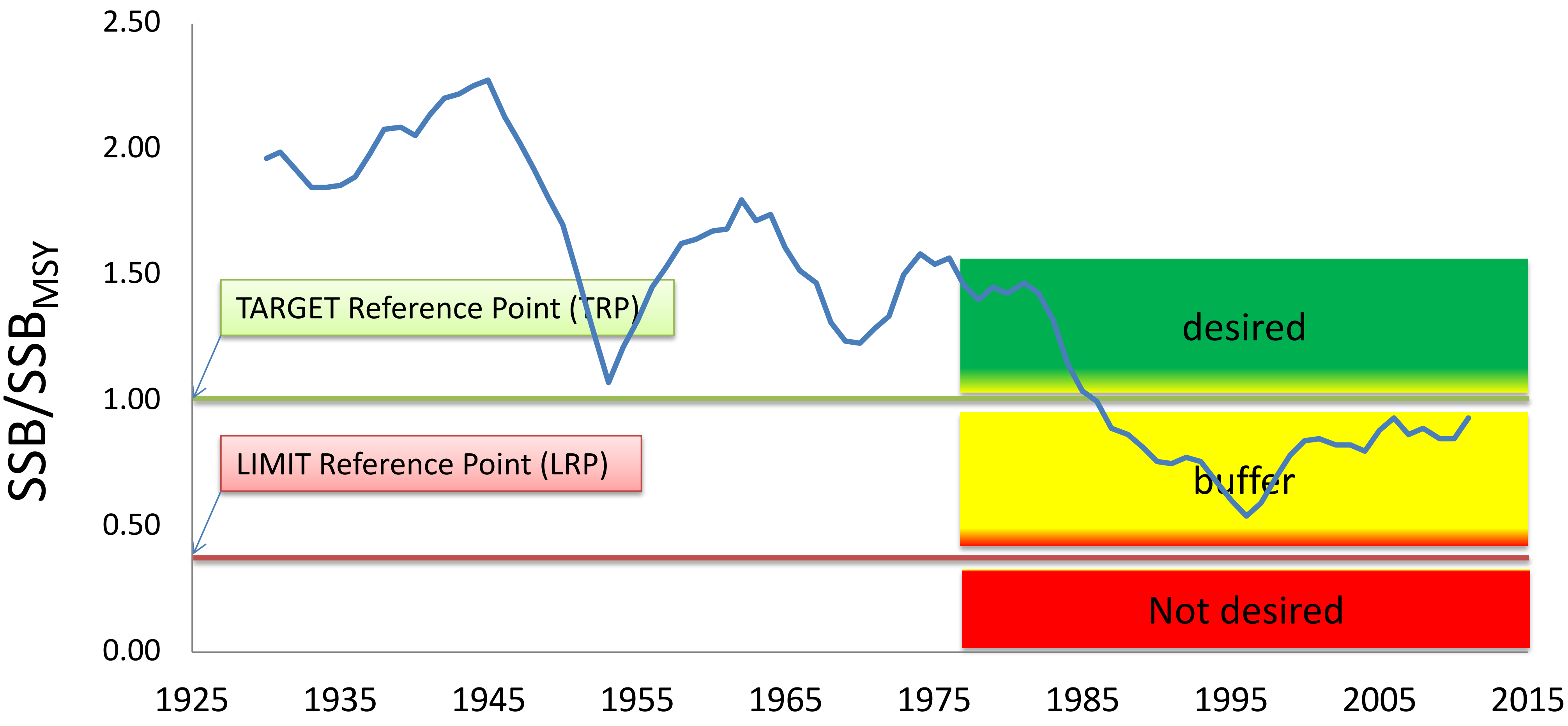


Reference Point is a **pre-determined** level of a given indicator that corresponds to a particular state of the stock that management either seeks to **achieve (TRP) or avoid (LRP).**

Provision of Management Advice



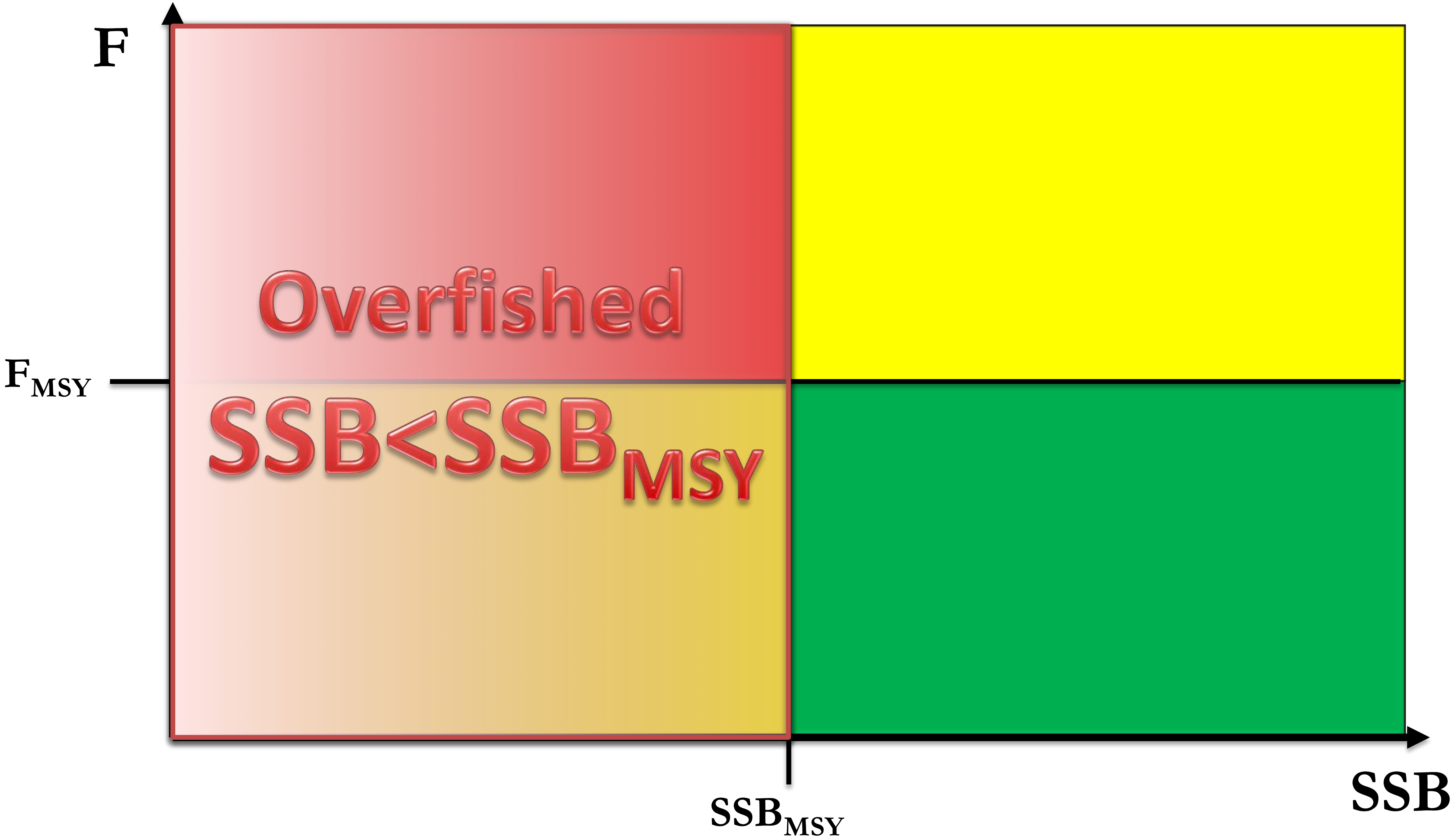
Resolution 15/10: Reference Points



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).**

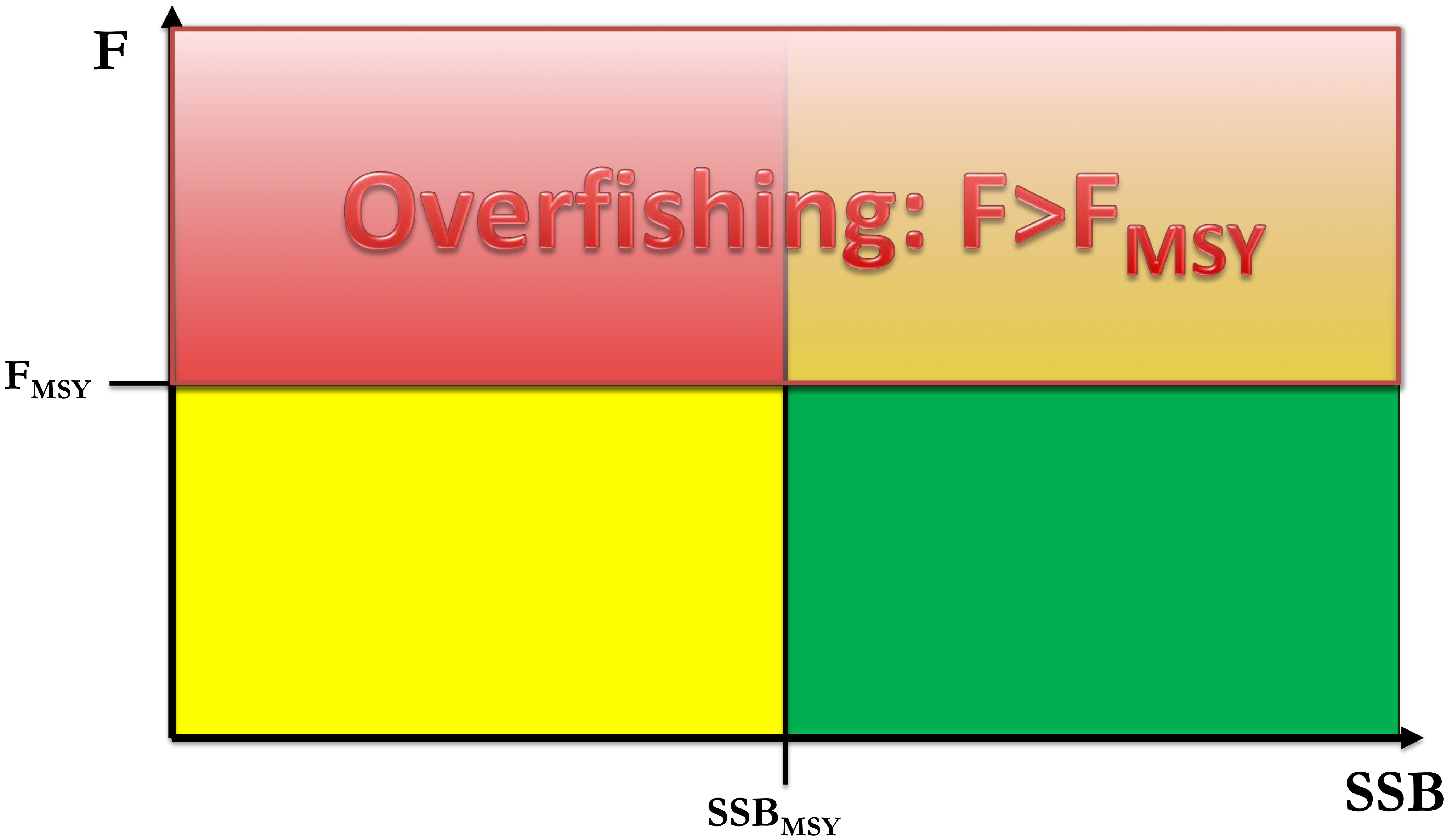
Providing scientific advice

"Kobe plot"

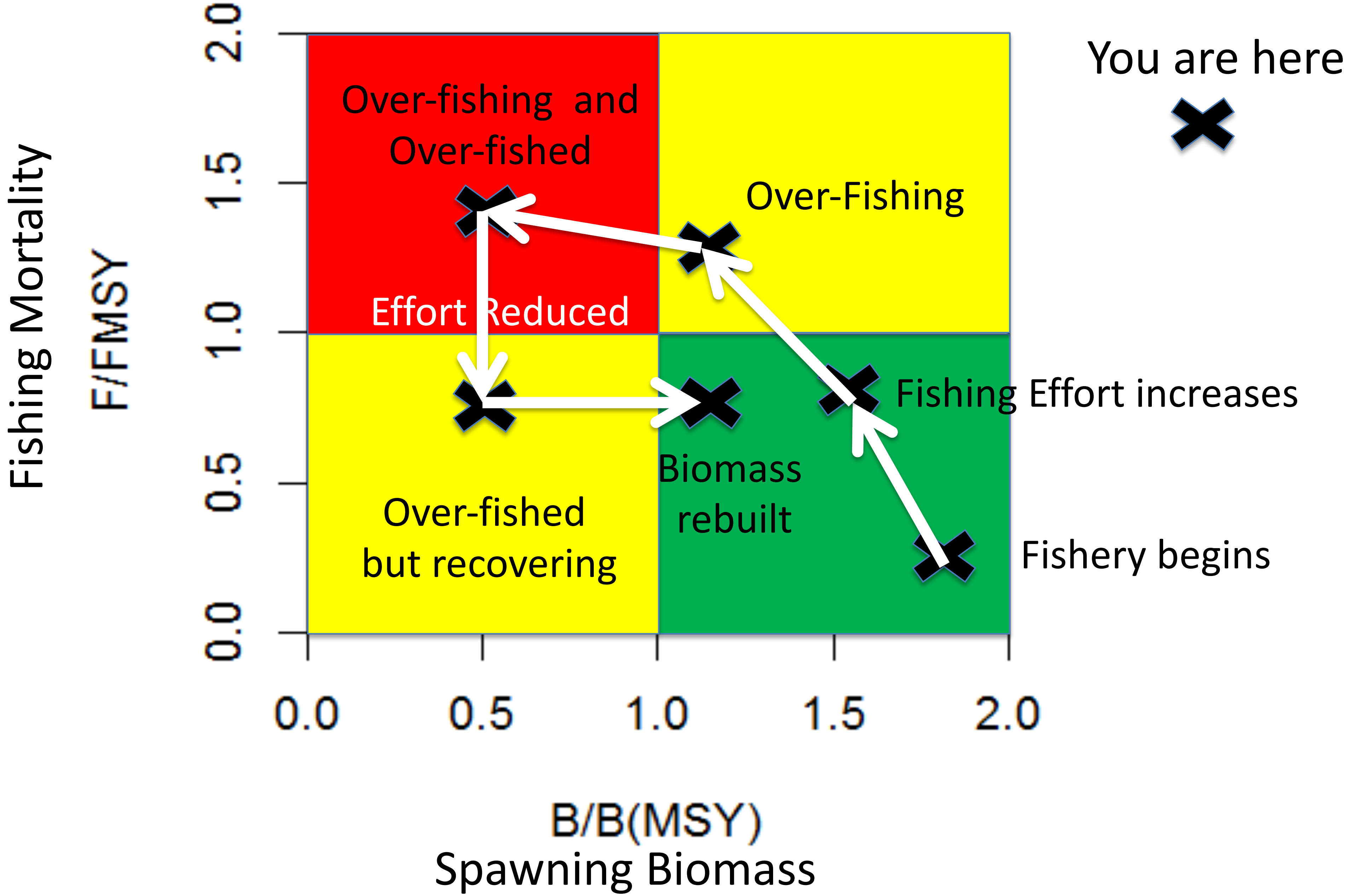


Providing scientific advice

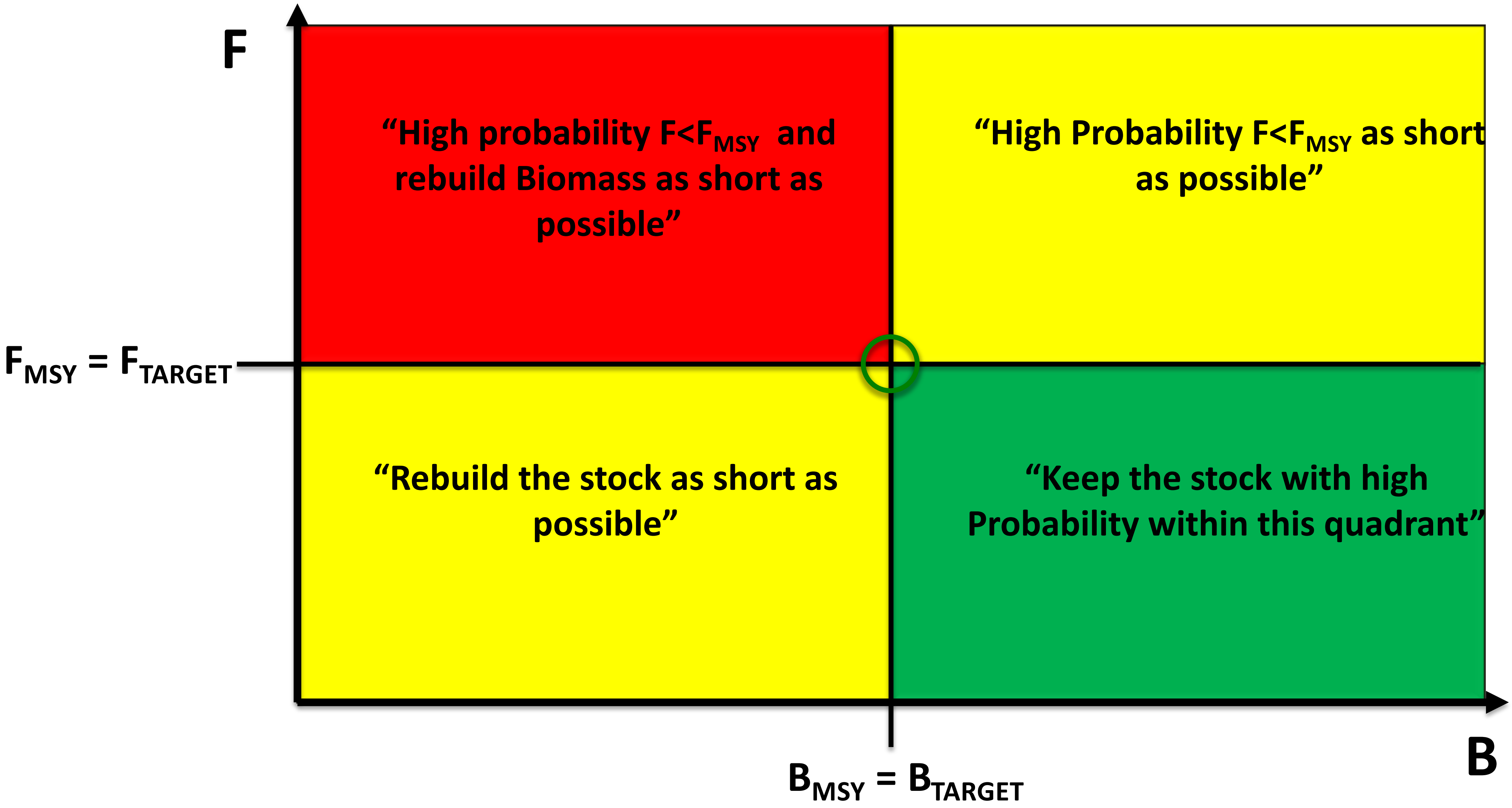
“Kobe plot”



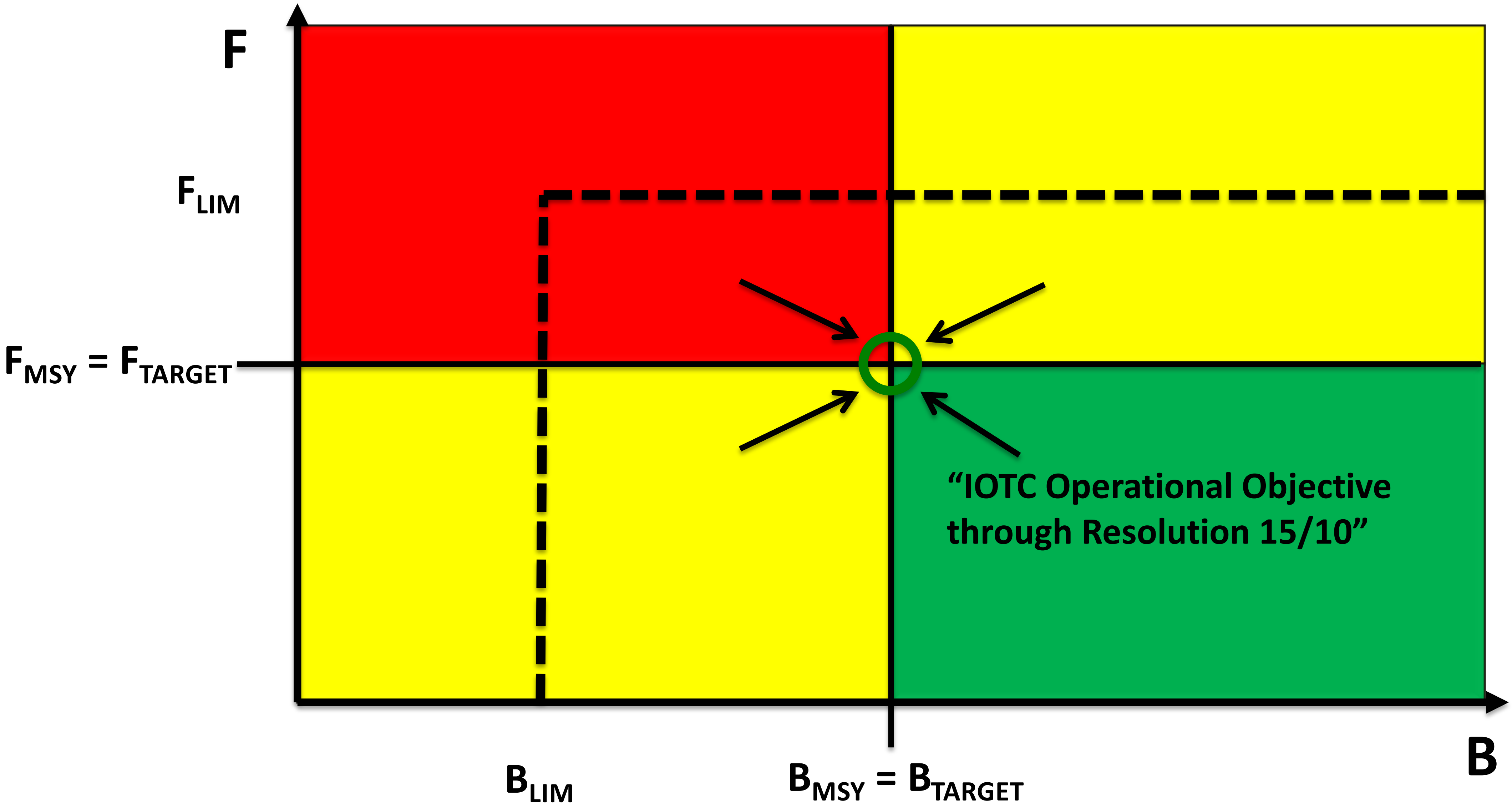
Providing scientific advice

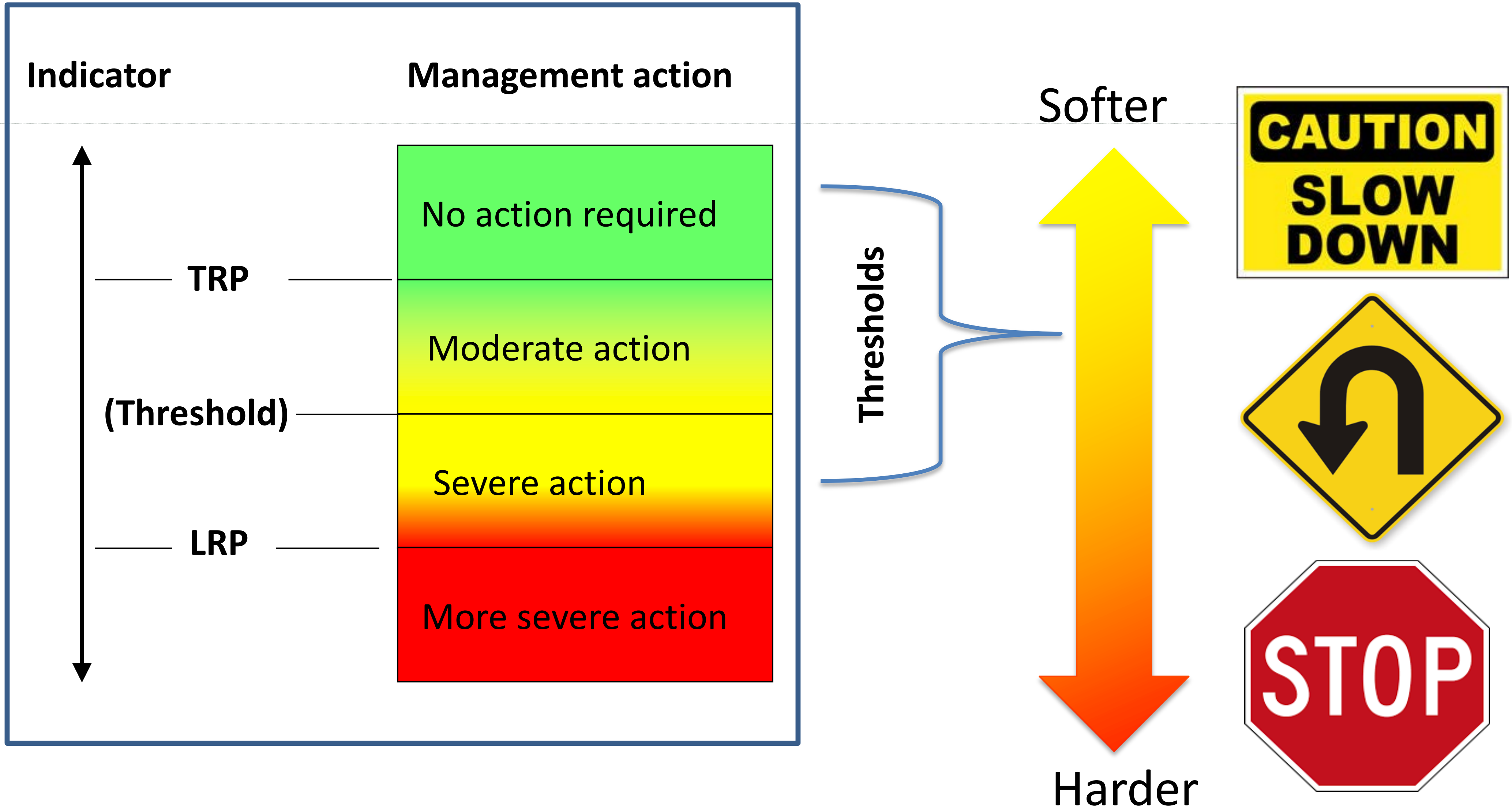


Resolution 15/10: Reference Points (Operational Objectives)



Provision of Management Advice

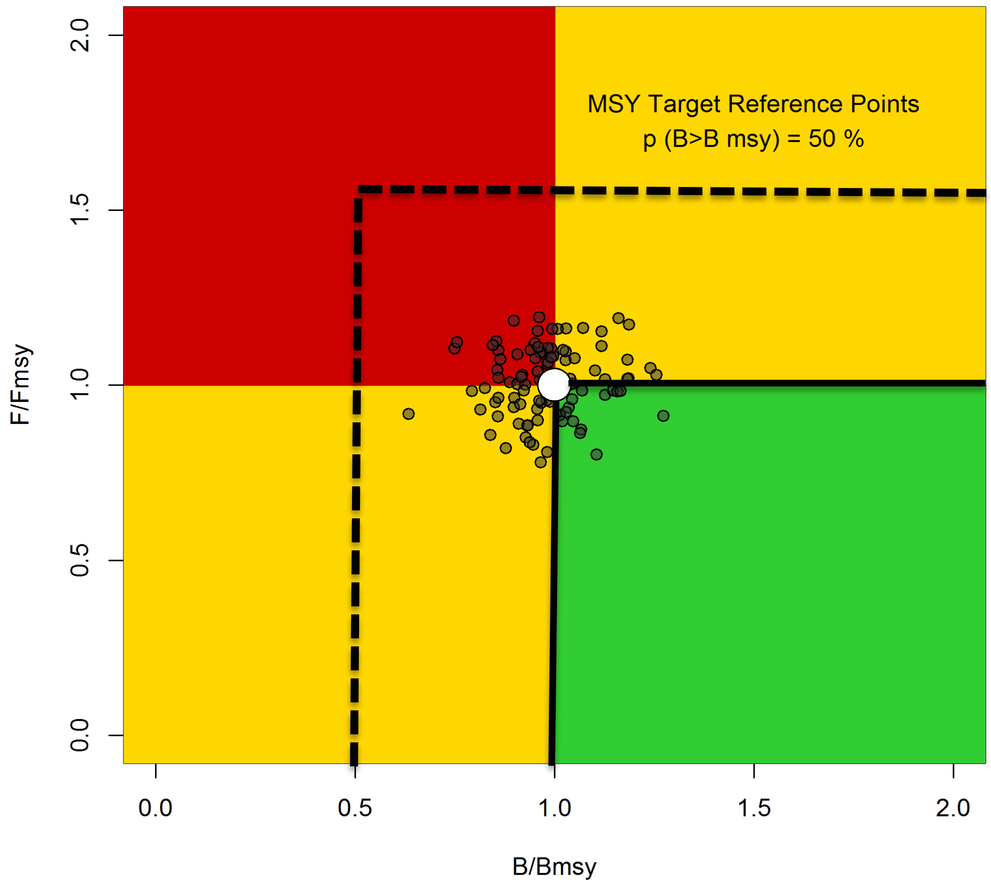




- **Target Reference Points** (TRPs): values for stock size and/or fishing mortality rate that a manager aims to **achieve and maintain**.
- **Limit Reference Points** (LRPs), which describe an undesirable state of the indicator that should be **avoided** with high probability.
- **Thresholds** defining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

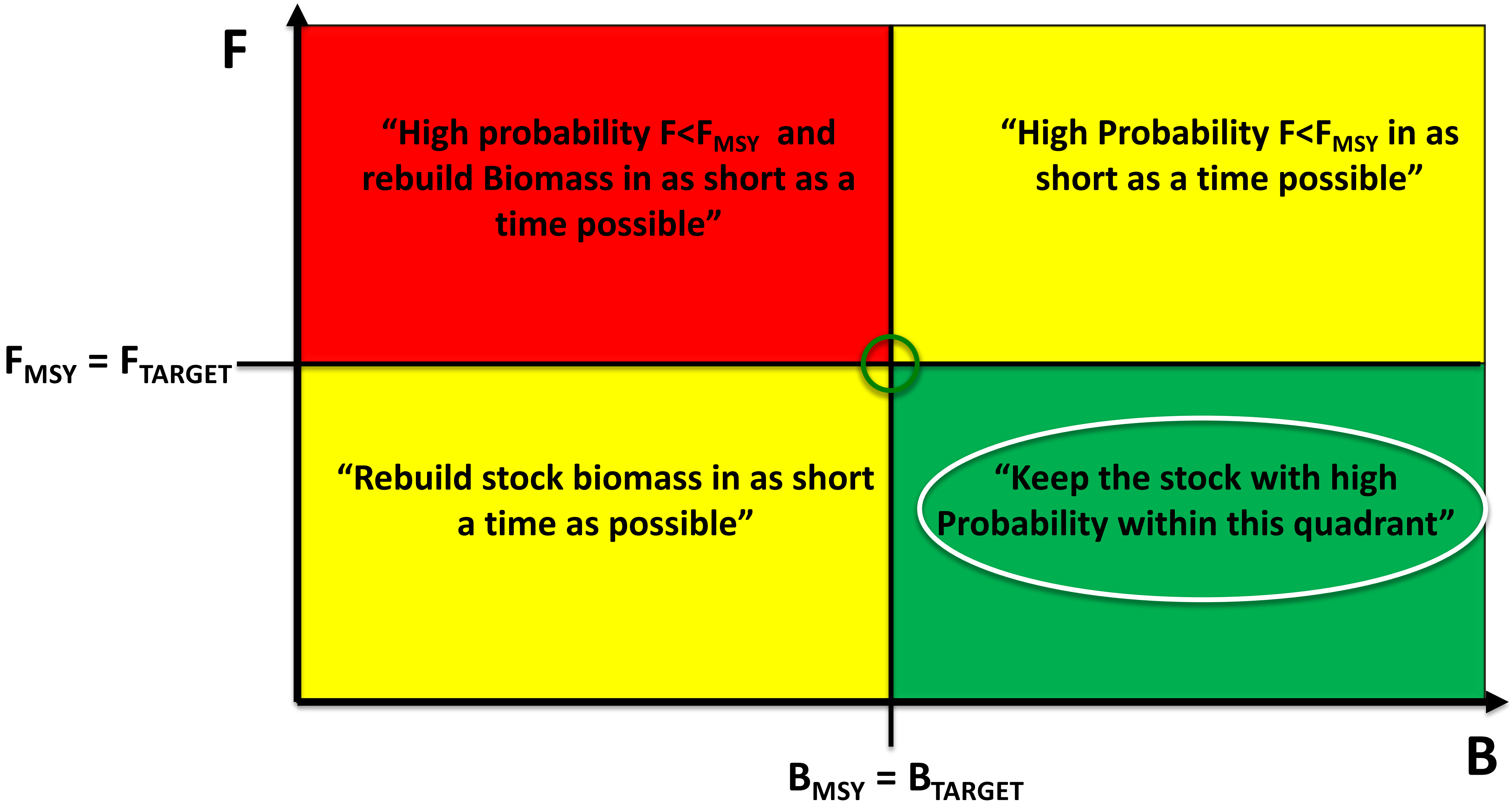
Provision of Management Advice

Where does IOTC want the fishery to be? If the objective is to be at or above BMSY and fishing at FMSY, there can be a ≈50 % chance of being overfished in the Kobe classification due to natural fluctuations.



Provision of Management Advice

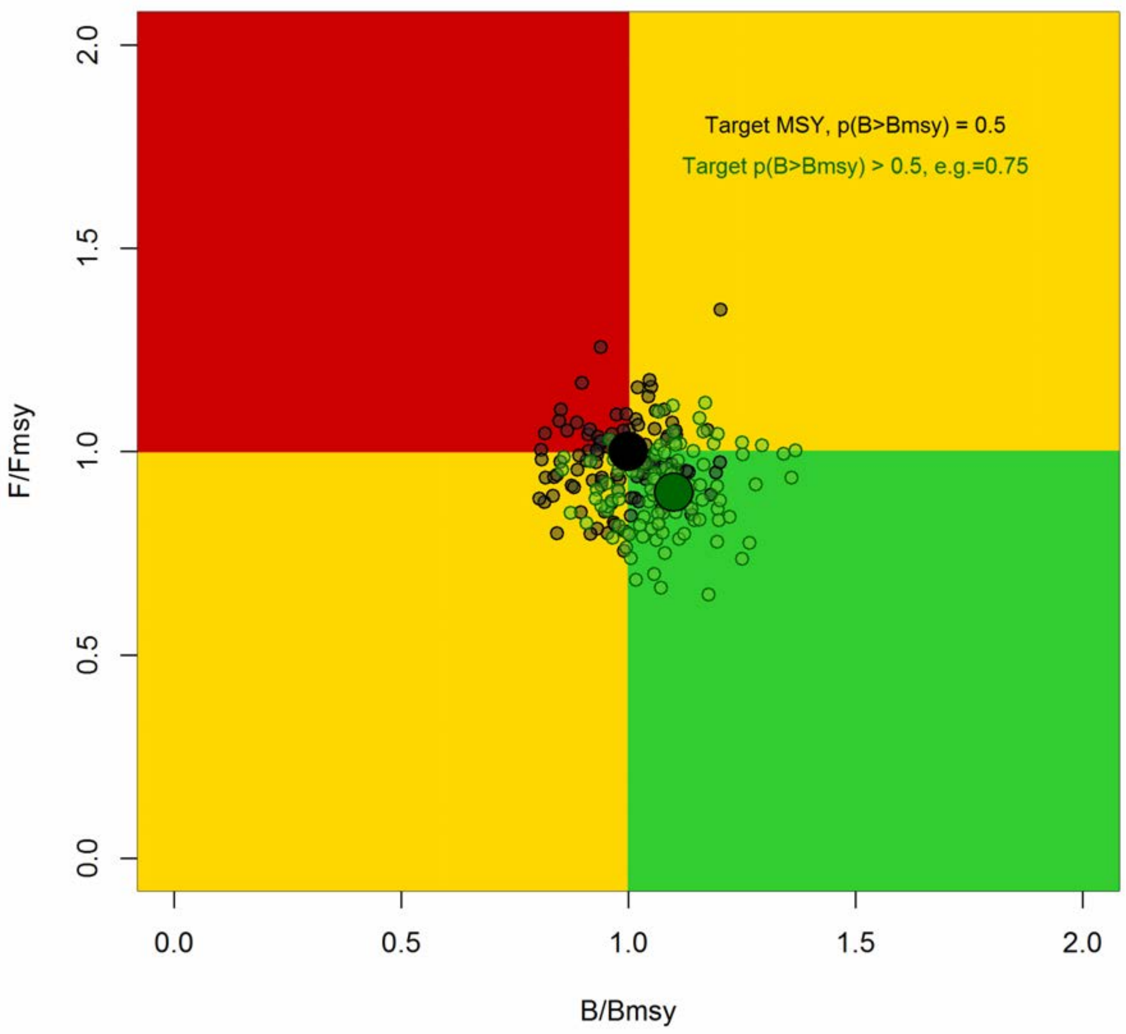
Resolution 15/10: Reference Points (Operational Objectives)



- … but what are the timeframes and probabilities?

Objectives

Where do we want the fishery to be, considering Decision Framework in Res 15/10?



OBJECTIVEs:

"Maintain the biomass at or above levels required to produce MSY or its proxy and maintain the fishing mortality rate at or below F_{MSY} or its proxy;" and

"Avoid the biomass being below B_{LIM} and the fishing mortality rate being above F_{LIM}"

Management Procedures: Objectives

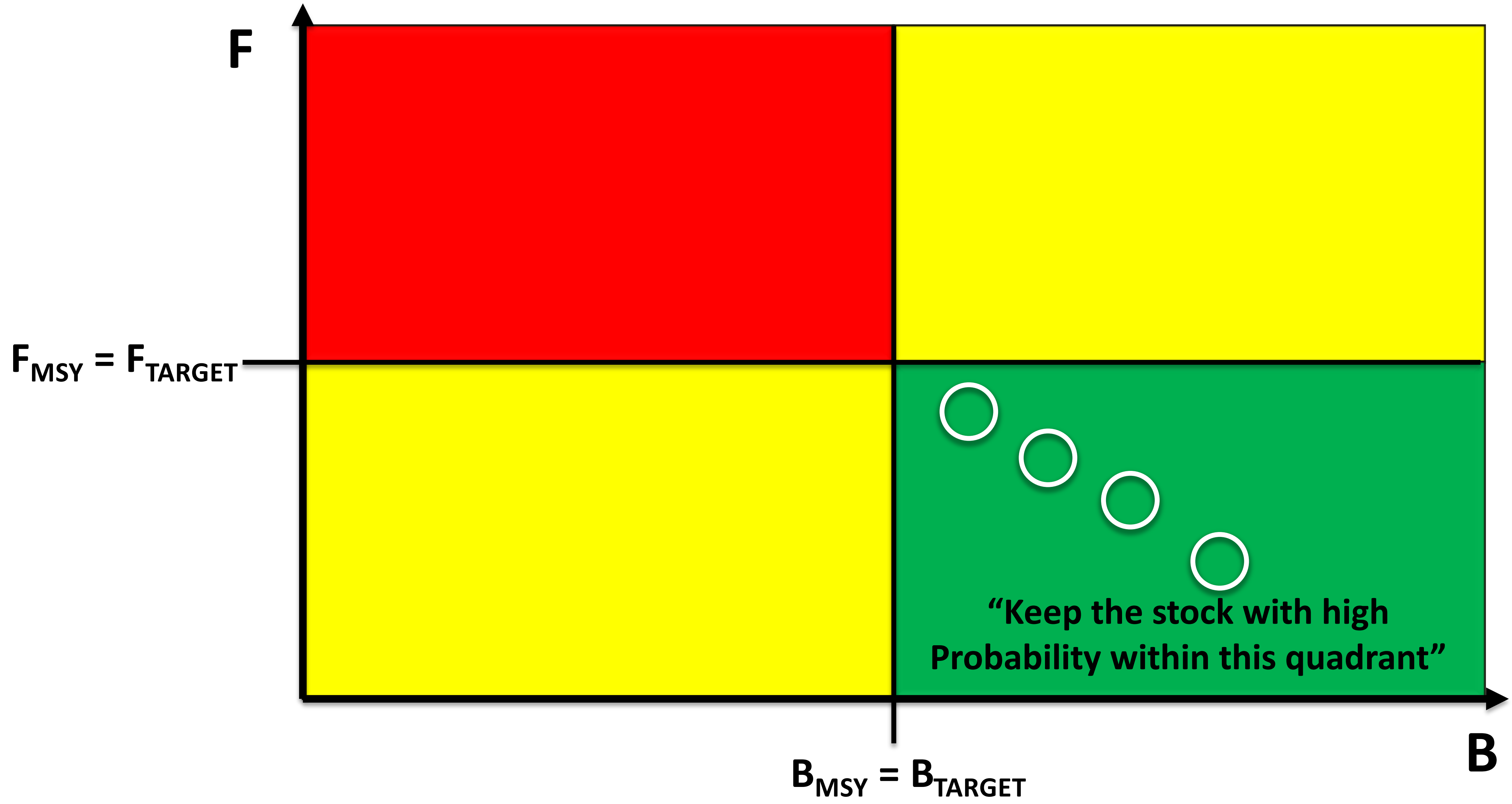
OBJECTIVE
TO MAINTAIN IN GREEN

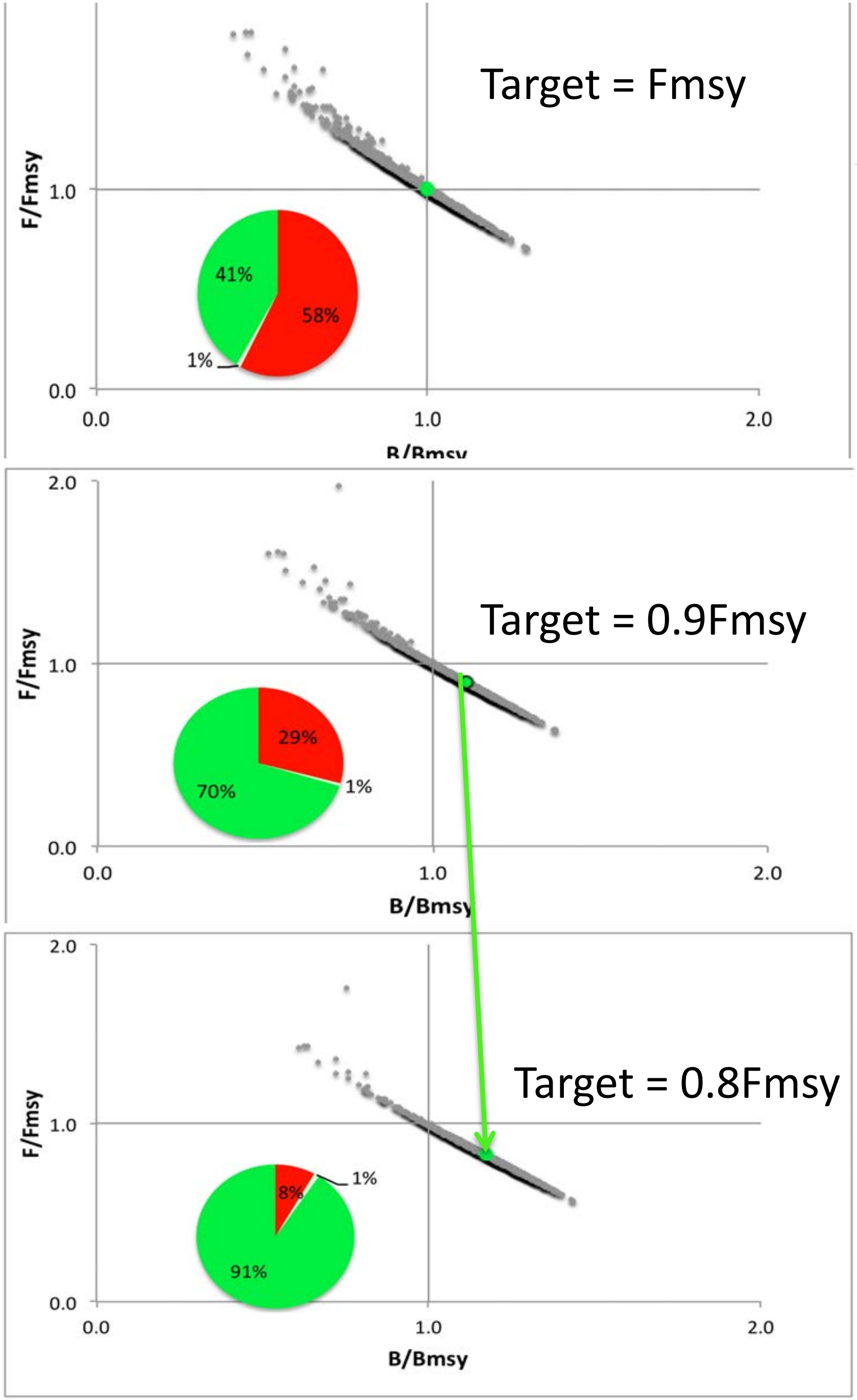
BUT, WHAT GREEN?

OR AT PROBABILITY?

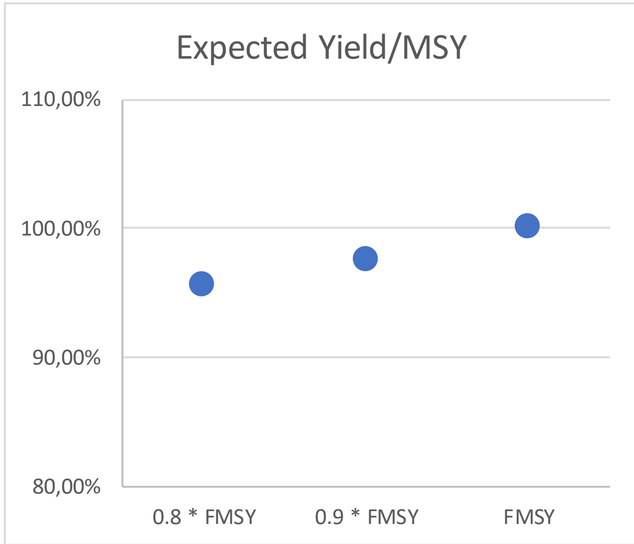
Management Procedures: Objectives

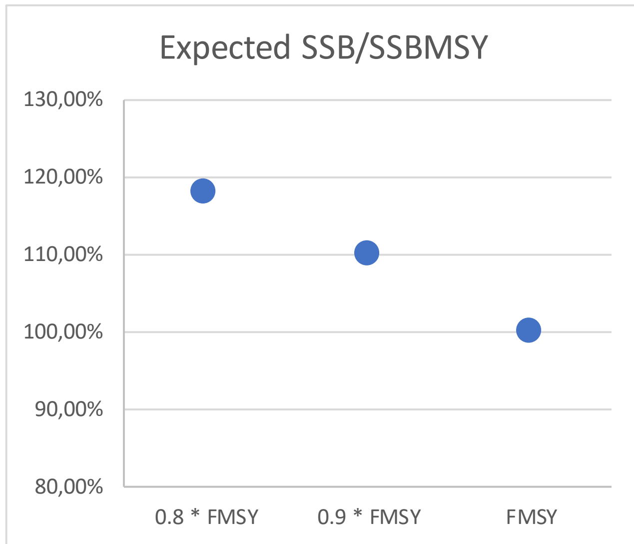
Resolution 15/10: Reference Points (Operational Objectives)





Uncertainty impacts on targeting



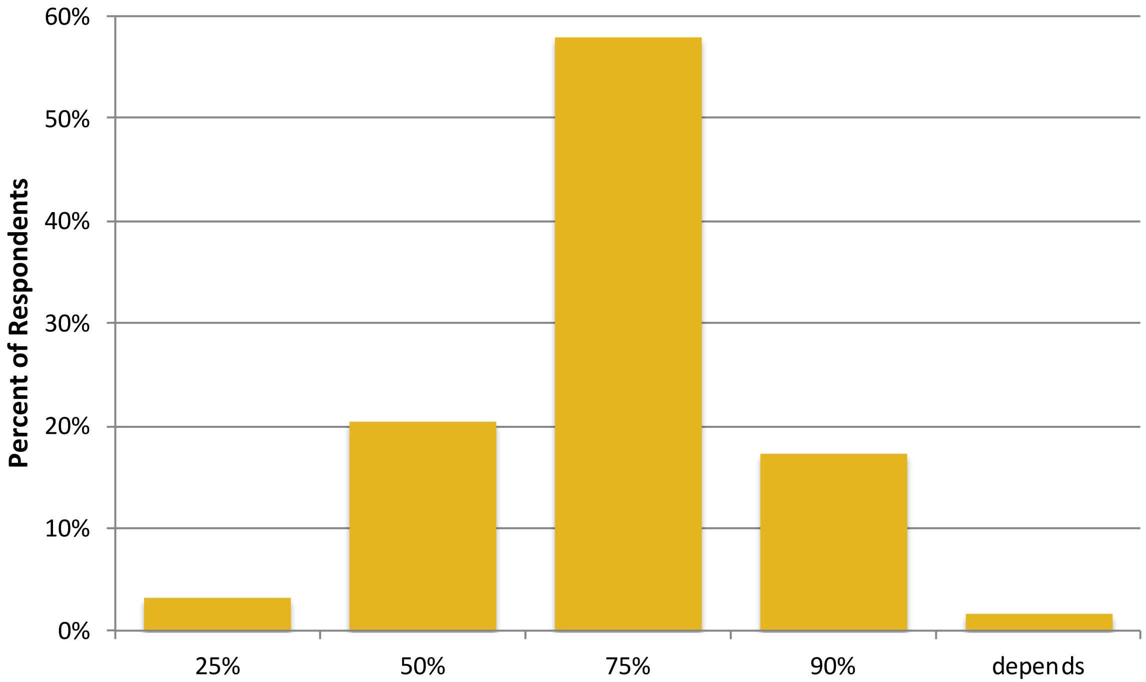


Relatively small, <5%, loss in Yield

Substantial gain in SSB with gain in P("Green")

What is High Probability of Achieving a Target?

Survey Says…..



From 2015 Surveys at IOTC's MPD02 and ICCAT's SWGSM (64 respondents). In keeping with other organizations, the majority view by participants was that ~75% (or 3 chances out of 4) is a high probability for achieving a target.

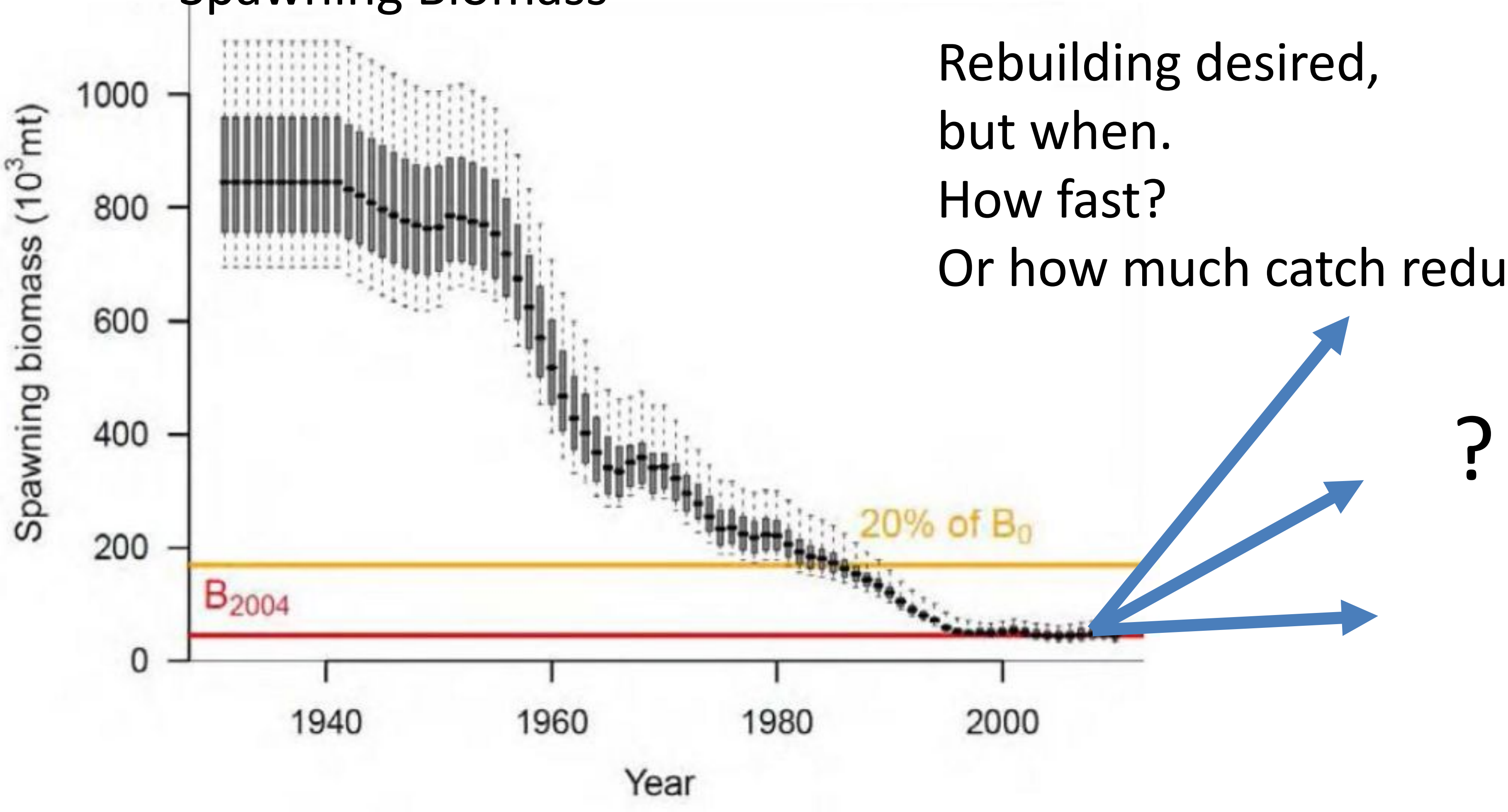
Harvest Control Rules: Timeline

Where and when do we want the fishery to be?

Harvest Control Rules (with Reference Points): Timelines

Where and when do we want the fishery to be?

Spawning Biomass



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

Objectives

- Green Zone with **high probability**
- In case of not green zone, come back as quick as possible with high probability.

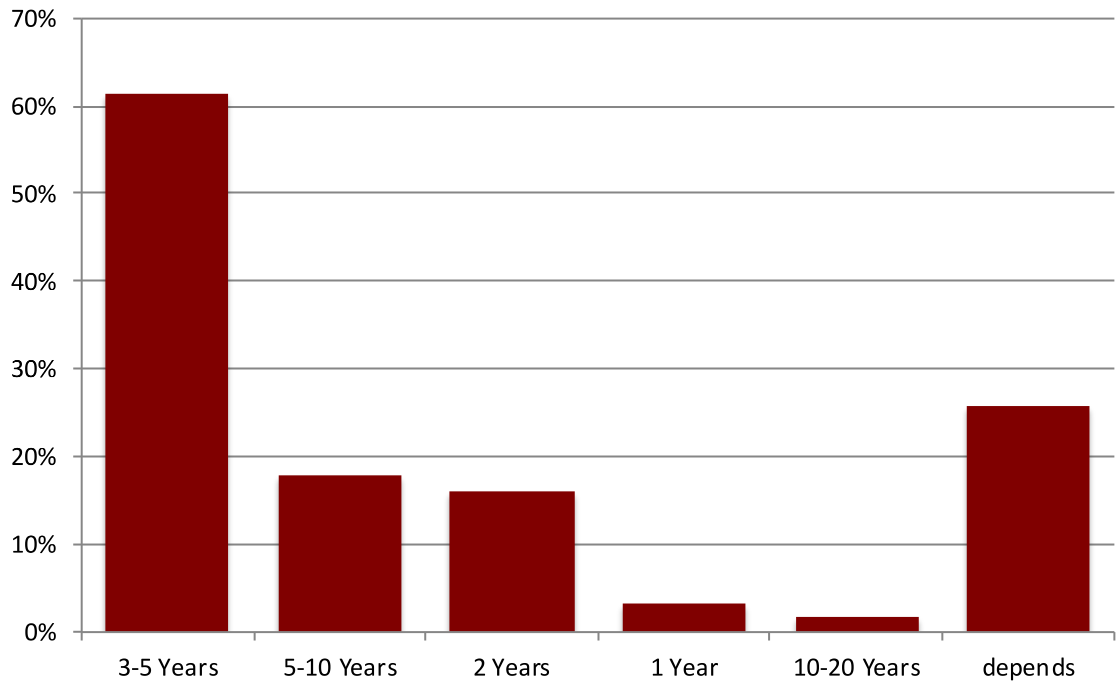
<u>Other Priorities (Social)</u>

- Employment/stability of catch
- Maximum Economic Yield Vs Maximum Sustainable Yield.
- Expanding Fleet Capacity/ Opportunity (Industry)
- Conserving stocks for Intrinsic Benefits (Enviros)

Inherently what you need to decide

- Balance long-term yield to long-term stock biomass.
- In case of adverse conditions, evaluate how long it may take to recover.
- Take a lot of pain now for benefits later or less now for longer rebuilding time

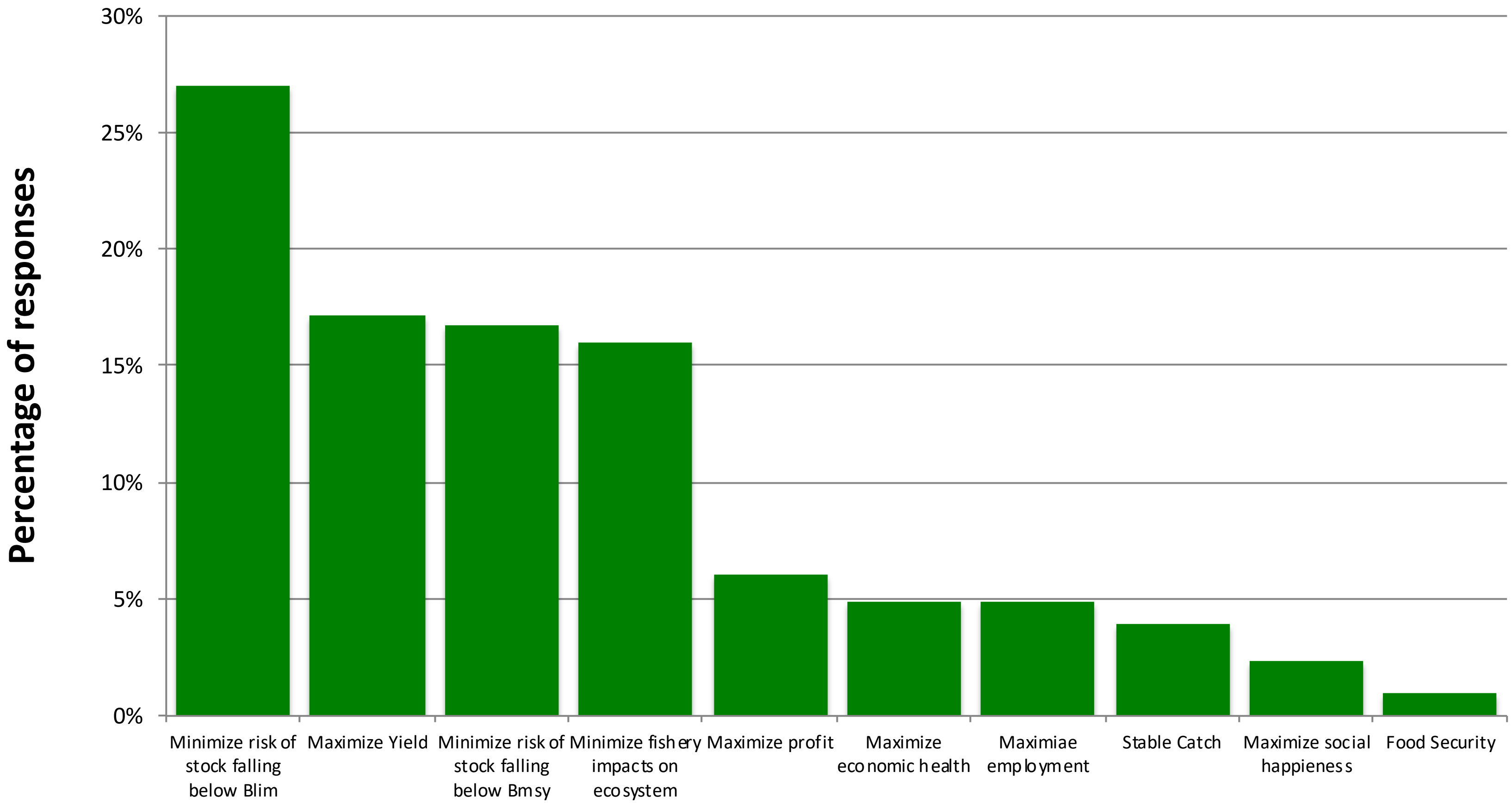
What should be `as short a time as possible' for recovery? Survey says …



- From 2015 Surveys at IOTC's MPD02 & ICCAT's SWGSM (76 respondents). Most participants viewed a time frame of 3-5 years in this context, although a high proportion of respondents indicated it depends on the stock of concern. Others indicated that time frames for managing fishing intensity (F) should be more immediate than for rebuilding biomass to desired levels.

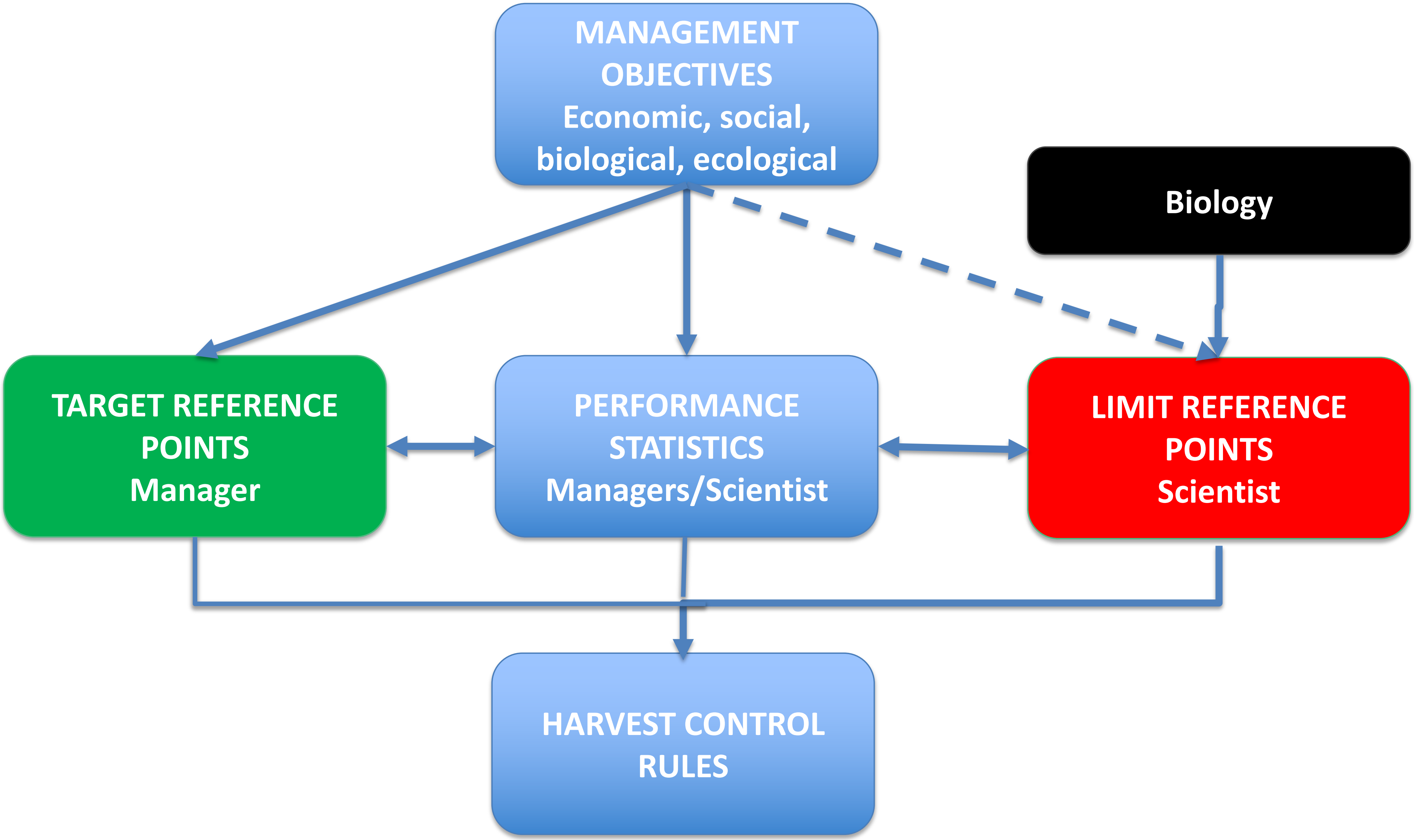
Harvest Control Rules: Trade-offs

Different Management Objectives ➔Trade offs

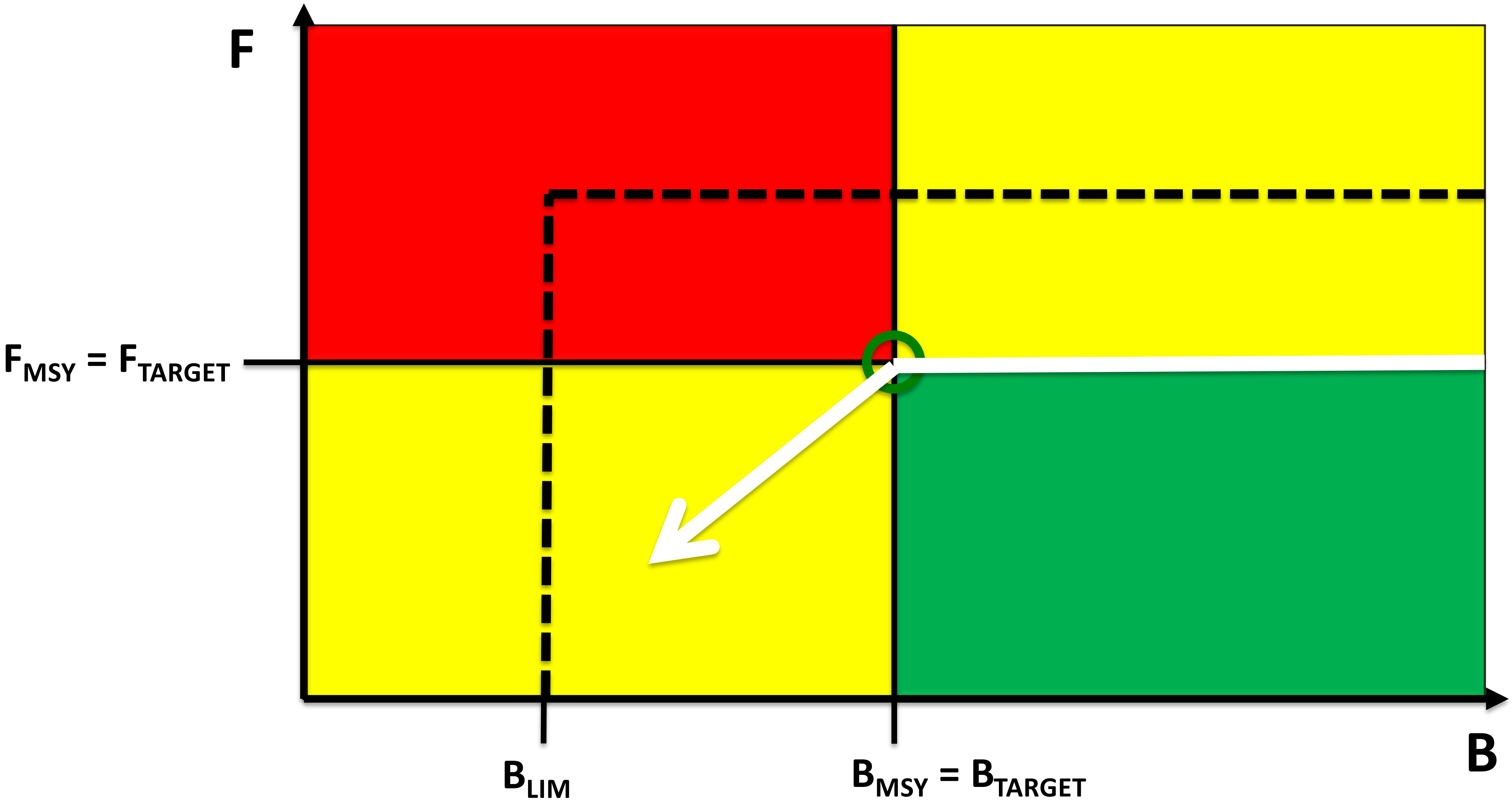


- From 2015 Survey at ICCAT's SWGSM. Considering priority given to the management objectives noted by Particiants, those related to 'Safety', 'Yield', and P(green) aka 'Sustainability' ranked highest followed by minimizing ecosystem impacts.

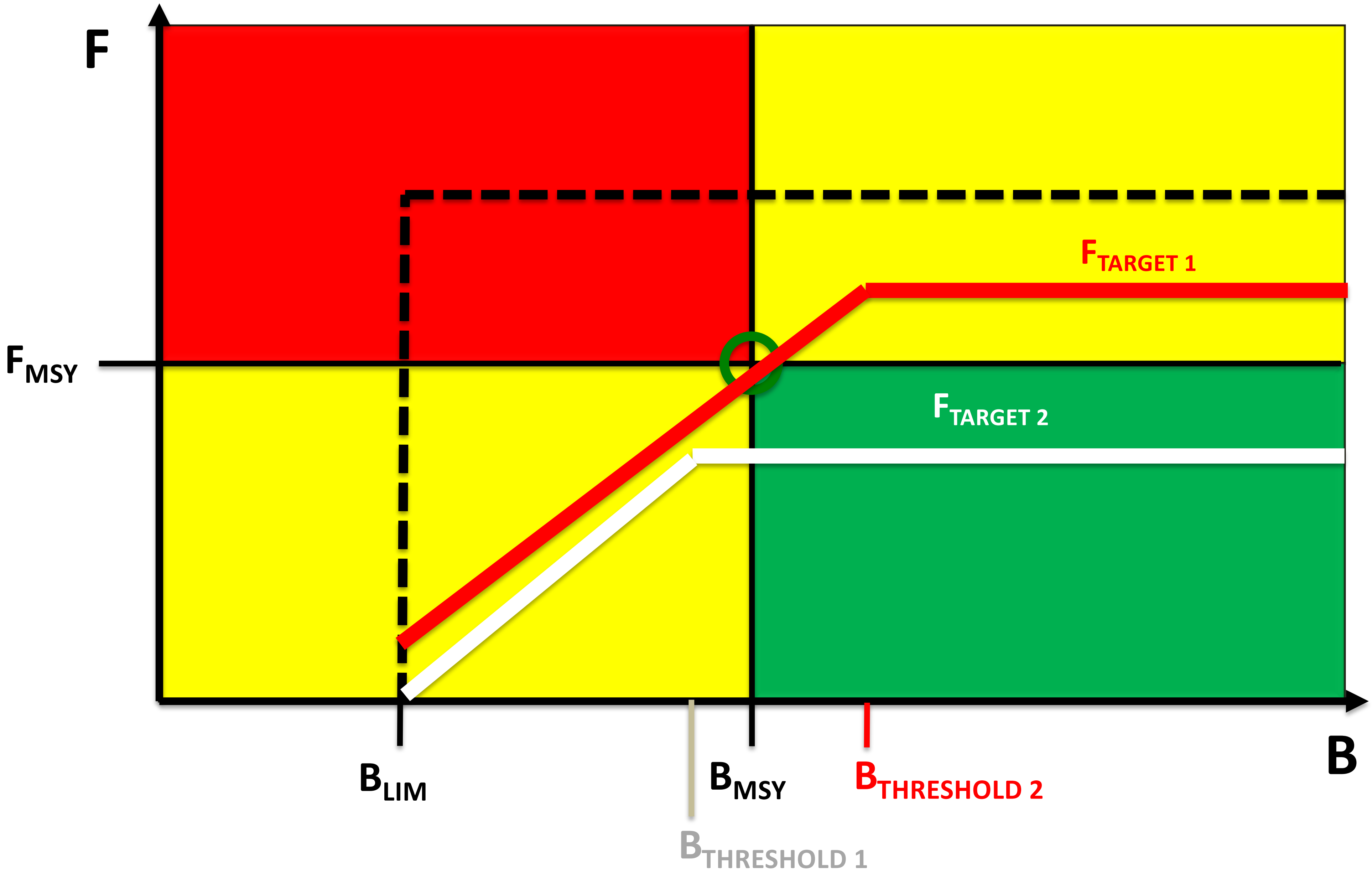
Harvest Control Rules



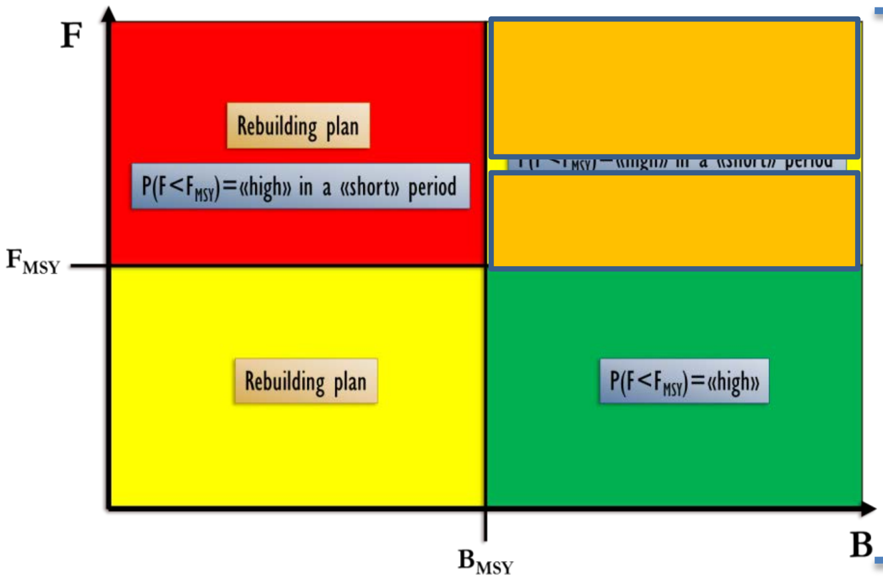
Harvest Control Rules



Harvest Control Rules



Harvest Control Rules (HCR)

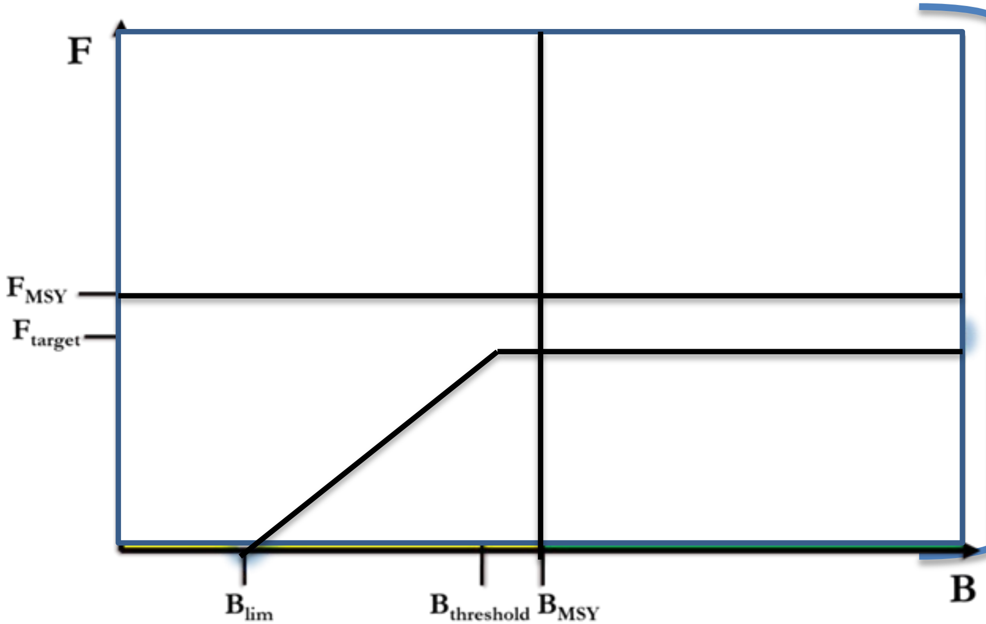


HIGH probability

IPCC: 80%
Canada: 75%
MSC: 70%-80%

SHORT period

USA: 10 years or 1.5 generations
Australia: 10 years + 1 generation
MSC: 2 generations



F target

[0.7, 0.75, 0.8, 0.85, 0.9 and 1] x F_{MSY}

B threshold

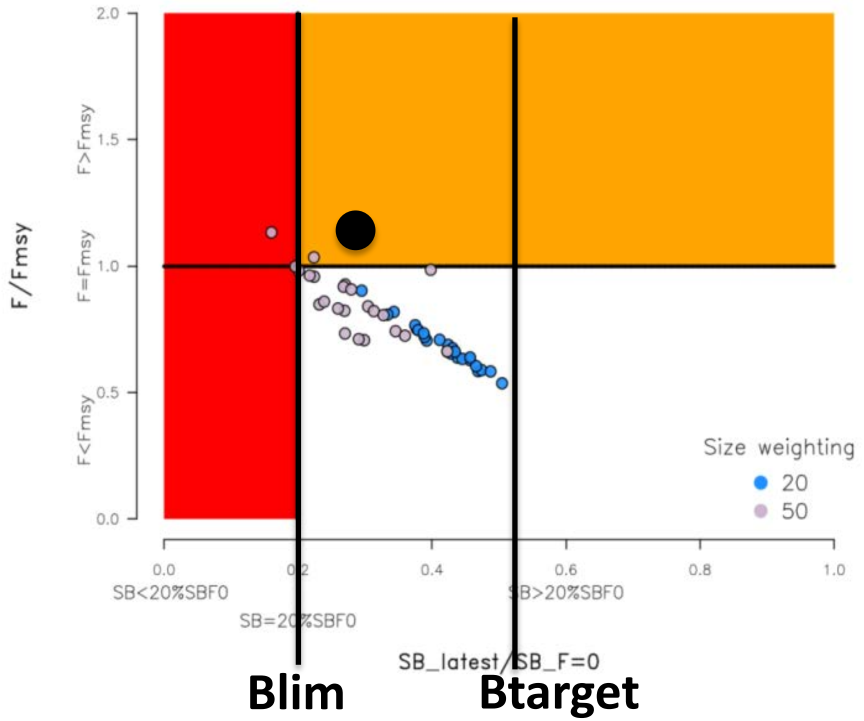
[0.6, 0.8 and 1] x B_{MSY}

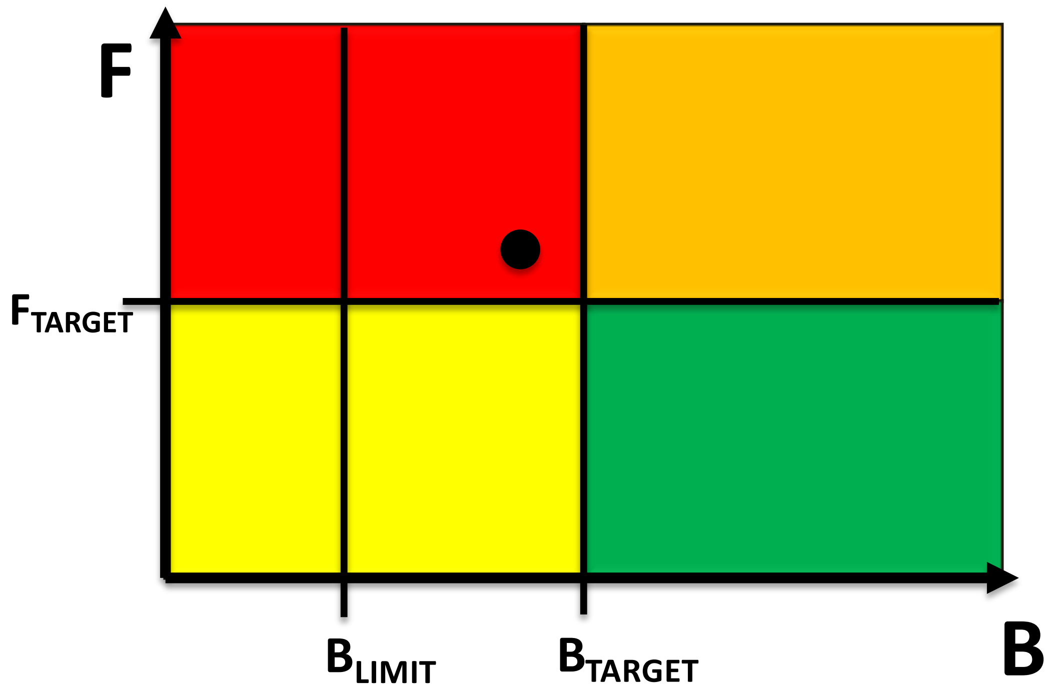
B lim

$0.4B_{MSY}$

Courtesy: ICCAT

Provision of Management Advice





MSE BASIC PRINCIPLES

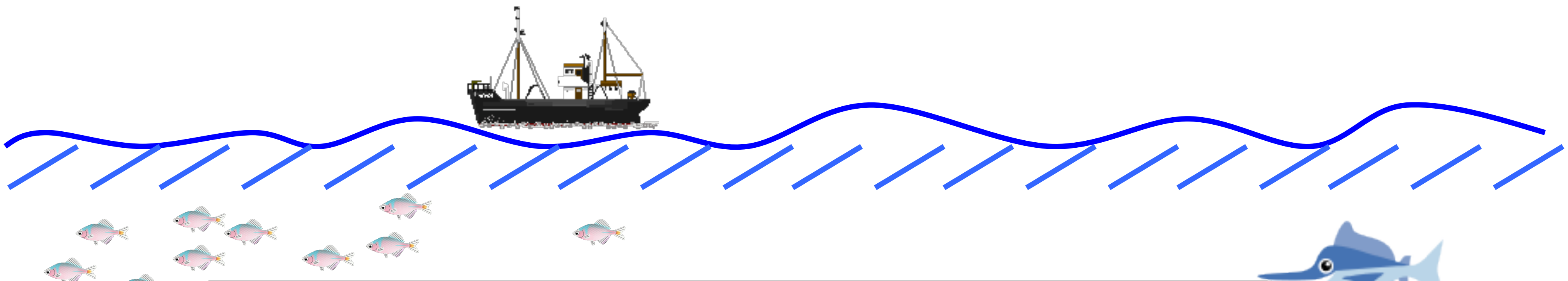
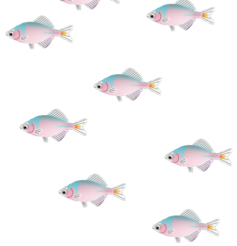
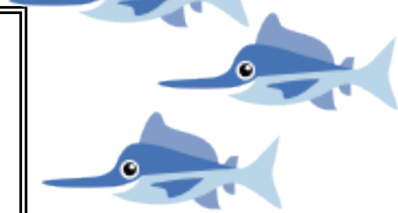
Food and Agriculture Organization of the United Nations

COMMON OCEANS

iotc ctoi

ISSF INTERNATIONAL SEAFOOD SUSTAINABILITY FOUNDATION

Fishery management

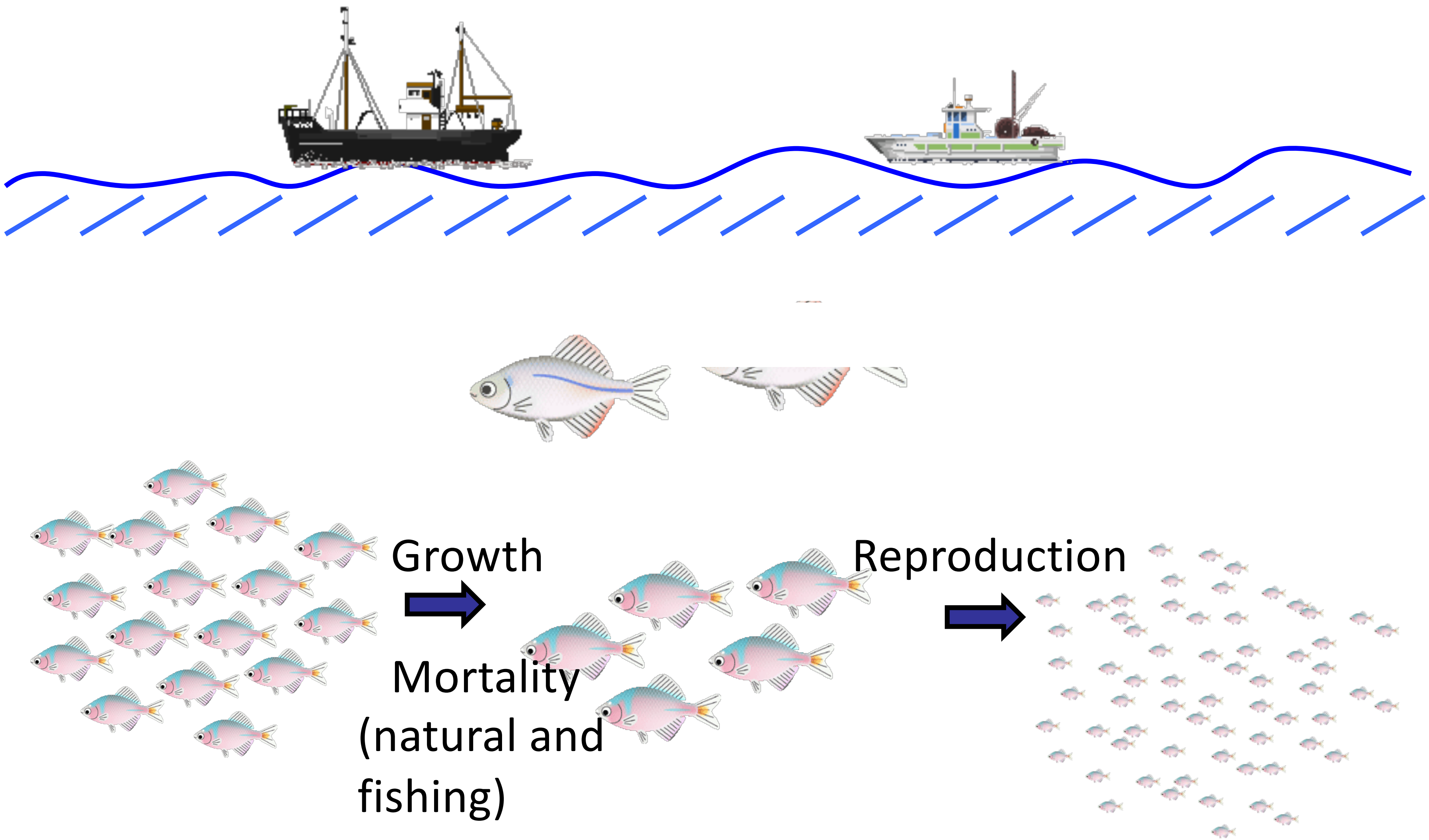
Whole ecosystem dynamics

Population dynamics (mortality, growth, reproduction)

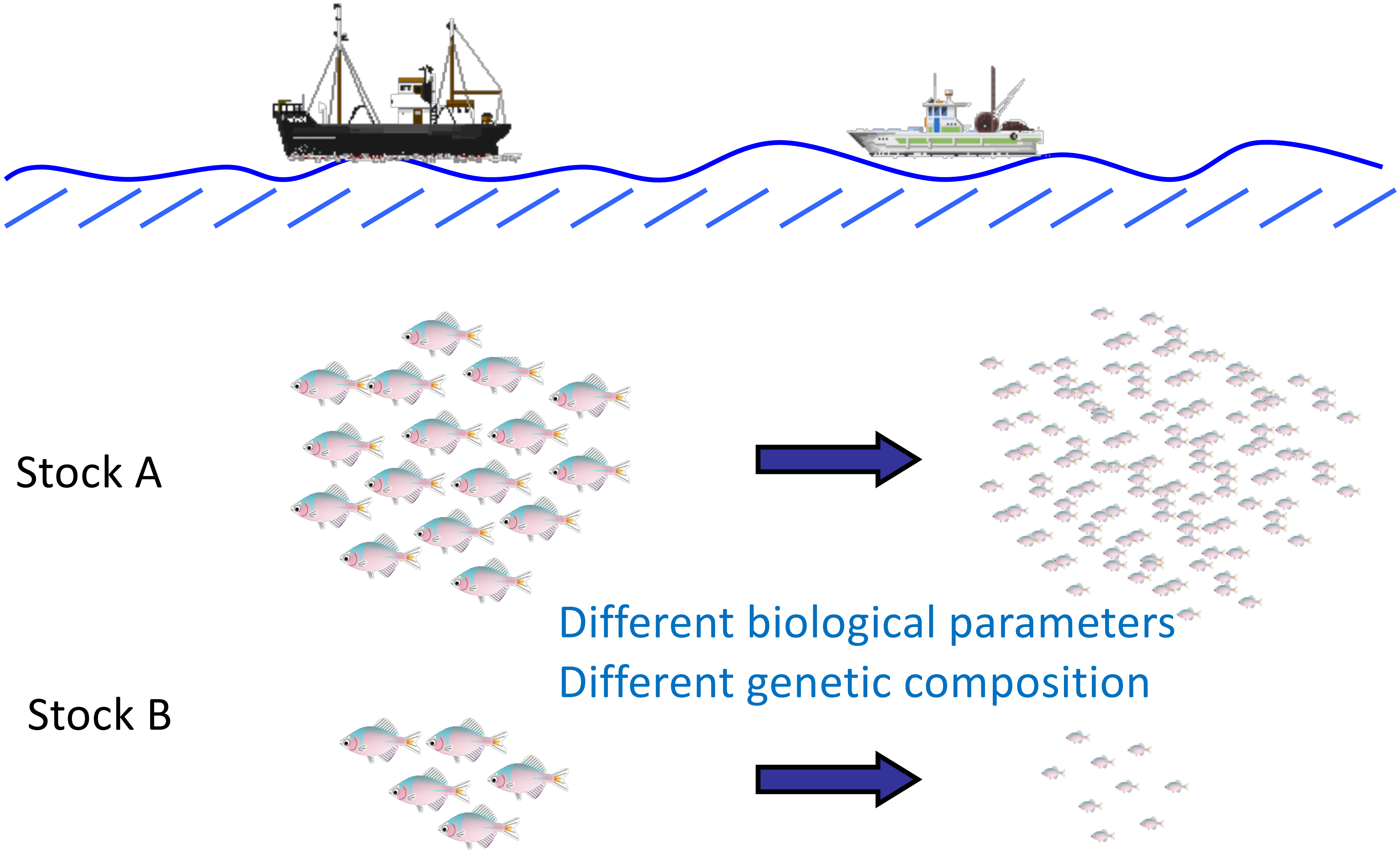
Environmental factors

Food web, genetic stock structure

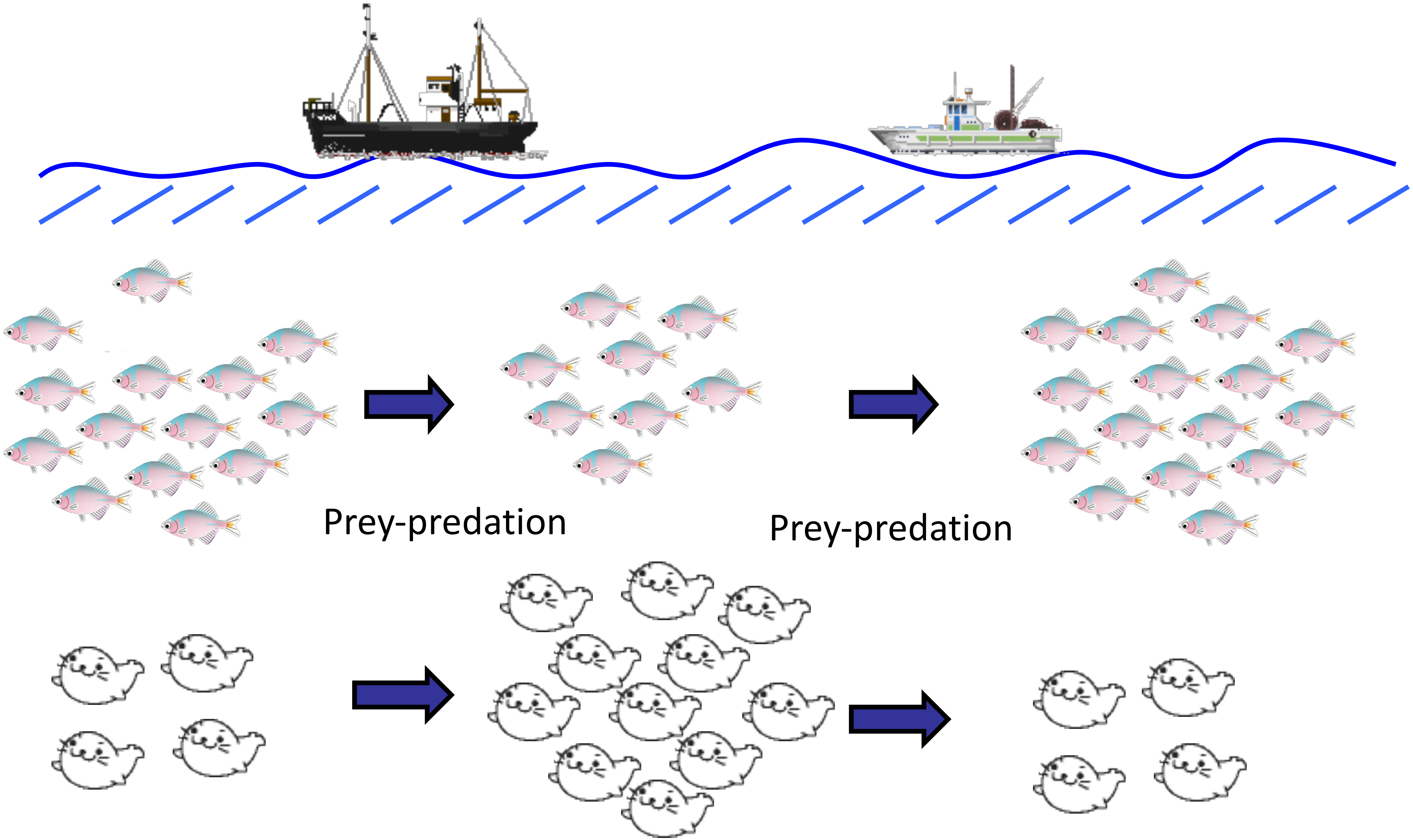
Fishery management



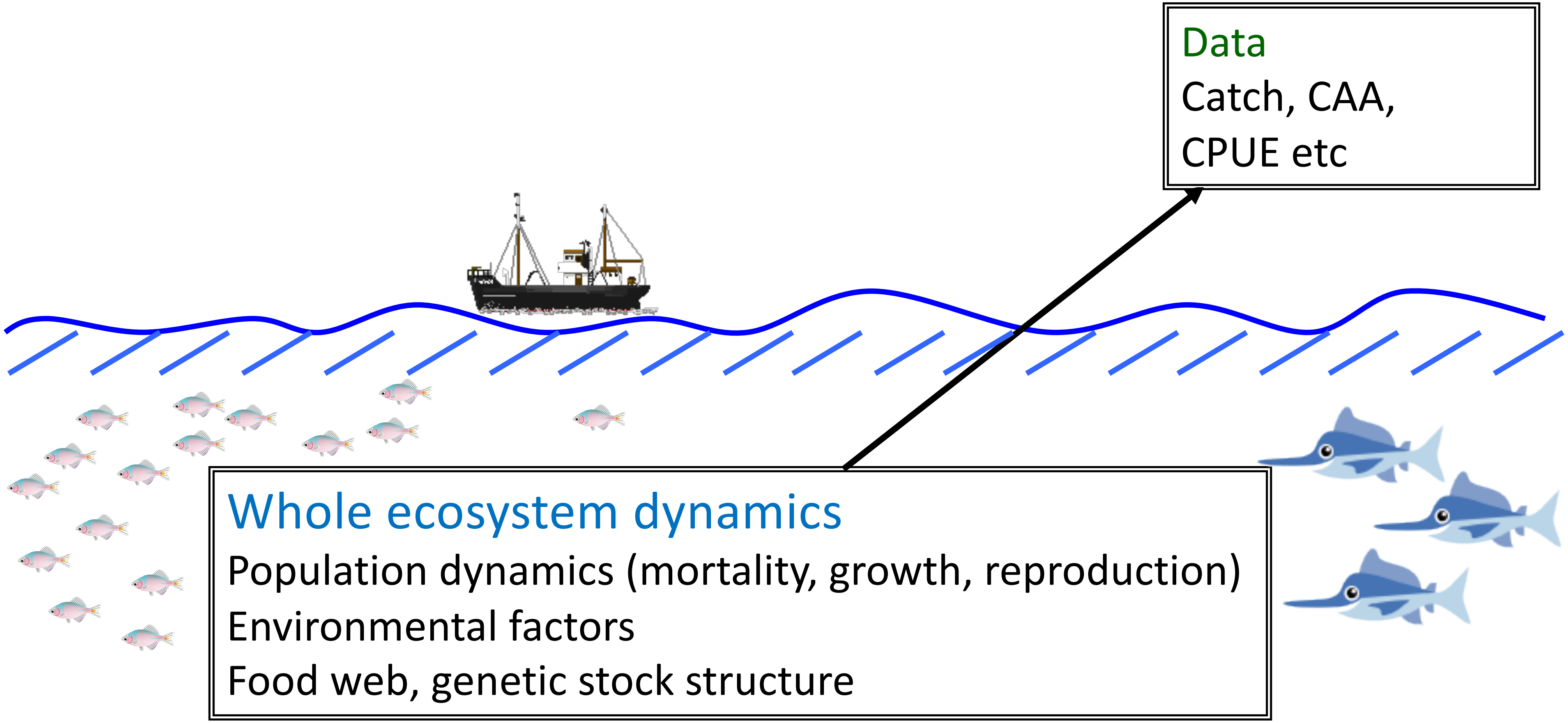
Fishery management



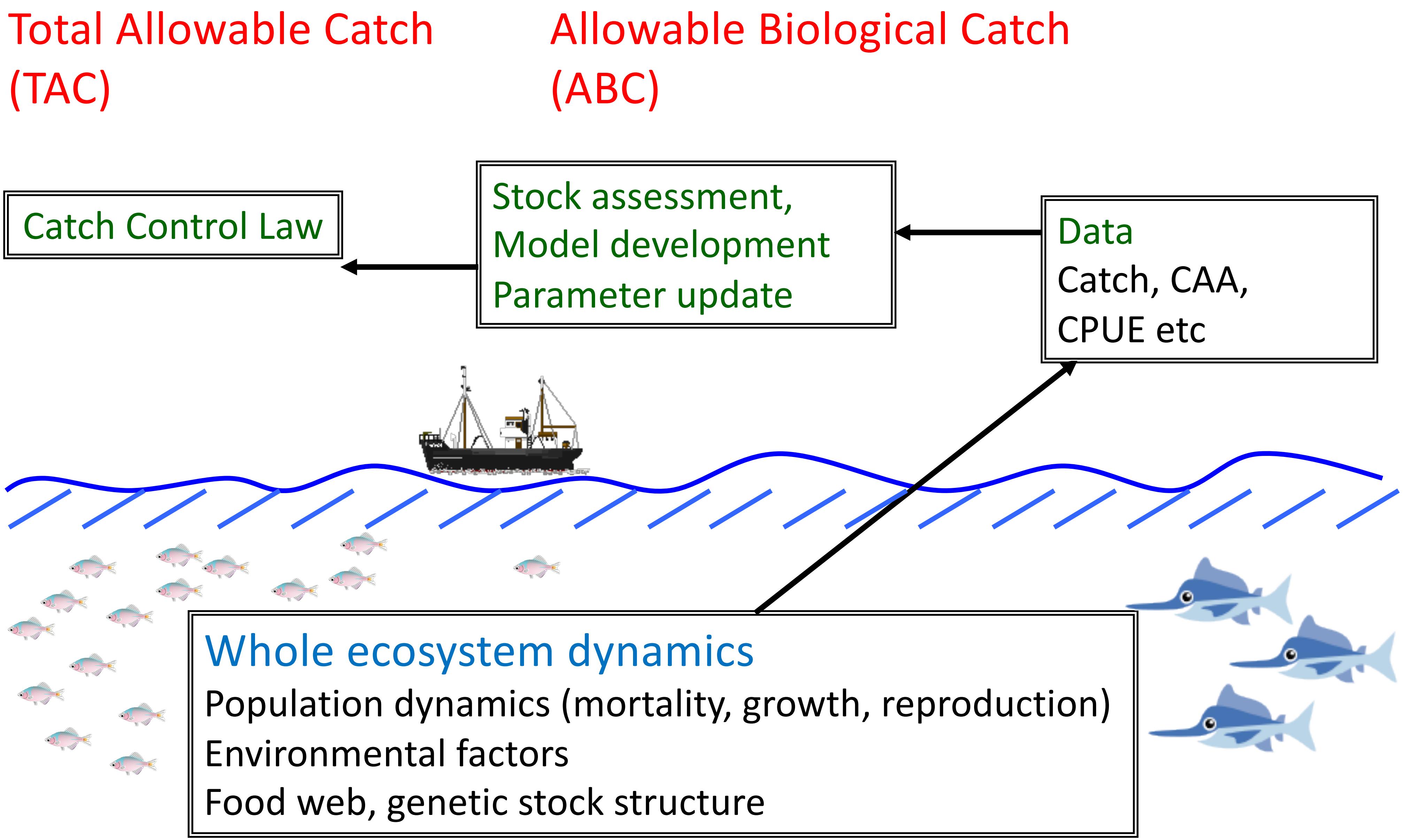
Fishery management



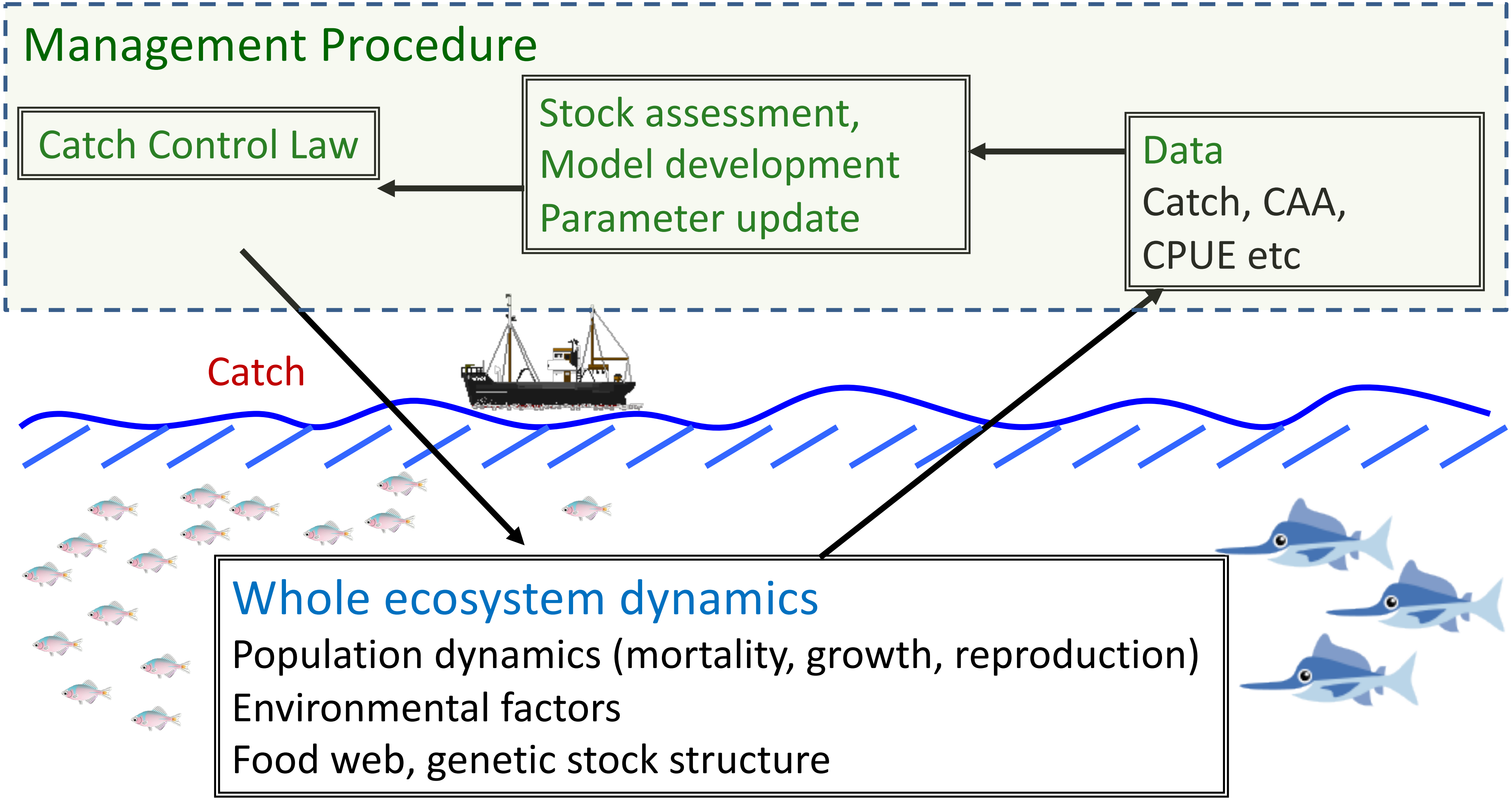
Fishery management

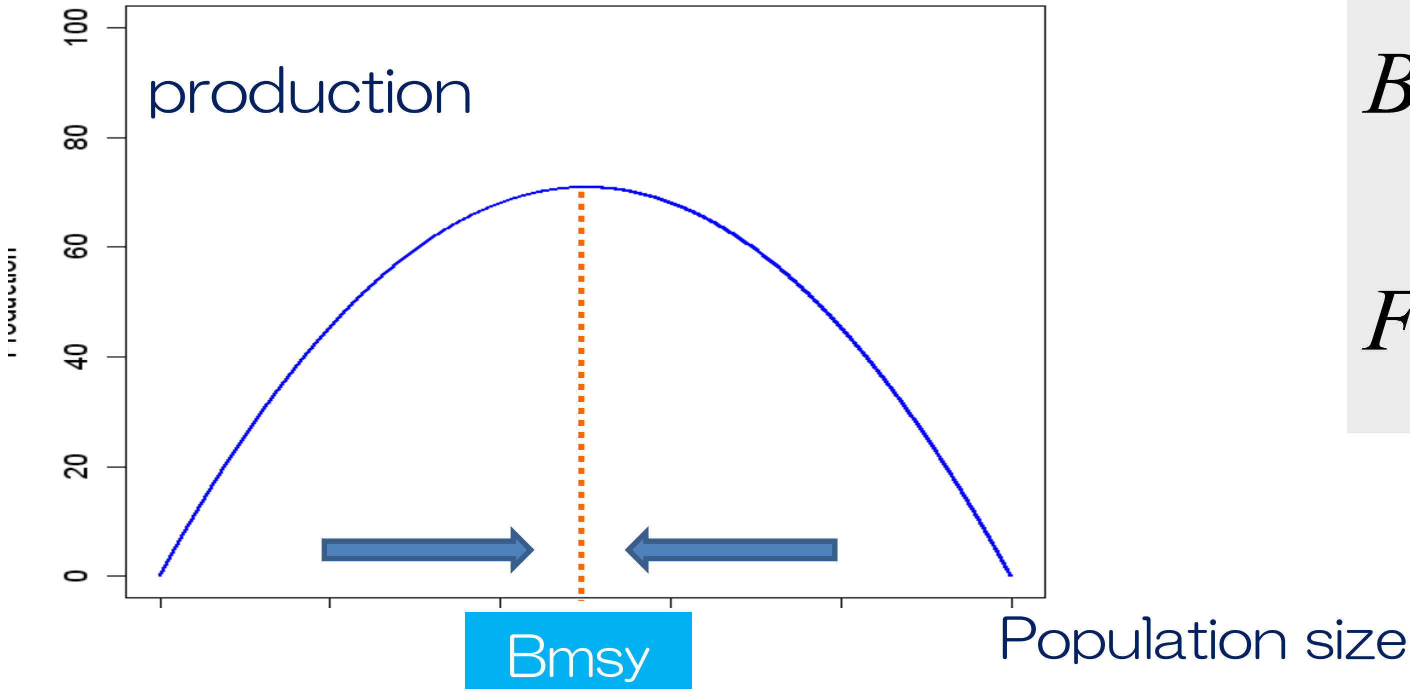


Fishery management



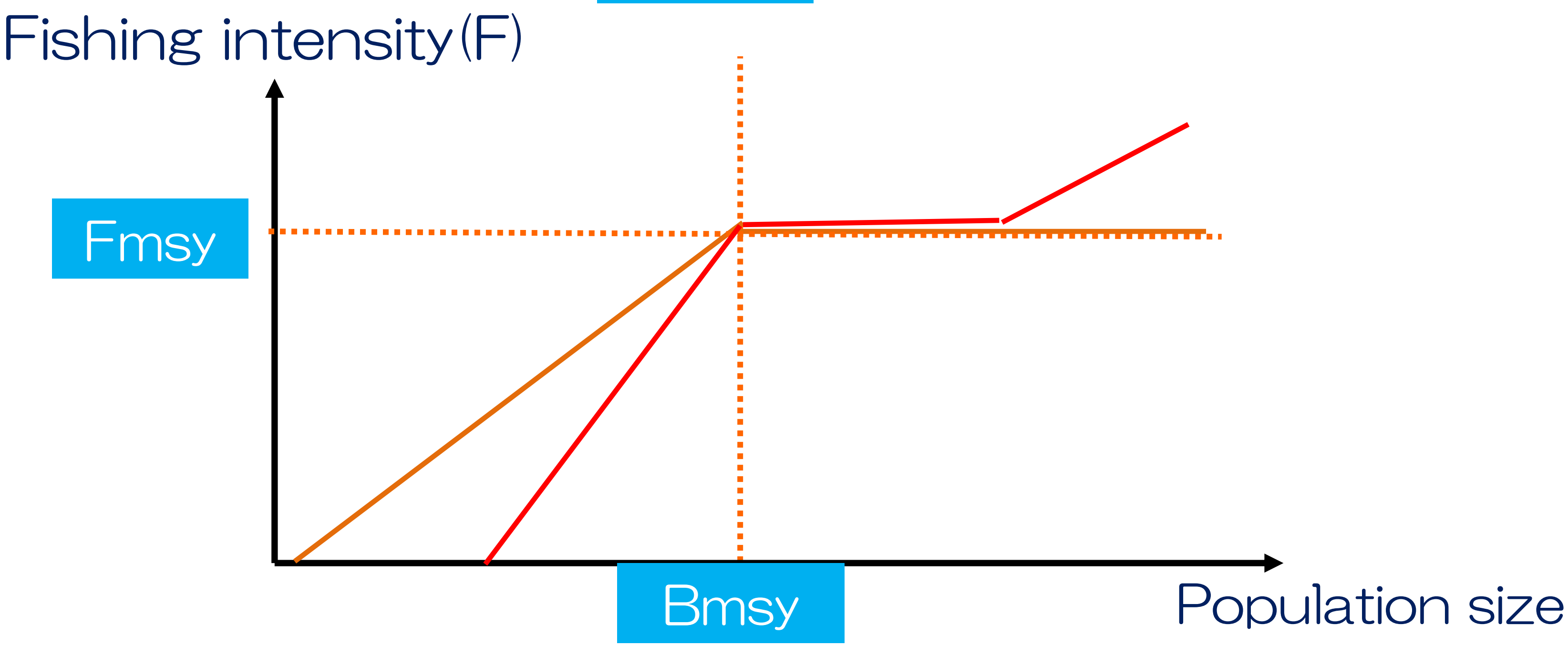
Fishery management



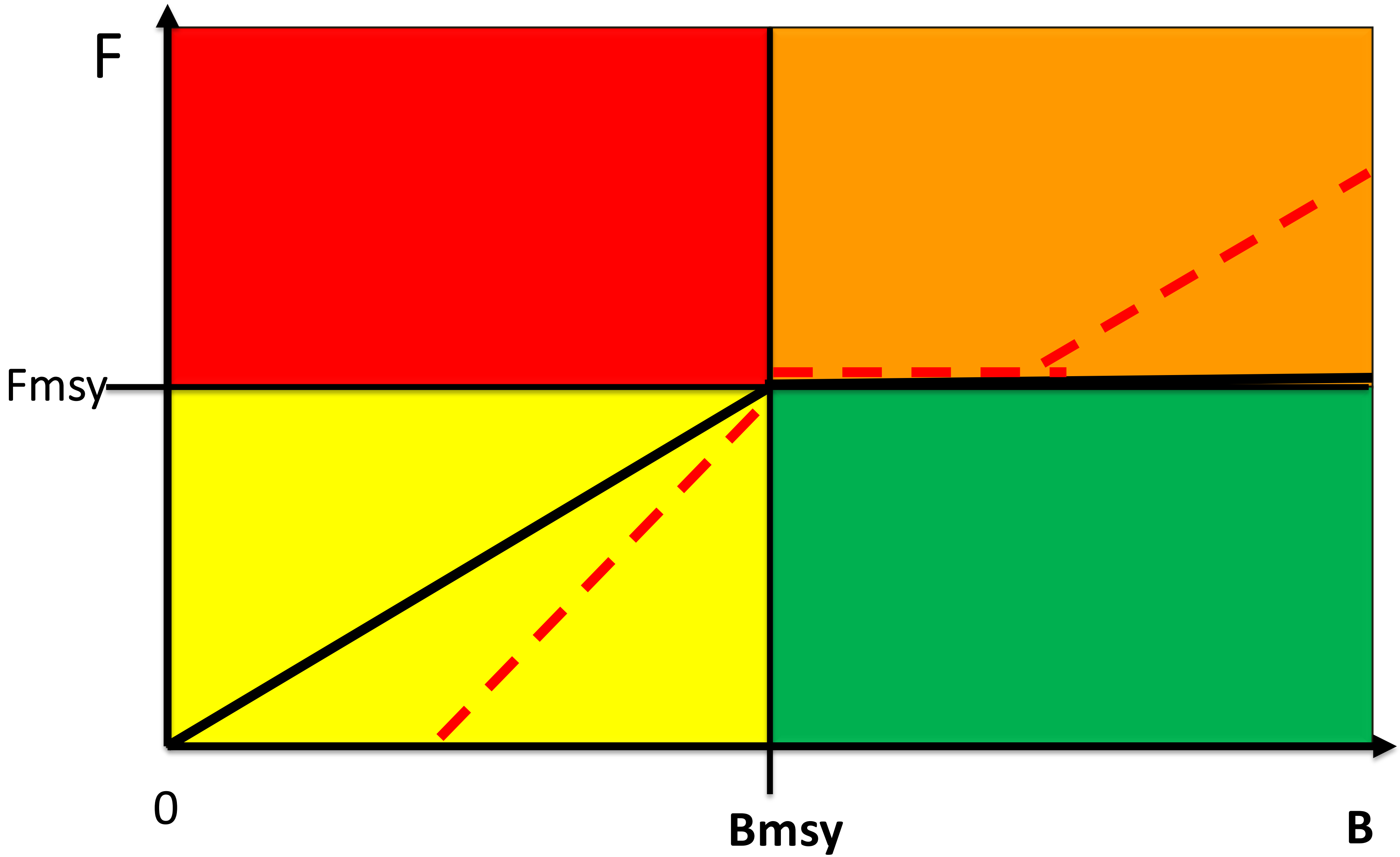


$$Bmsy = \frac{K}{2}$$

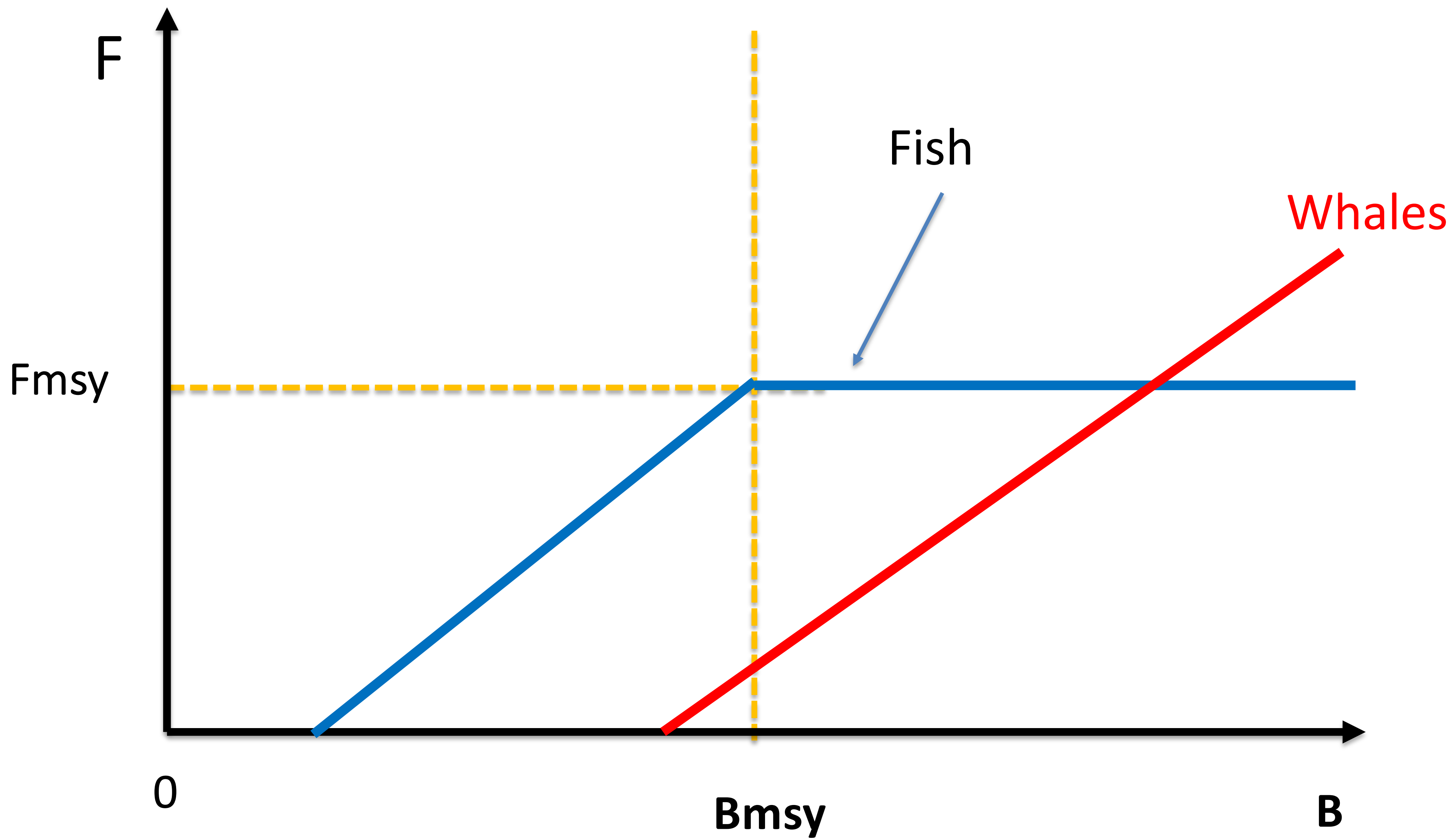
$$Fmsy = \frac{r}{2}$$



Kobe plot上に管理方式を上書きすると

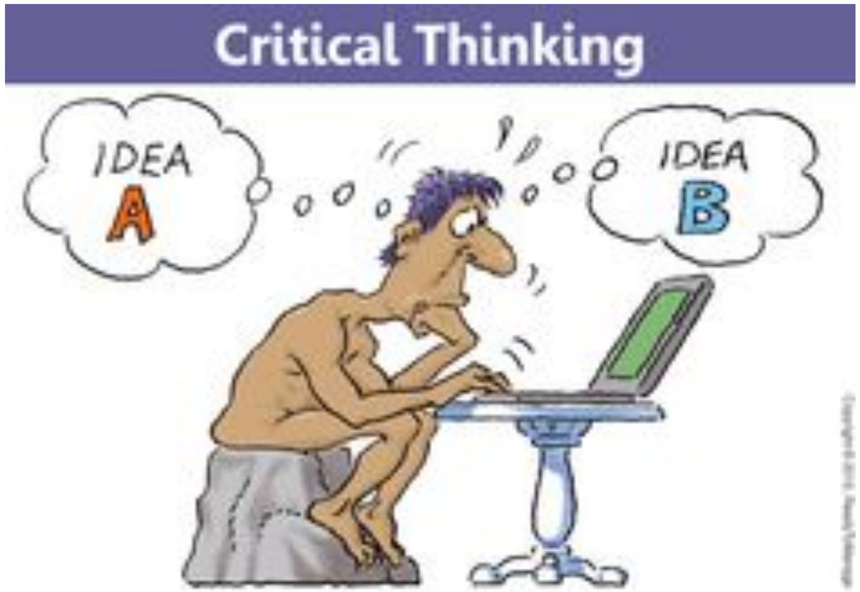


Catch Limit Algorithm (CLA) for management of whales



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



Why MSE ?

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

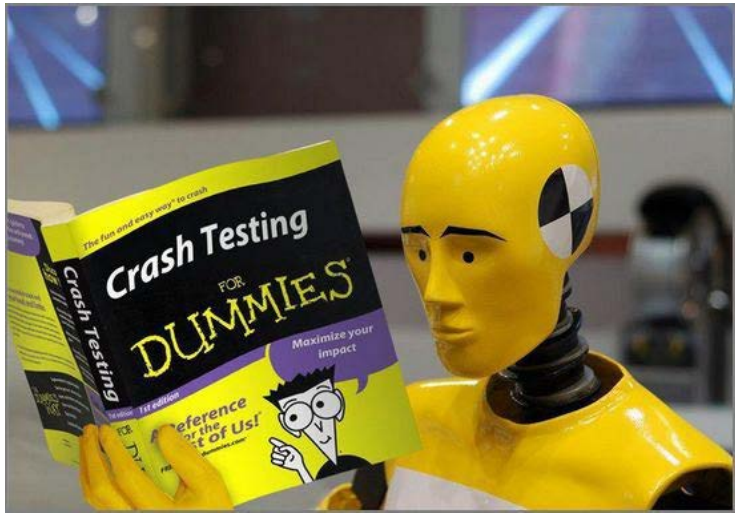
→ **you need predetermined goals/objectives**

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!

What is MSE ?

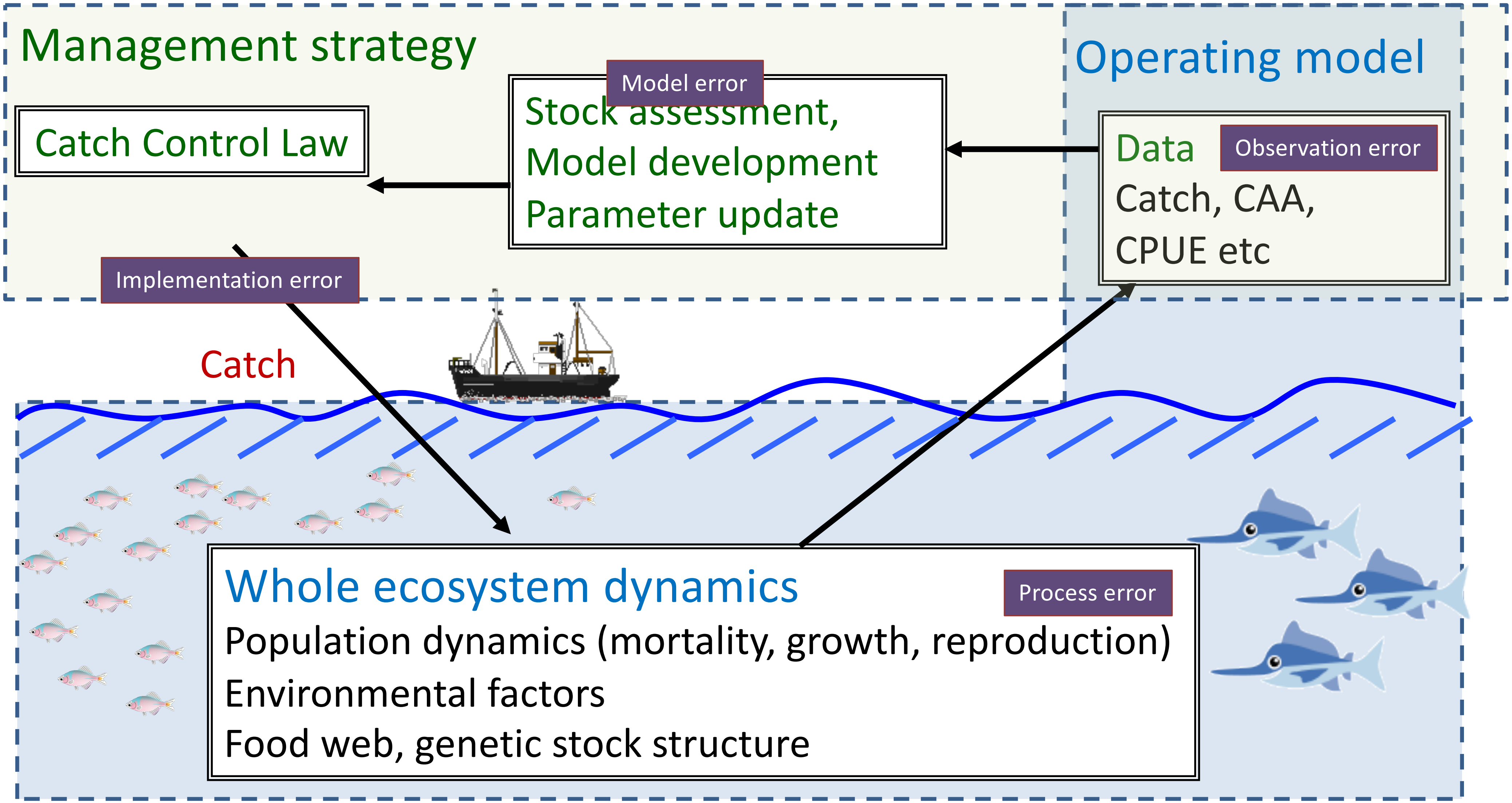
- A simulation framework for assessing the performance of management procedures
- A pioneer work: IWC/SC's RMP
- Since then, the idea has been used and developed for lots of species (not only fishery resources but also terrestrial animals)
- The questions are: if goals/objectives are achieved or not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

What is MSE ?

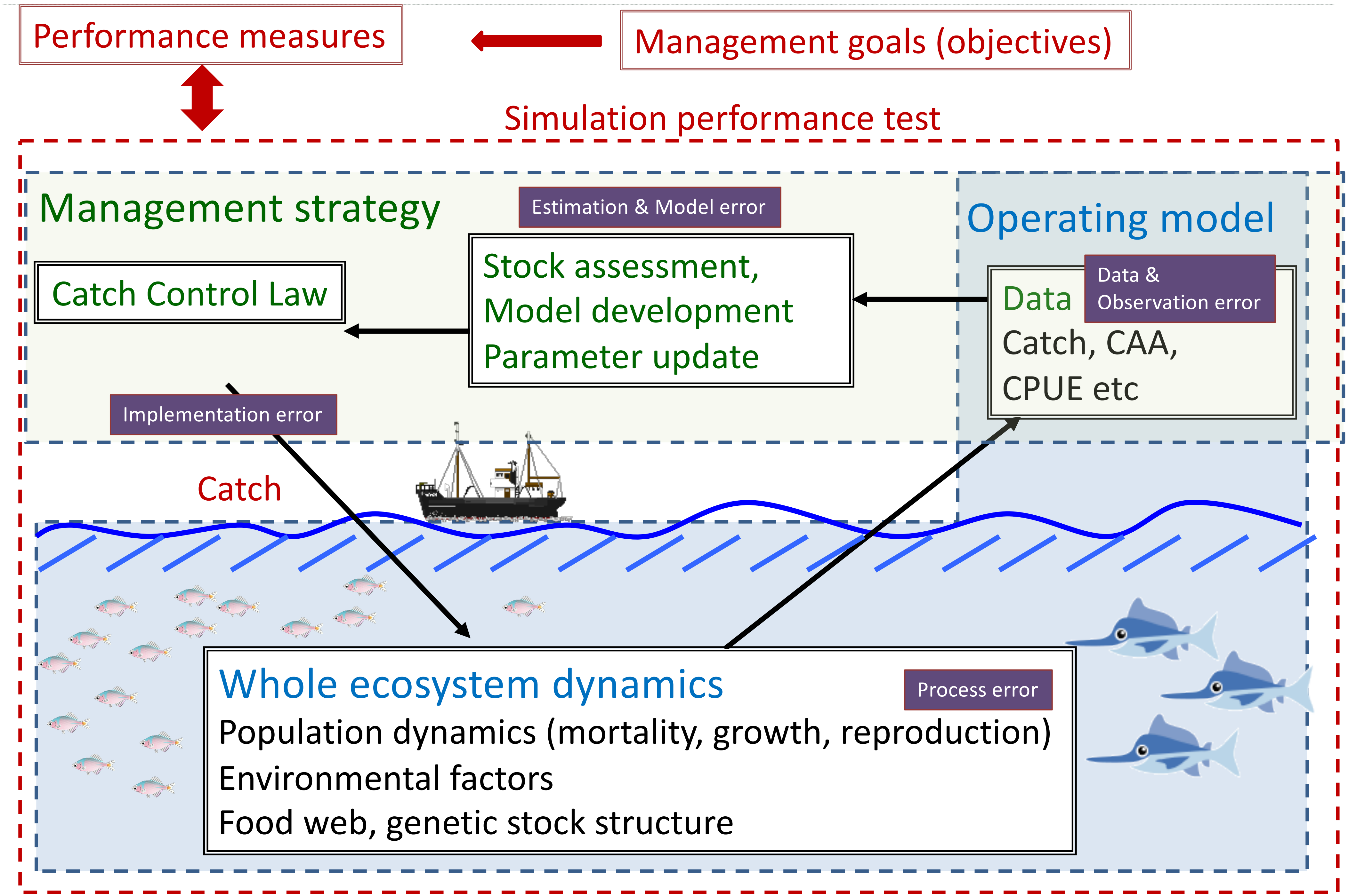
- Possible to handle various types of uncertainty
  (e.g. Francis & Shotton 1997)
  - Uncertainty in data and input parameters
  - Process uncertainty (e.g. process errors, environmental)
  - Estimation uncertainty (estimation error, SE, CV)
  - Model uncertainty
  - Implementation uncertainty
- Possible to test adaptive management procedures
- 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

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.



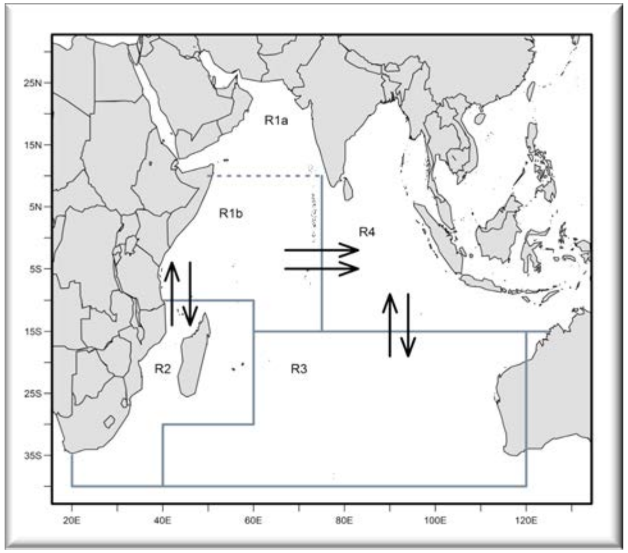
Management Strategy Evaluation (MSE)



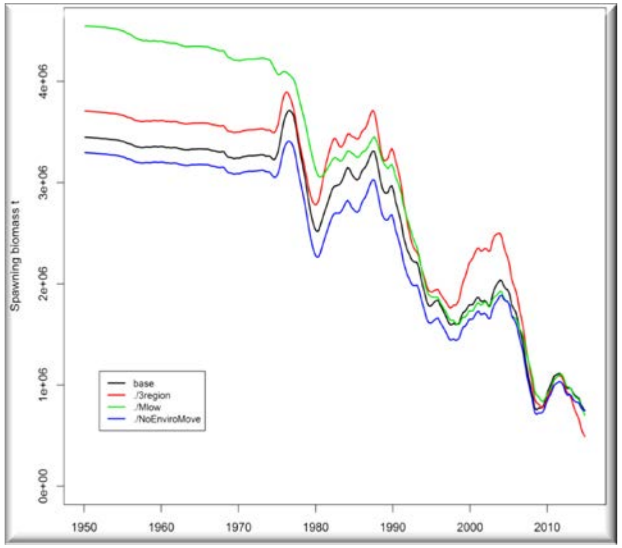
Operating Models (OMs)

Usually based on existing stock-assessment with

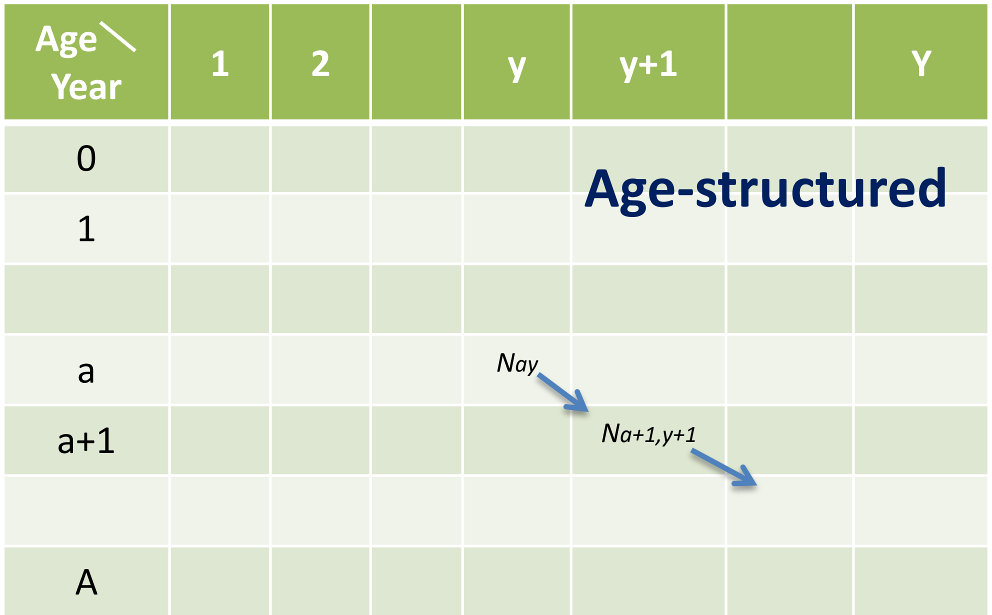
- Best-available information
- Plausible range of biological ecological parameters

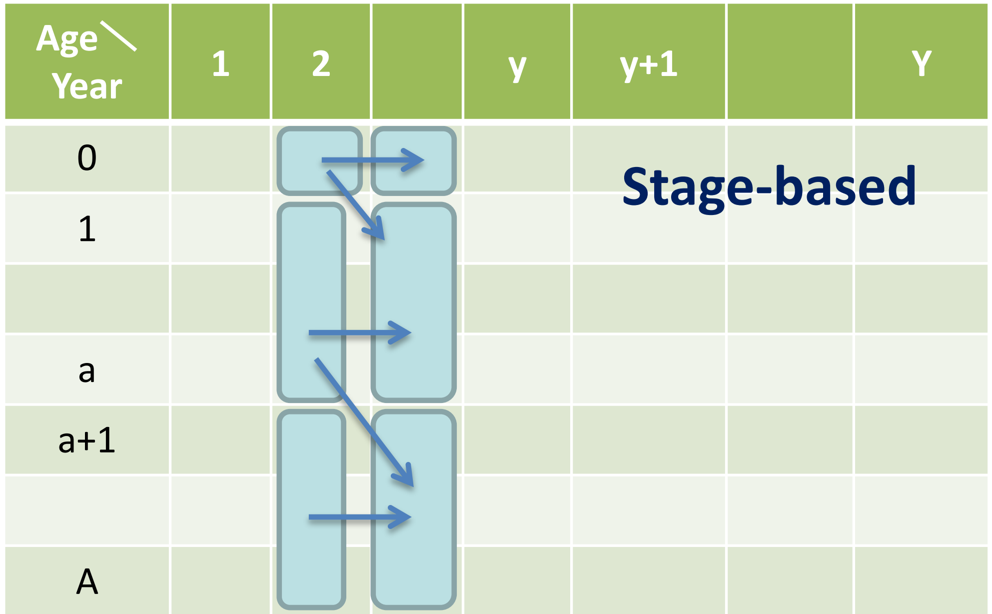


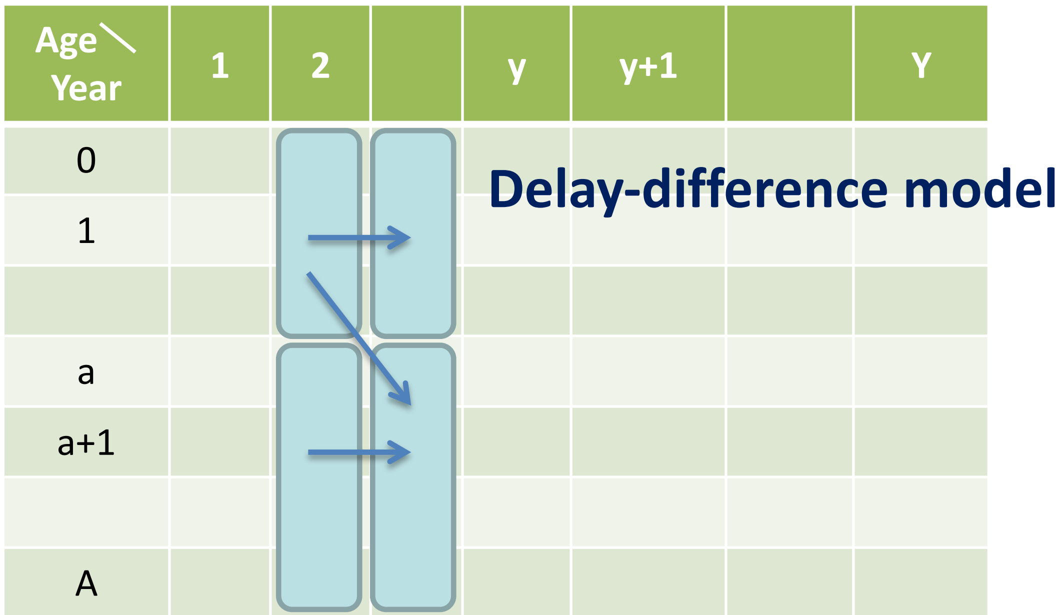
- As virtual reality
- Uncertainty with respect to
  - data
  - parameters
  - models
  - estimation
  - stochastic process in population
  - implementation

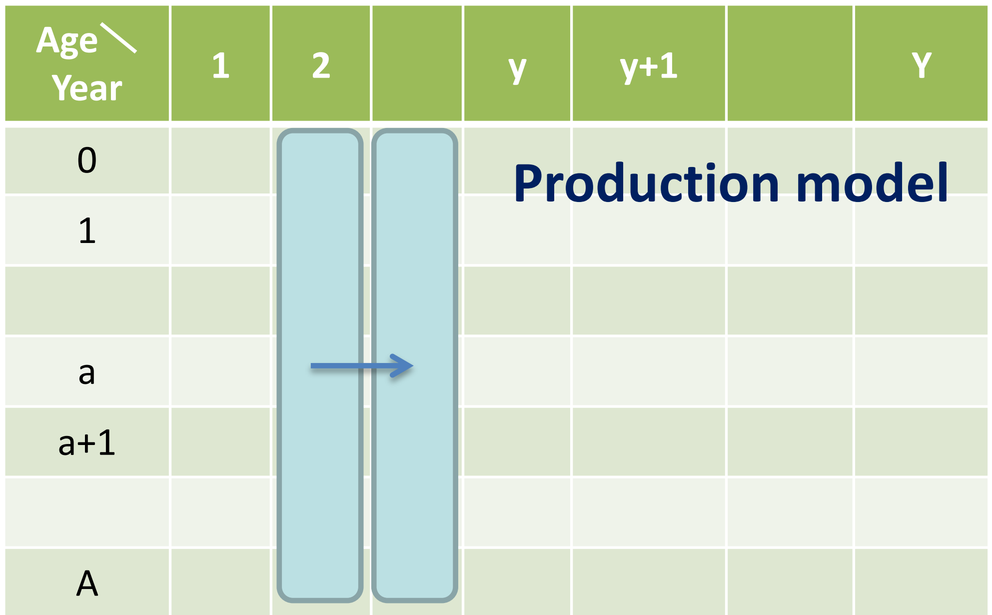


Possible range of stock assessment models









Management Procedures (MPs)

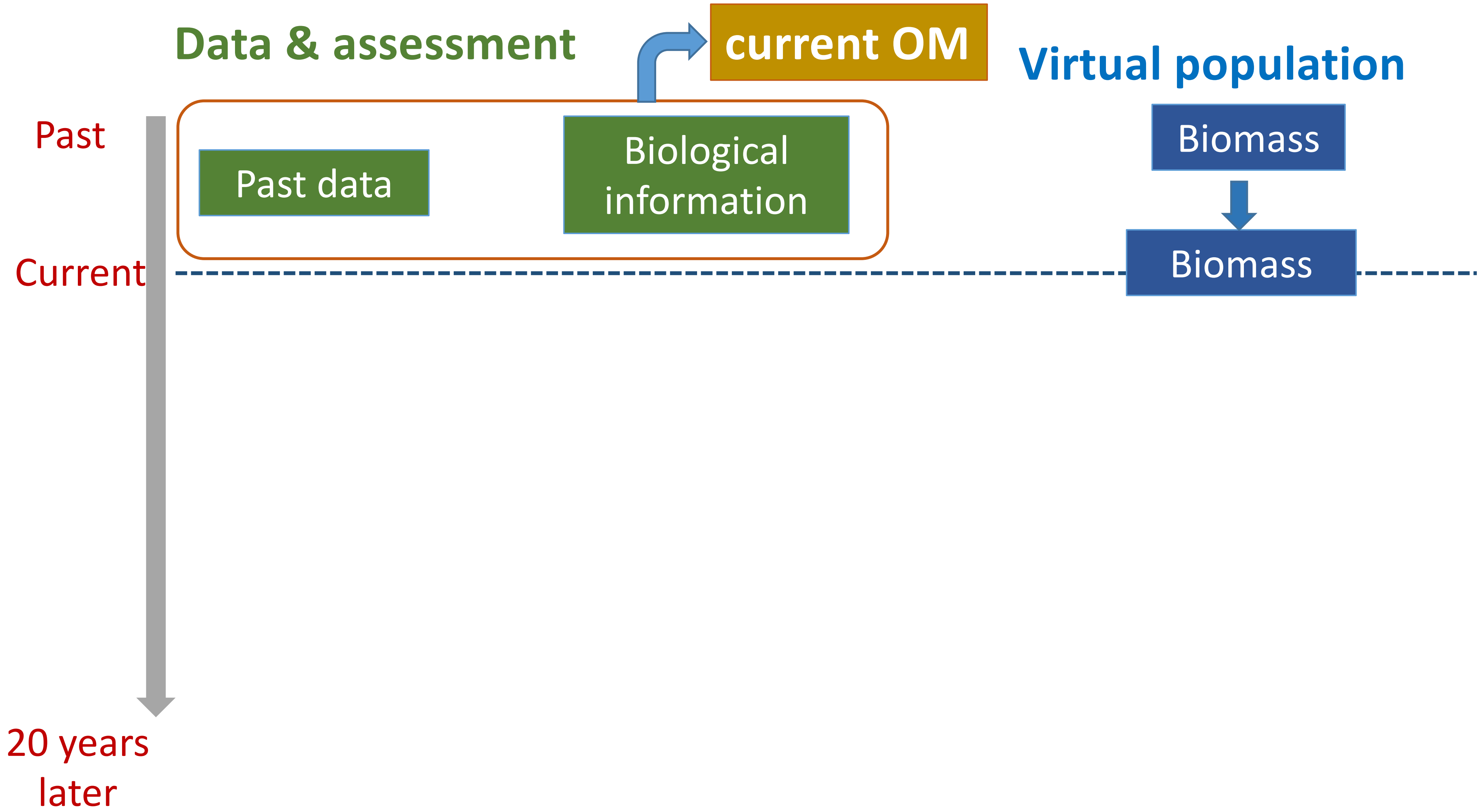
MPs including HCRs

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

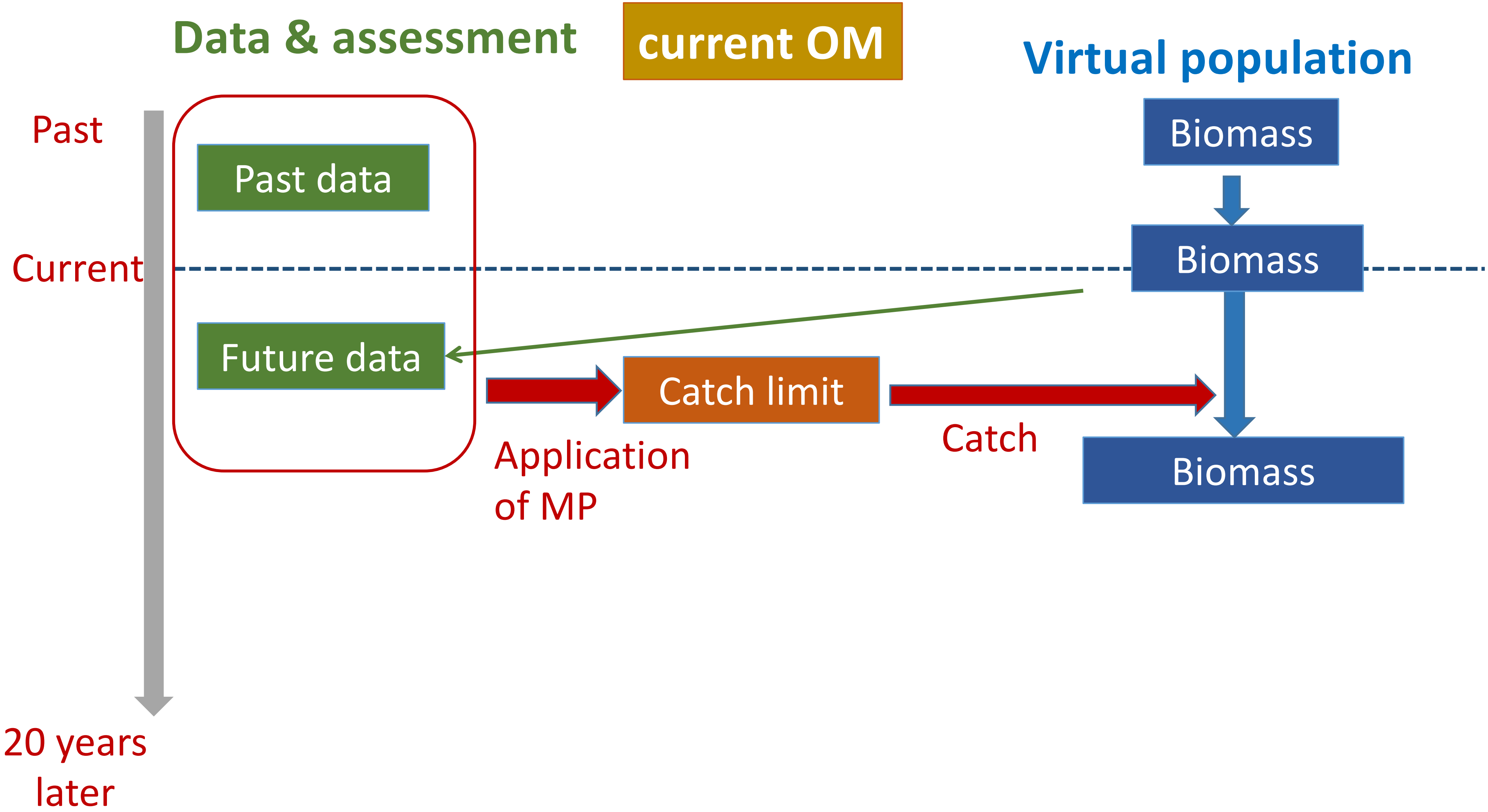
Note: Any MPs do not know the reality of OMs !!

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

Update of MPs



Update of MPs

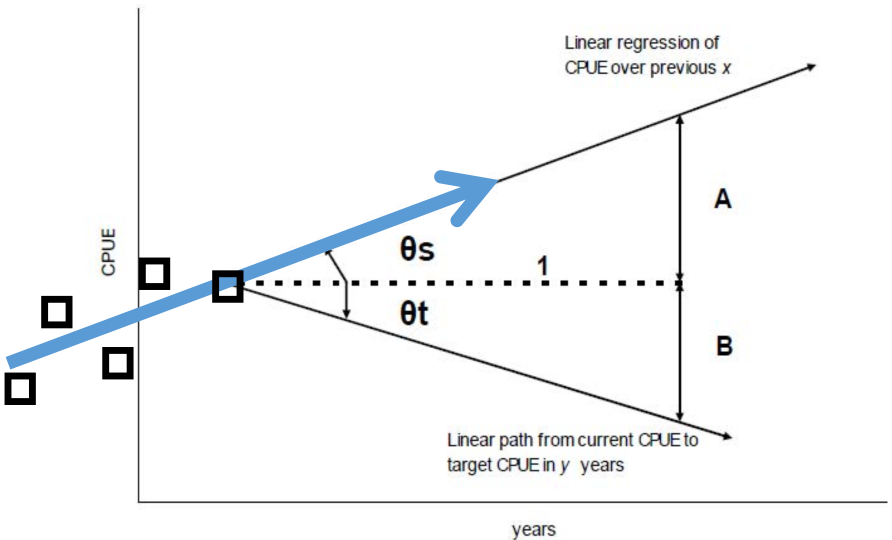


Currently two types of MPs

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

1) Empirical MP:

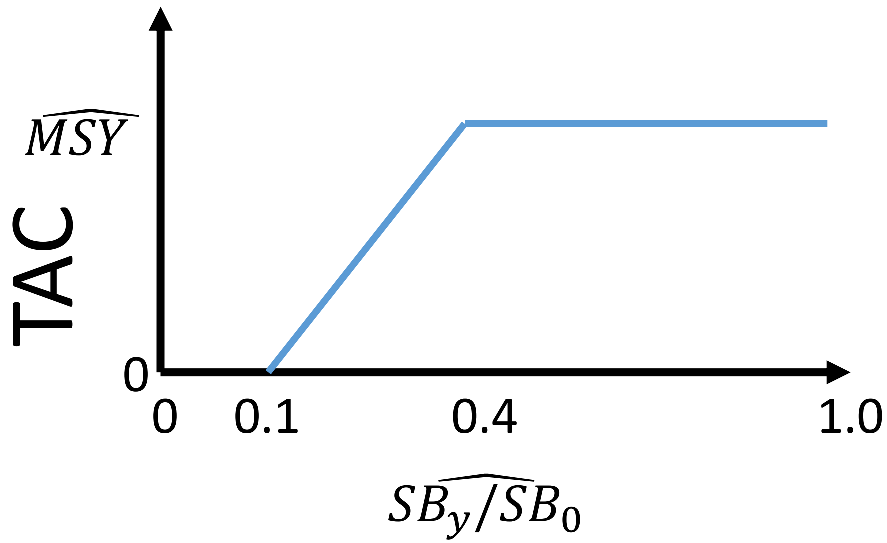
Aims to keep the stock near a target CPUE



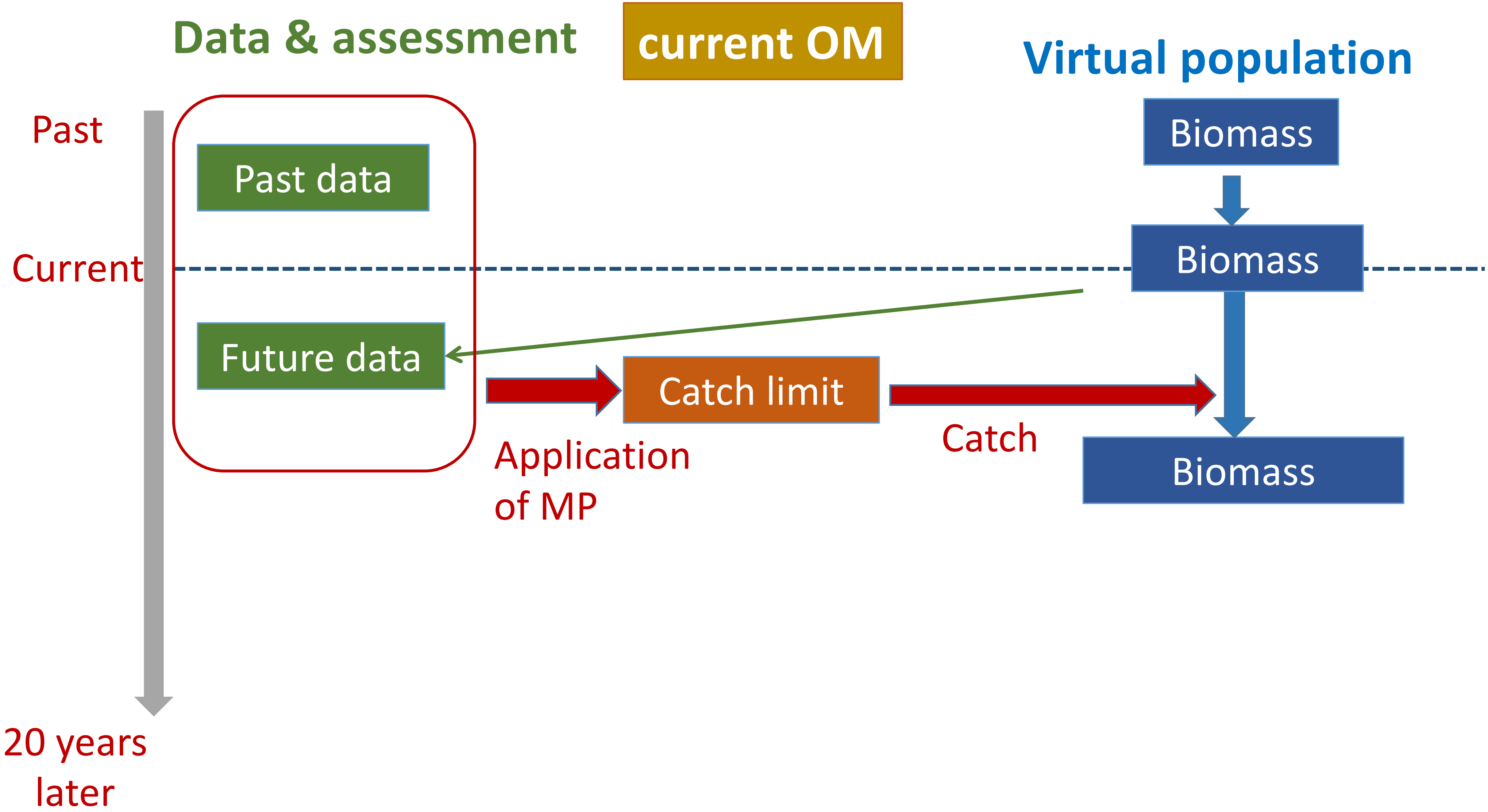
CPUE<Target
TAC decrease

2) Model-based MP:

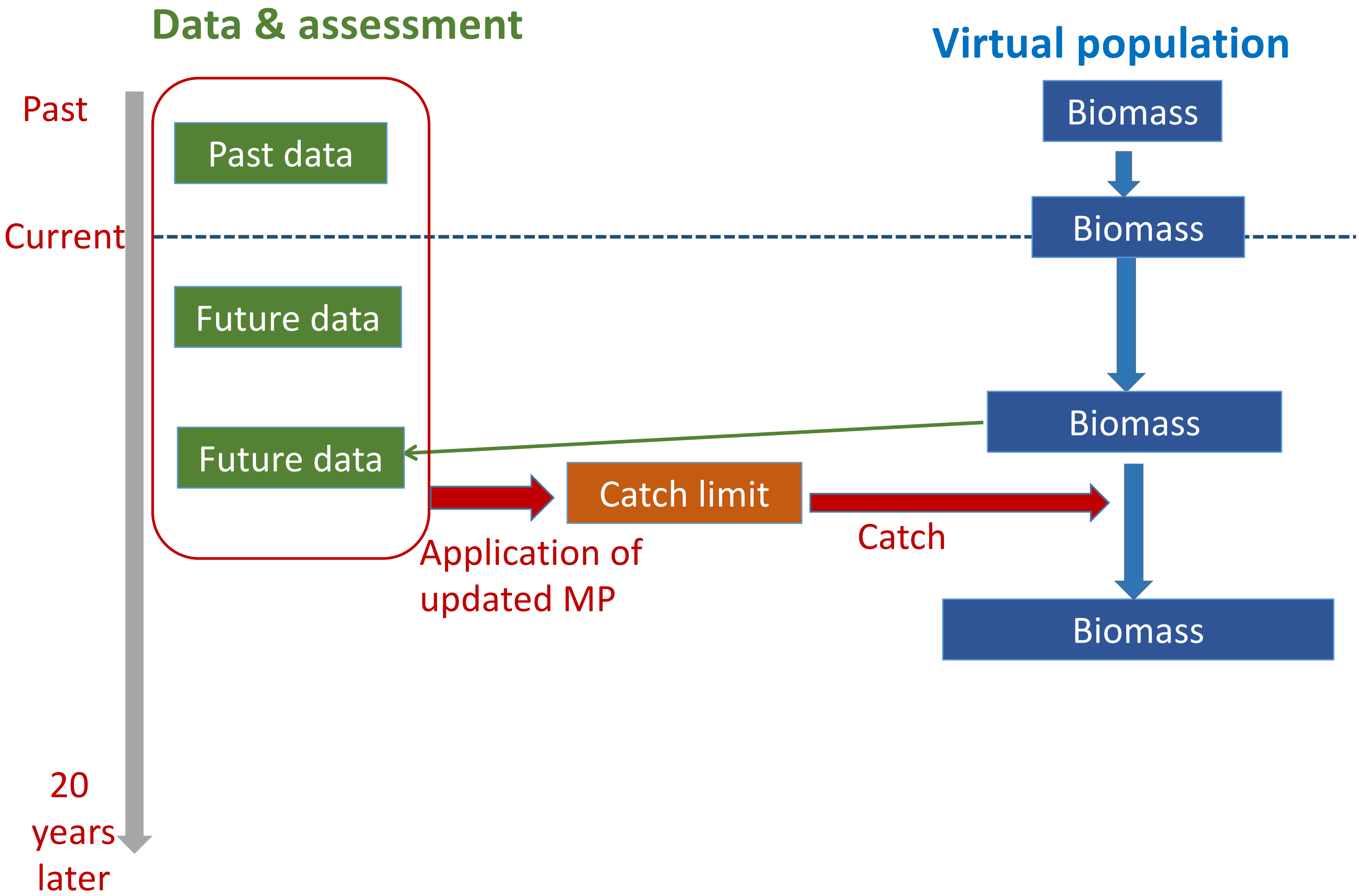
- Fits a Pella-Tomlinson surplus production model,
- Set the TAC using a 40:10-type HCR



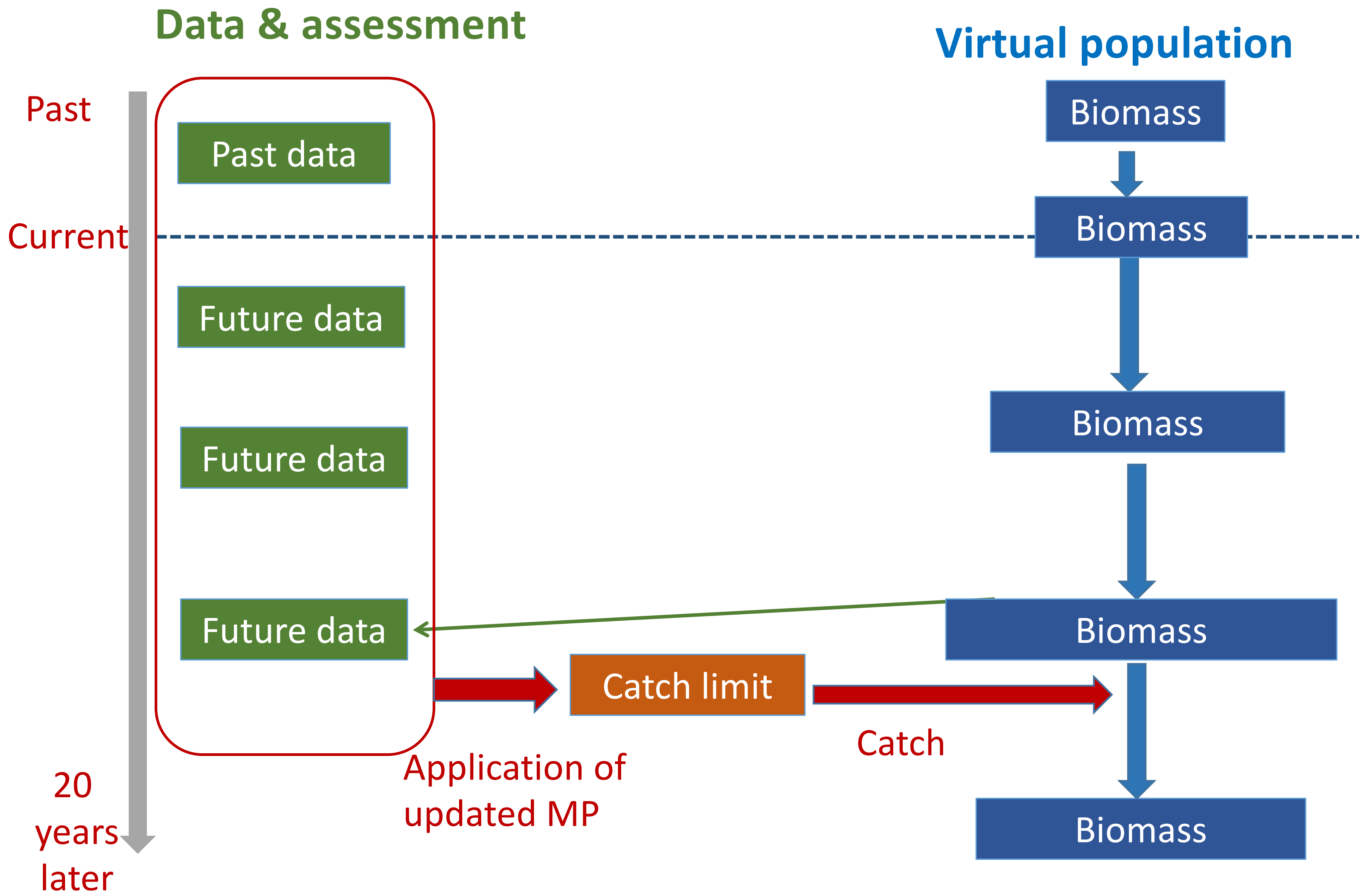
Update of MPs

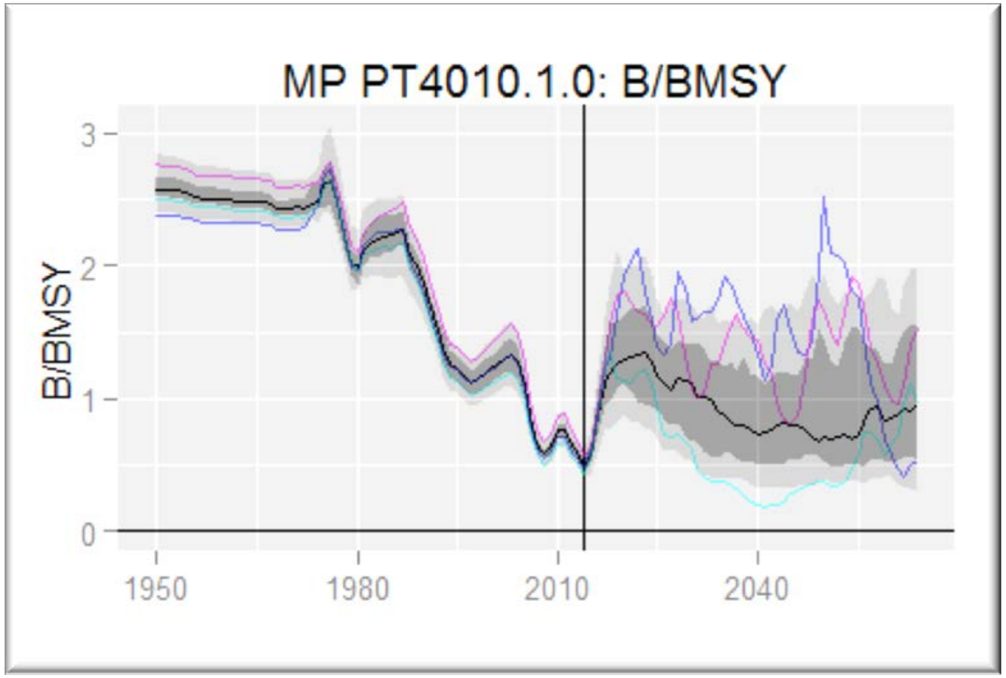


Update of MPs

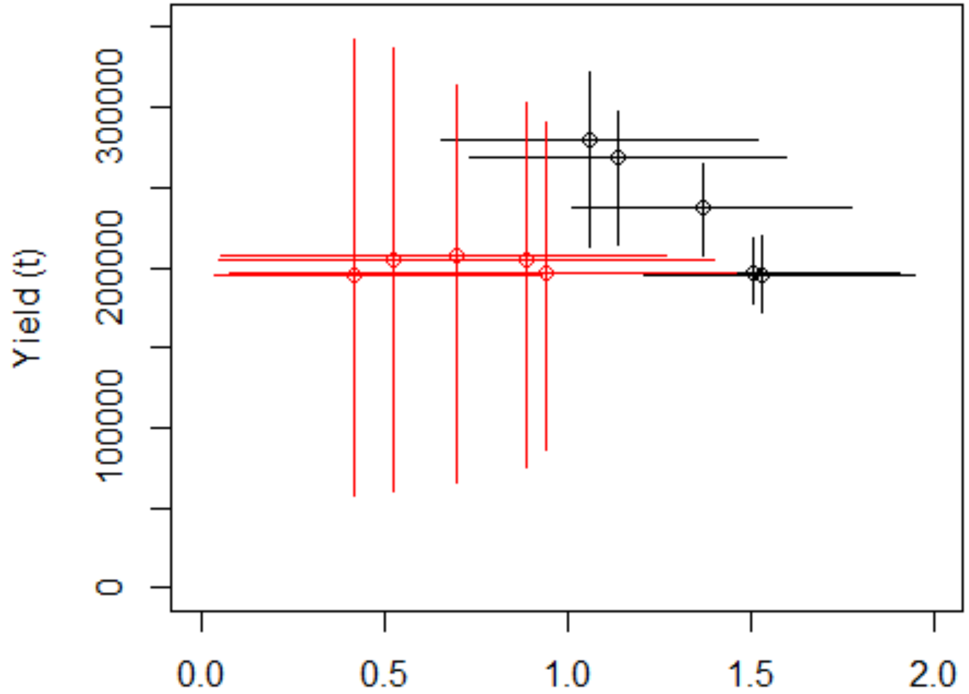


Update of MPs

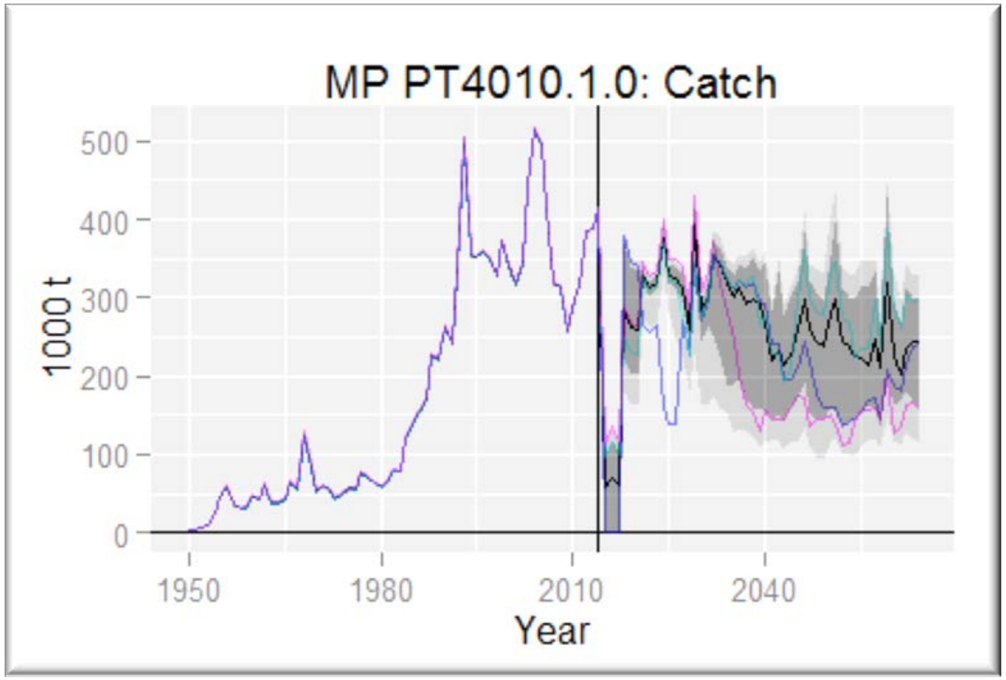




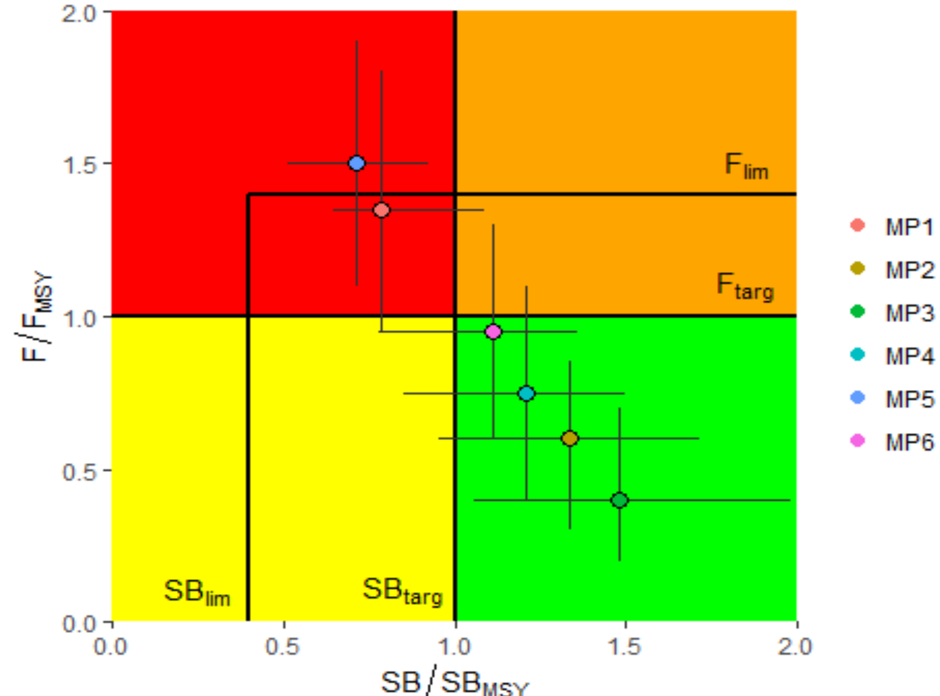
MP PT4010.1.0: B/BMSY
B/BMSY
0
1
2
3
1950
1980
2010
2040



Yield (t)
0
100000
200000
300000
0.0
0.5
1.0
1.5
2.0



MP PT4010.1.0: Catch
1000 t
0
100
200
300
400
500
1950
1980
2010
2040
Year



F/F_{MSY}
SB/SB_{MSY}
0.0
0.5
1.0
1.5
2.0
F_{lim}
F_{targ}
SB_{lim}
SB_{targ}
MP1
MP2
MP3
MP4
MP5
MP6

Management Strategy Evaluation

Simulation testing to

- *Develop management procedure strategy for a particular fishery*
- *Evaluate generic management procedure*
- *Identify management procedures that will not work and should therefore be eliminated from further consideration*
- *Evaluate benefits of additional data collection.*

Key Note: The aim is to find **management procedure** through Simulation Testing that are **<u>robust to major uncertainty</u>** (rather than strategies that are optimal if a particular scenario is true)

Management Procedure: the combination of pre-defined data, together with an algorithm to which such data are input to provide a value for a set of implementable management measures.

Management Strategy Evaluation

- MSE …. what are we *evaluating*?

"Simulated reality"
Operating Model

Management Strategy Evaluation

- MSE …. what are we *evaluating*?

"Simulated reality"
Operating Model

Management Procedure

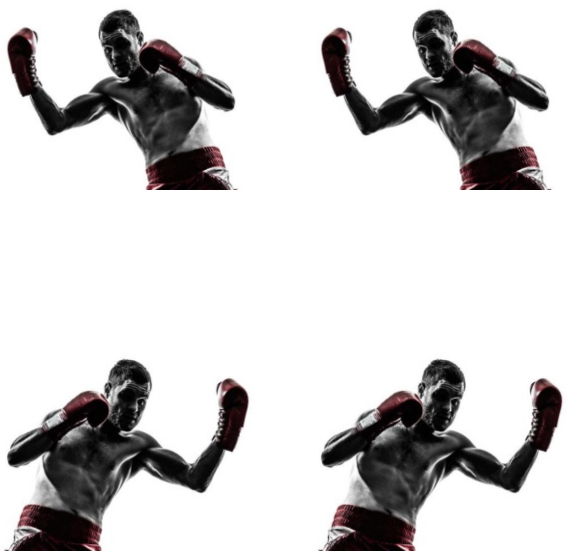
- MSE …. what are we *evaluating*?

But WHAT IF?

"Simulated reality"
Operating Model

Management Strategy Evaluation

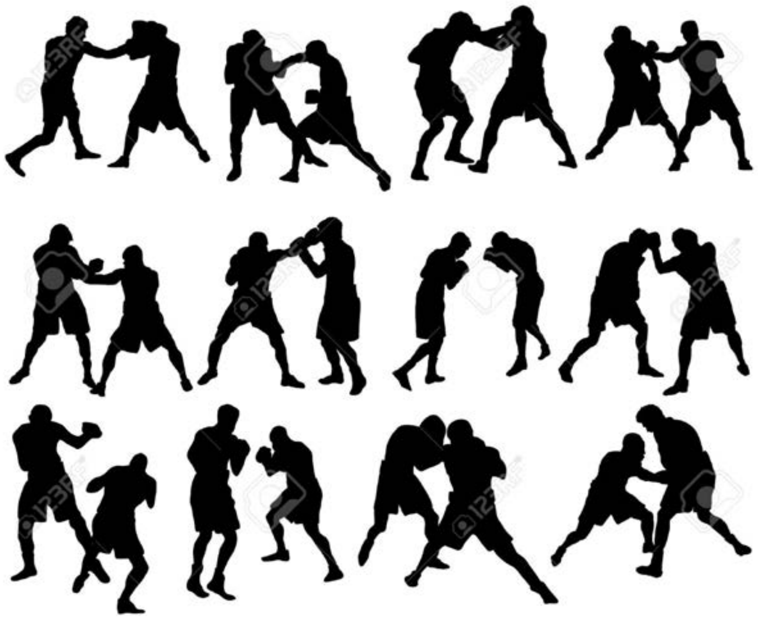
- MSE …. what are we *evaluating*?



“Simulated reality”
Operating Model

But WHAT IF?

- MSE …. what are we ***evaluating***?

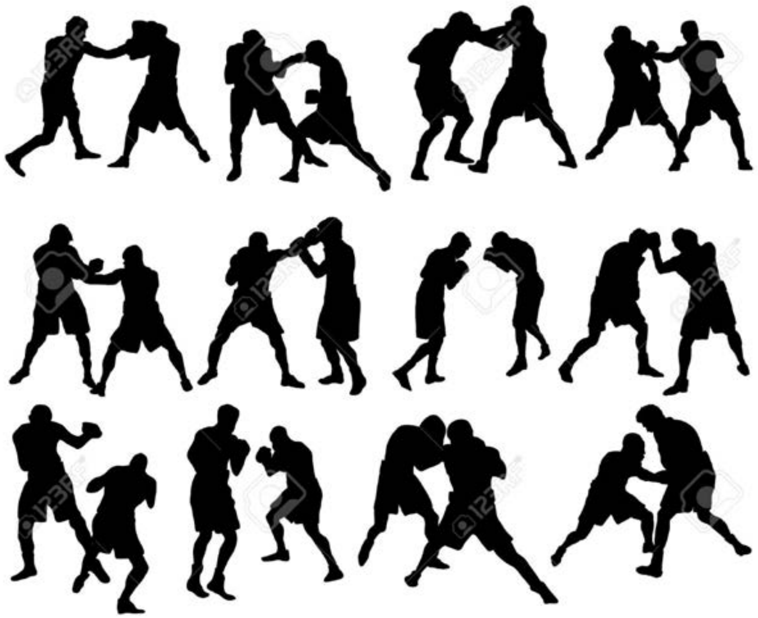


But WHAT IF?

"Simulated reality"
Operating Model

Management Strategy Evaluation

- MSE …. what are we ***evaluating***?



“Simulated reality”
Operating Model

Management Procedure

The aim is to find a **Management Procedure** through Simulation Testing that is **robust to major uncertainty**

Management Strategy Evaluation

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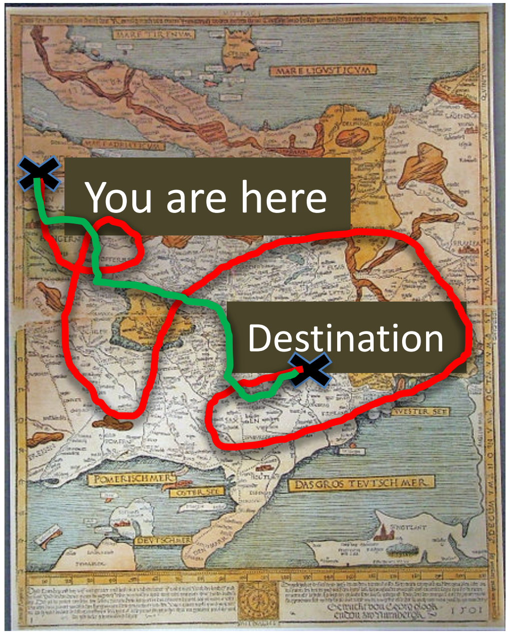
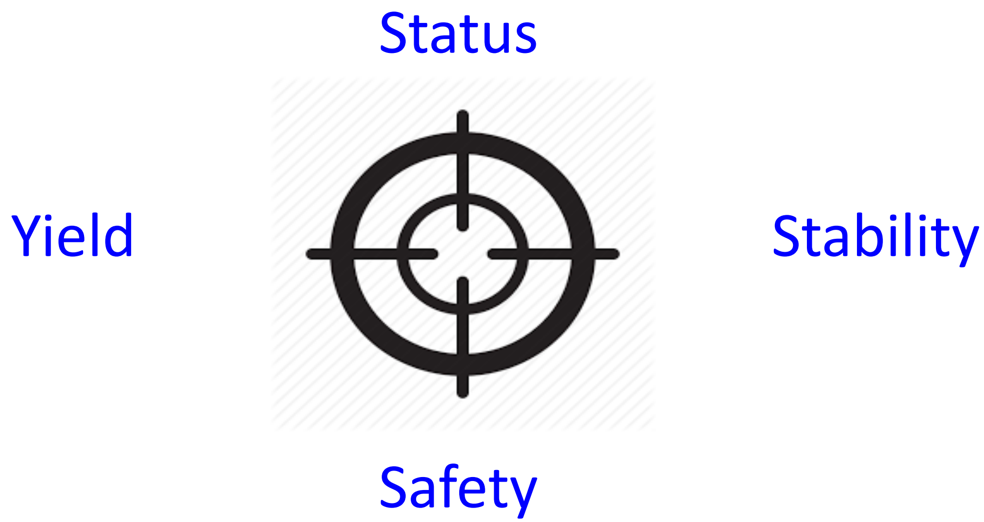
Management Procedure: the combination of pre-defined data, together with an algorithm to which such data are input to provide a value for a set of **implementable management measures**.

“Agreeing the rules of the game before it is played”

Doug Butterworth

Management Procedure





- Stock assessment – where we were and are now
- Management procedure – How/When to get to the target
- MSE – What's "*the best*" way to the target (eg a MP meeting the target and provided most appropriate trade-off results between desired management objectives)

Management Strategy Evaluation
PROCESS

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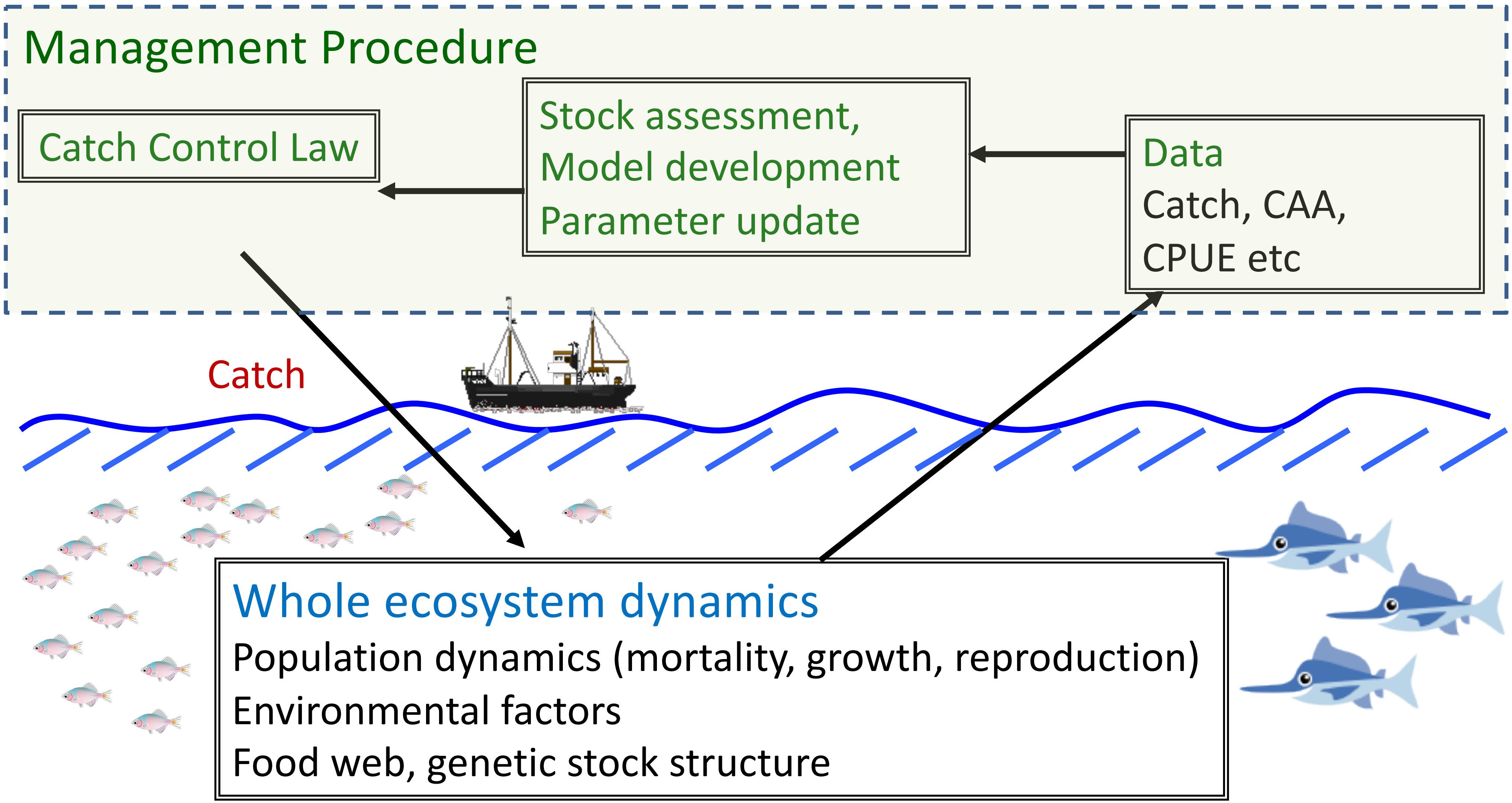
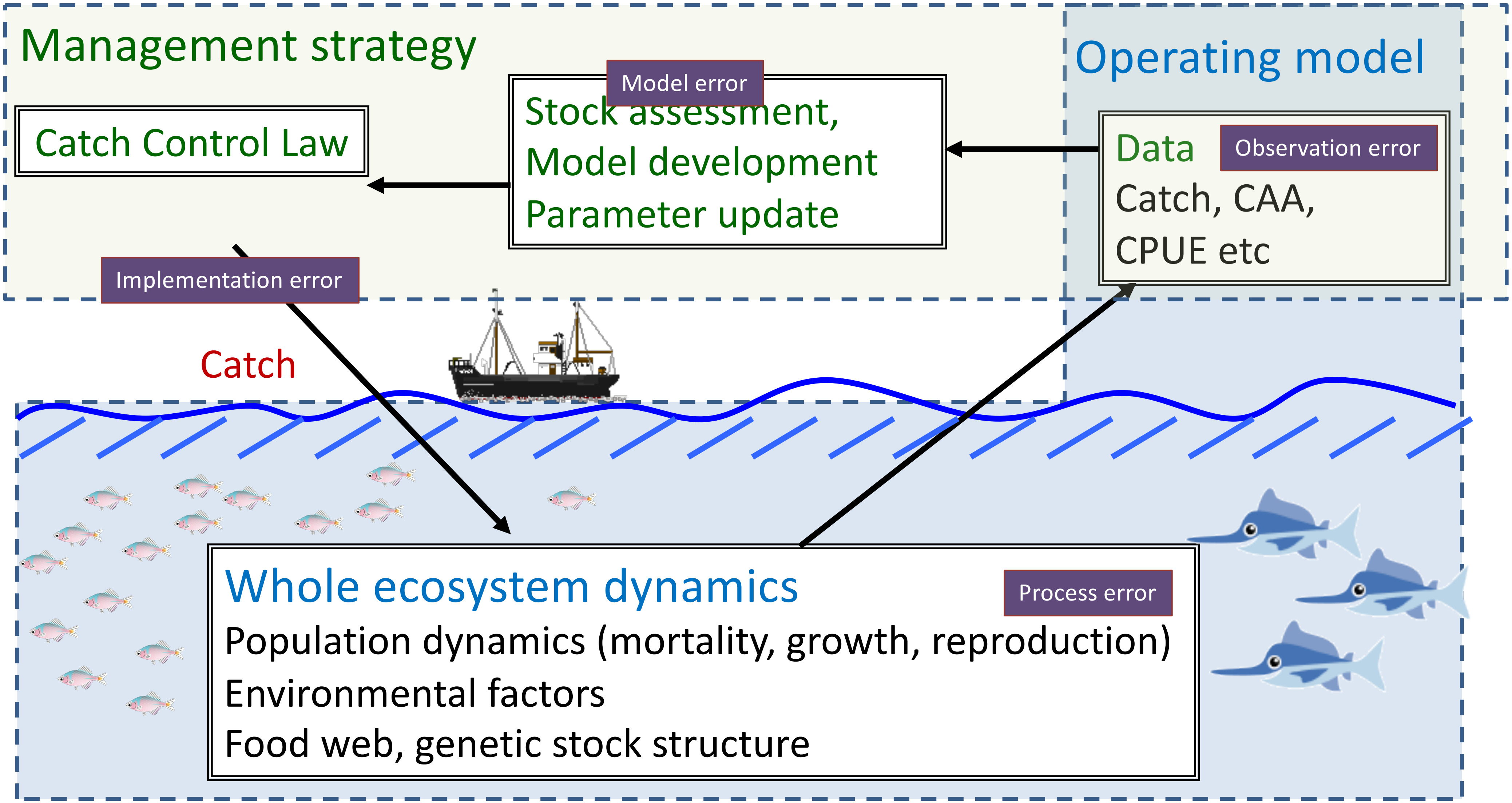
Fishery management



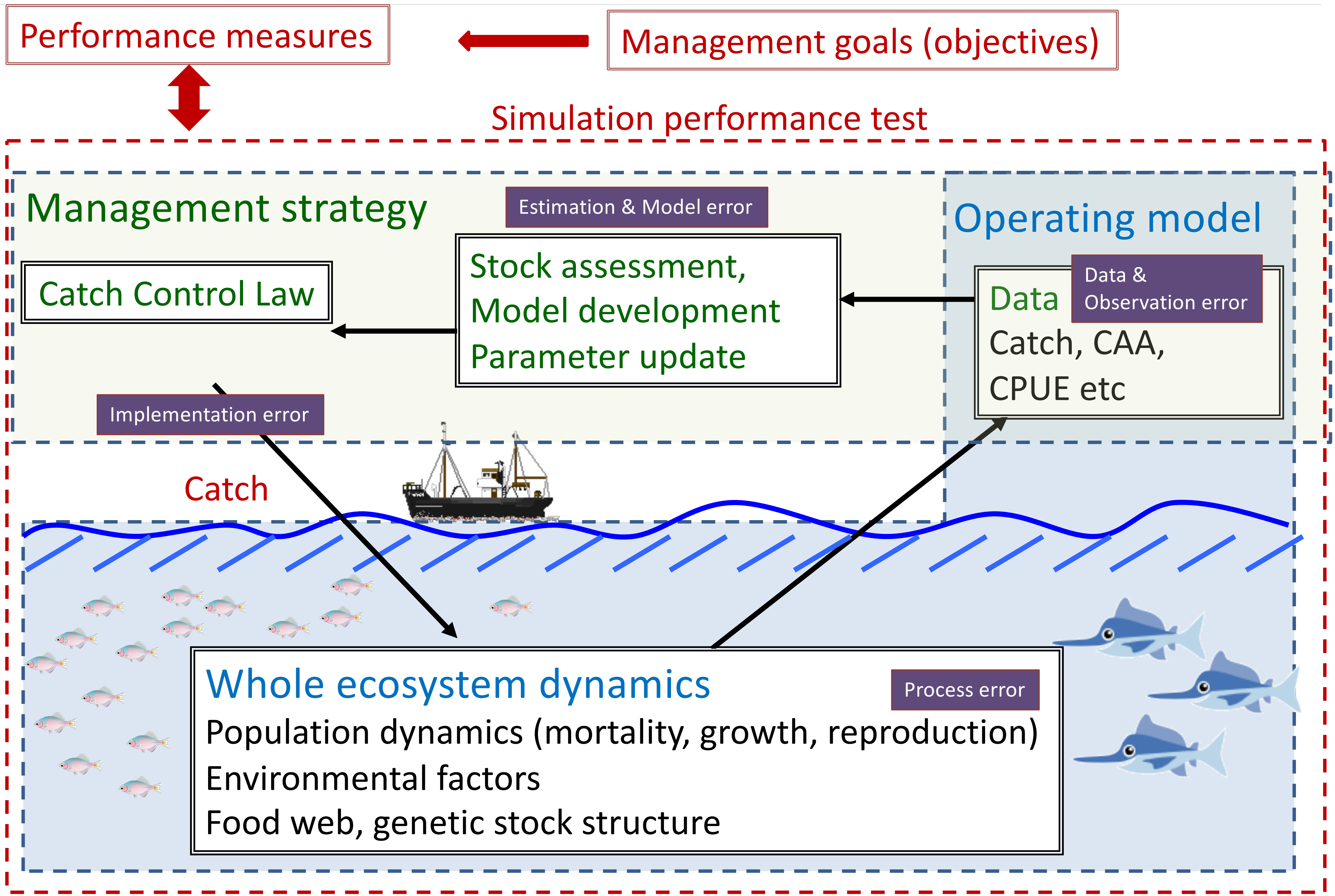
Fishery management

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.



Management Strategy Evaluation (MSE)



MSE Process

1. Identification of management objectives and quantifiable performance measures

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

3. Development of candidate Management Procedures (MPs)

4. Simulation testing of candidate MPs with the OMs

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

6. Implementation of the MP.

Skipjack Harvest Control Rule (HCR)

Simulation Testing:

- Assume "consensus stock assessment" will be available with known statistical properties
- Simulate fishery
- Simulate stock assessment result
- Use HCR to set quota

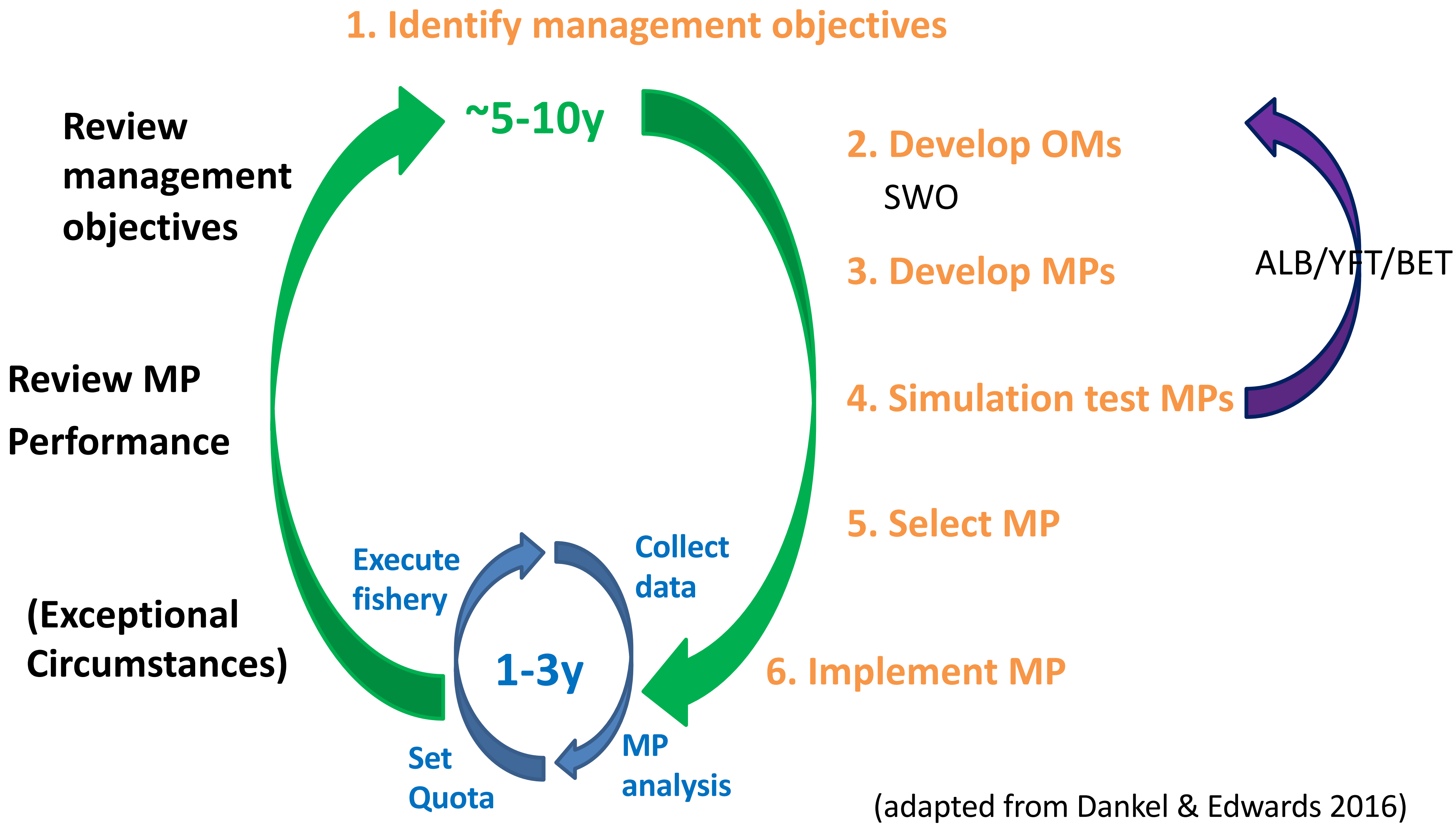
Management Procedure (BET, ALB, YFT, SWO)

Simulation Testing:

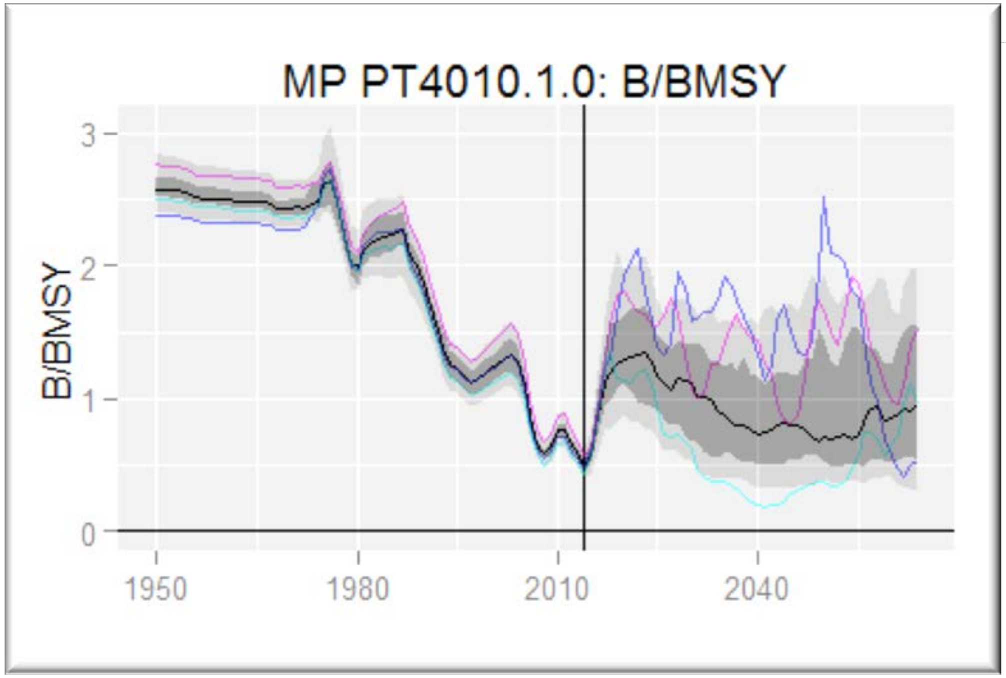
- Predefine data collection, analysis and HCR
- Simulate fishery
- Simulate Data collection and estimate "indicators"
- Use MP to set quota

i.e. "consensus stock assessment" is not a problem – it is already agreed and tested as part of the MP

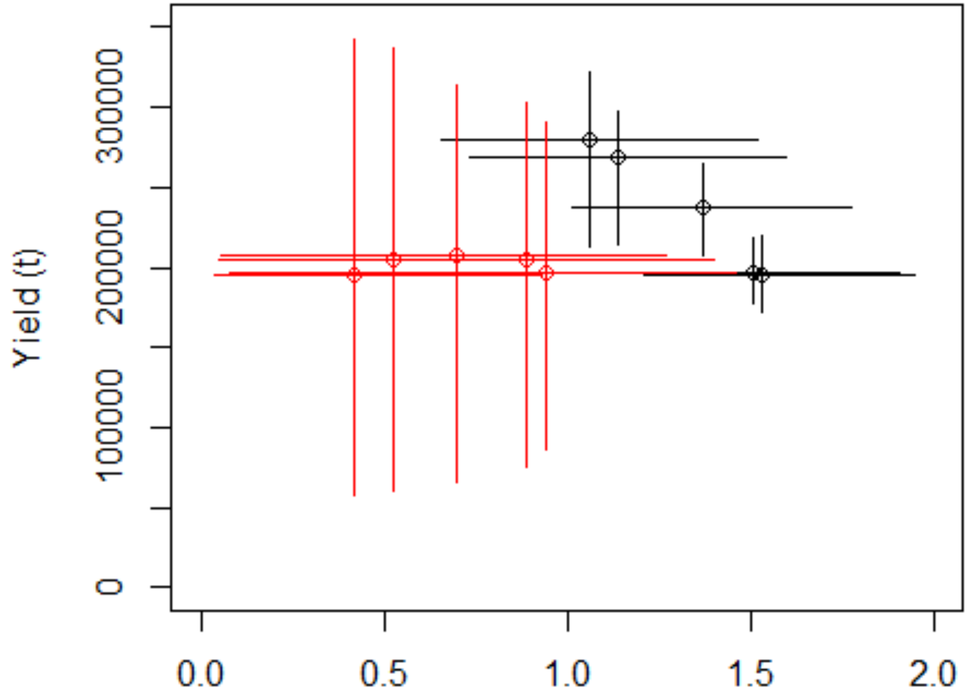
MSE: Fishery Management Cycle



(adapted from Dankel & Edwards 2016)



MP PT4010.1.0: B/BMSY
B/BMSY
0
1
2
3
1950
1980
2010
2040



Yield (t)
0
100000
200000
300000
0.0
0.5
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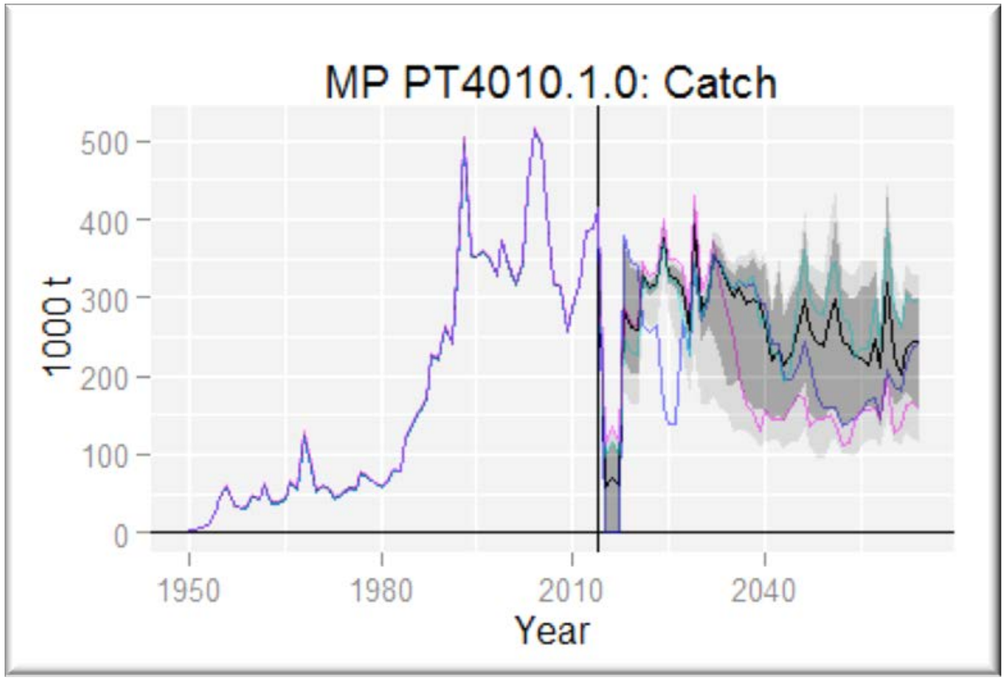
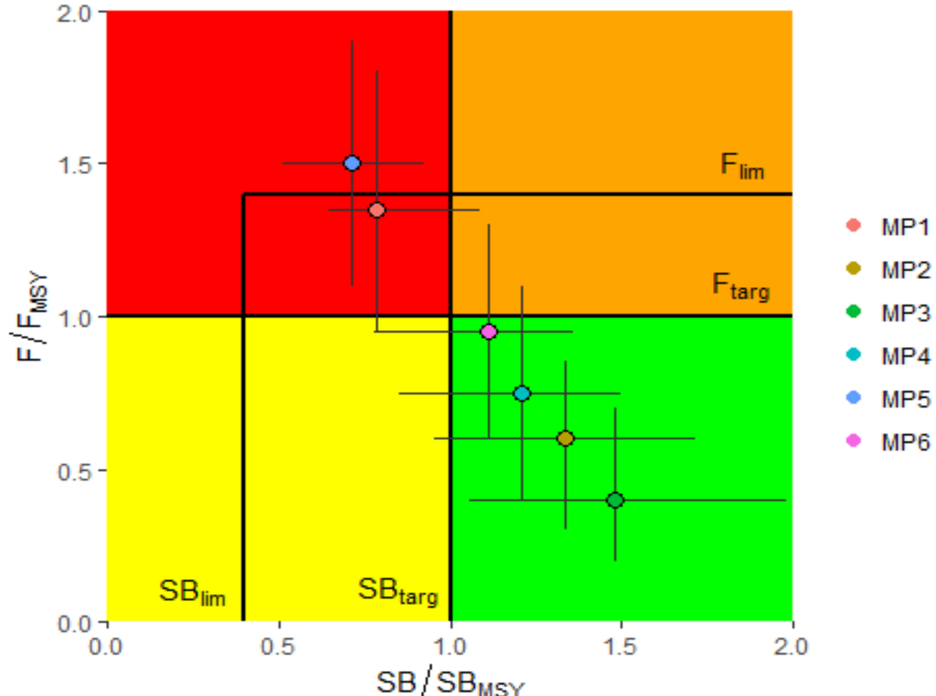
1.5
2.0



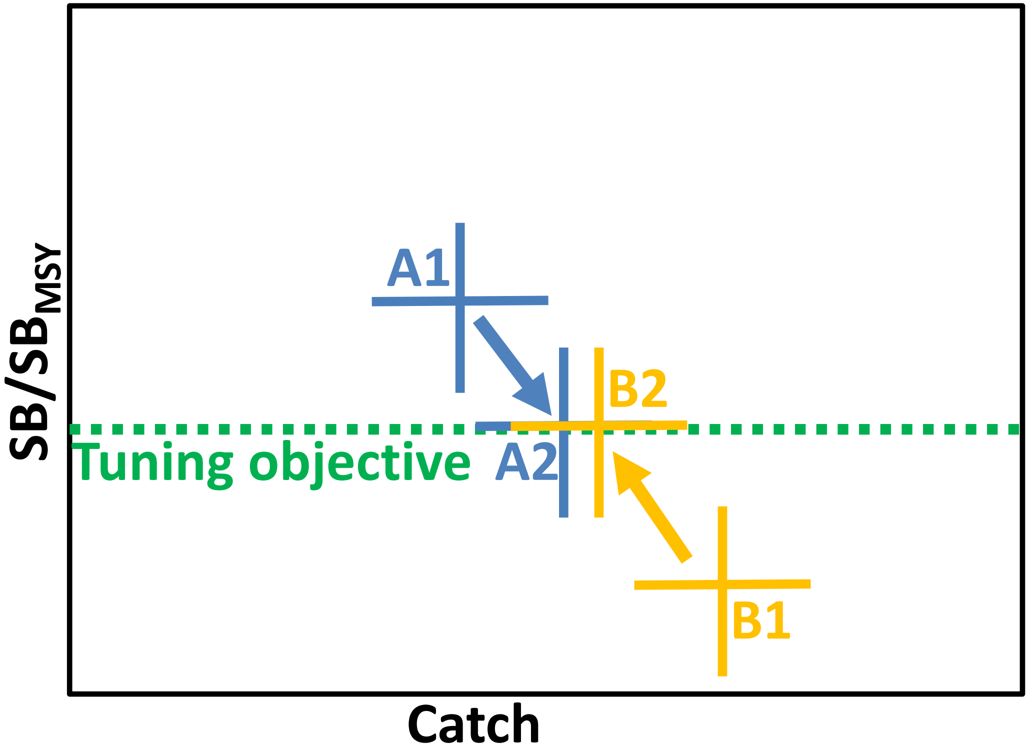
MP PT4010.1.0: Catch
1000 t
0
100
200
300
400
500
1950
1980
2010
2040
Year



F/F_MSY
SB/SB_MSY
F_lim
F_targ
SB_lim
SB_targ
0.0
0.5
1.0
1.5
2.0
MP1
MP2
MP3
MP4
MP5
MP6

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

MSE: “Meta-rules” higher level oversight MP-based management

“Exceptional Circumstances”

- Rare events, when the fishery system falls outside of the scope of the simulation testing, e.g.
  - Critical CPUE data are no longer available
  - Large IUU catches identified
  - Sustained recruitment failure, etc.
- Requires regular monitoring (e.g. indicator-based rather than comprehensive stock assessment)
- What to do?
  - Suspend MP with ad hoc management until a new MP can be developed and implemented

NOT a mechanism to simply avoid an inconvenient management action

ROLES AND RESPONSABILITIES

Why MSE?

- Framework of "Evaluation of Management Procedures" is not only a computational tool !!
- Rather, a tool to bridge between

"Stakeholders/decision makers"

- Identify management objectives
- Make potential ideas plausible ways of management and feasibility
- Make decisions on the final set of management procedures

"Scientists"

- Translate the management objectives to performance measures and risk indicators
- Develop population dynamics with reality
- Improve better management procedures to meet the objectives

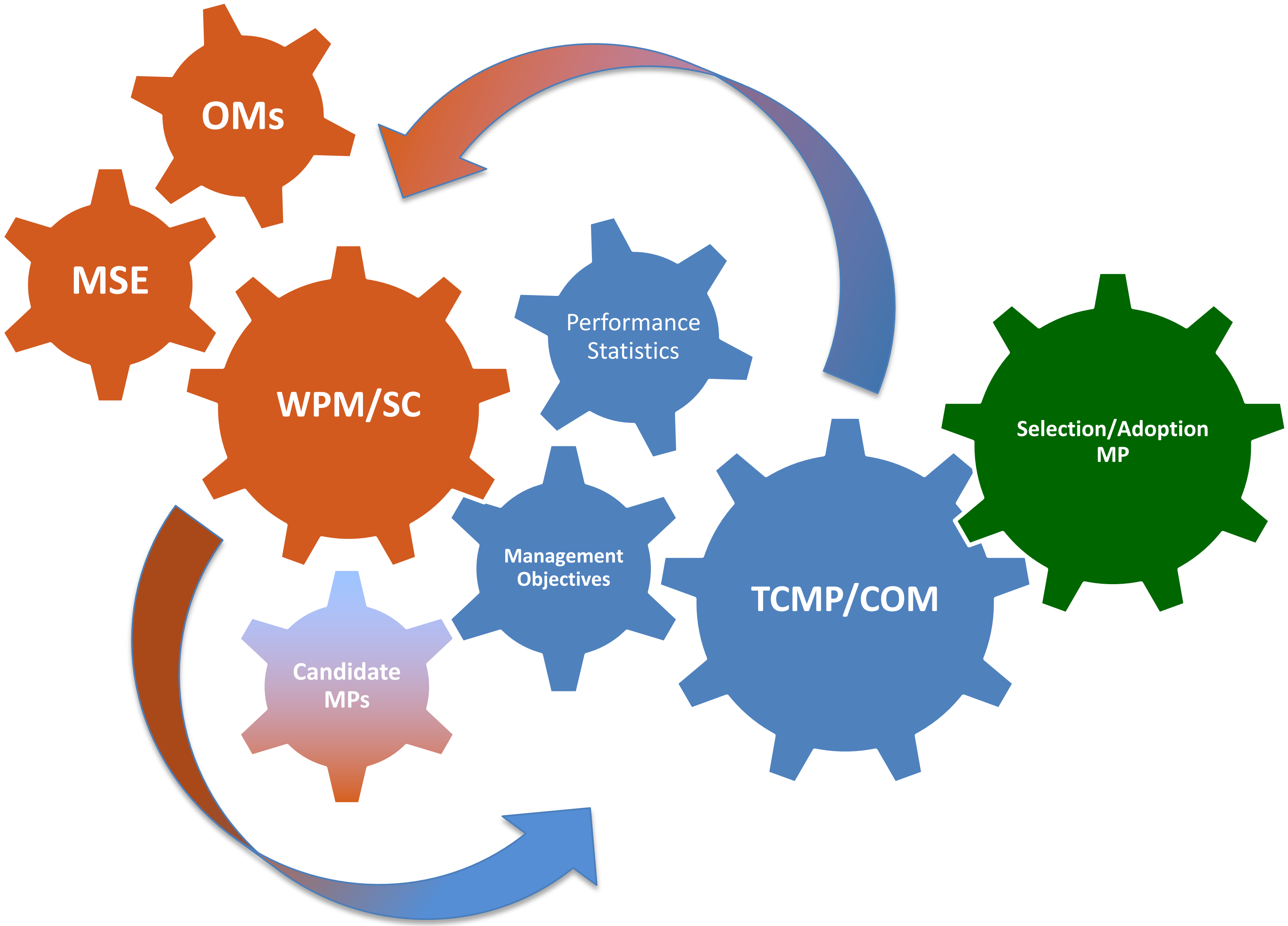
MP-MSE Process: Roles and Responsabilities

A simulation process like MSE does not consist of a series of linear steps, but rather feedback and rethinking need to be undertaken at each step in the process

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

MP-MSE Process: Roles and Responsabilities

A simulation process like MSE does not consist of a series of linear steps, but rather feedback and rethinking need to be undertaken at each step in the process



SELECTION of OBJECTIVES, TIMEFRAMES & PROBABILITIES = TUNING (i.e. FACILITATING THE PROCESS)

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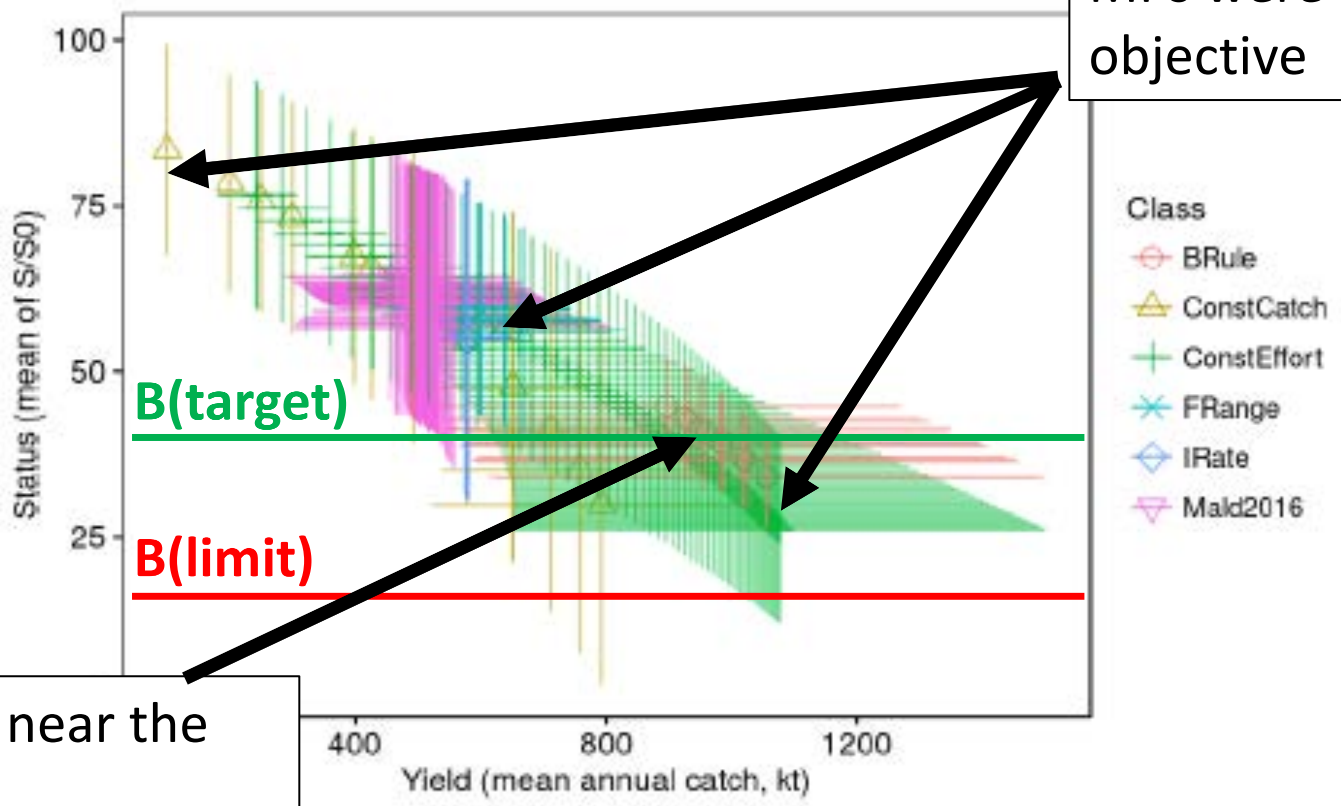
There are some management objectives expressed in the Commission documents

- e.g. Maintain the biomass at the B(target) reference point on average

Performance of most MPs were far from this objective



2-3 MPs were near the target

Tunning Criteria from TCMP02

TCMP02 AGREED in the following TUNING CRITERIA to be tested for TCMP03:

BIGEYE

- Pr(Kobe green zone 2030:2034) = 0.5.
- Pr(Kobe green zone 2030:2034) = 0.6.
- Pr(Kobe green zone 2030:2034) = 0.7.

The stock status is in the Kobe green quadrant over the period 2030-2034 exactly 50, 60 or 70% % of the time (averaged over all simulations).

YELLOFIN

- Pr(SB(2024)>=SB(MSY)) = 0.5.
- Pr(SB(2029)>=SB(MSY)) = 0.5.
- Pr(SB(2034)>=SB(MSY)) = 0.5.

Average SB in 2024, 2029 and 2034 exceeds SB_{MSY} in exactly 50% of the simulations.

KEY ISSUES TO CONSIDER FOR FEEDBACK

MSE

- Advice on key management objectives to aid tuning process
- Secondary objectives and improvement of performance indicators,
- Other considerations:
  - 3 year TAC setting,
  - TAC changes constrains,
  - Maximum TAC
- Time lag between MP-TAC implementation
- Time of MP revision

STOCK STATUS

- Advice on definition of overfished/overfishing

MSE

- Advice on key management objectives to aid tuning process
- Secondary objectives and improvement of performance indicators,

Status : maximize stock status	
1. Mean spawner biomass relative to pristine	SB/SB_0
2. Minimum spawner biomass relative to pristine	SB/SB_0
3. Mean spawner biomass relative to SB_{MSY}	SB/SB_{MSY}
4. Mean fishing mortality relative to target	F/F_{tar}
5. Mean fishing mortality relative to F_{MSY}	F/F_{MSY}
6. Probability of being in Kobe green quadrant	SB,F
7. Probability of being in Kobe red quadrant	SB,F

MSE

- Advice on key management objectives to aid tuning process
- Secondary objectives and improvement of performance indicators,

Safety : maximize the probability of remaining above low stock status (i.e. minimize risk)	
8. Probability of spawner biomass being above 20% of SB_0	*SB*
9. Probability of spawner biomass being above B_{Lim}	*SB*
Yield : maximize catches across regions and gears	
10. Mean catch (1’000 t)	*C*
11. Mean catch by region and/or gear (1’000 t)	*C*
12. Mean catch relative to MSY	*C/MSY*

MSE

- Advice on key management objectives to aid tuning process
- Secondary objectives and improvement of performance indicators,

Abundance: maximize catch rates to enhance fishery profitability	
13. Mean catch rates (by region and gear) (for fisheries with meaningful catch-effort relationship)	*I*
Stability: maximize stability in catches to reduce commercial uncertainty	
14. Mean absolute proportional change in catch	*C*
15. % Catch co-efficient of variation	*C*
16. Probability of shutdown	*C*

BUT ALSO TO CONSIDER THE

- Different behavior of the MP simulations depending on the Population Starting point: healthy stock vs. overfished stock.
  - Not only the objective is important but also how it is reached.
- 1 phase MP including Recovery + maintaining the stock in good condition or 2 phase MP with recovery phase + after recovery phase,
- Timeframe of averaging performance statistics when in recovery vs maintaining healthy stock

Advantages of Management Procedure Tuning

- Helps clarify the Commission objectives
  - Can achieve highest priority objective exactly
  - Much easier to select among MPs on the basis of secondary and tertiary performance measures
- Simplifies communication of results
  - i.e. from many (100s) of MPs to a small number (5-10)
- Allows MP developers to focus on the appropriate trade-off space
  - Better MP performance is achievable with a narrower focus
- The guiding principle for MP selection is the management performance, not the HCR
- MP control parameters may or may not correspond to TRPs and LRPs

PRESENTATION OF MSE RESULTS AGREED BY SC

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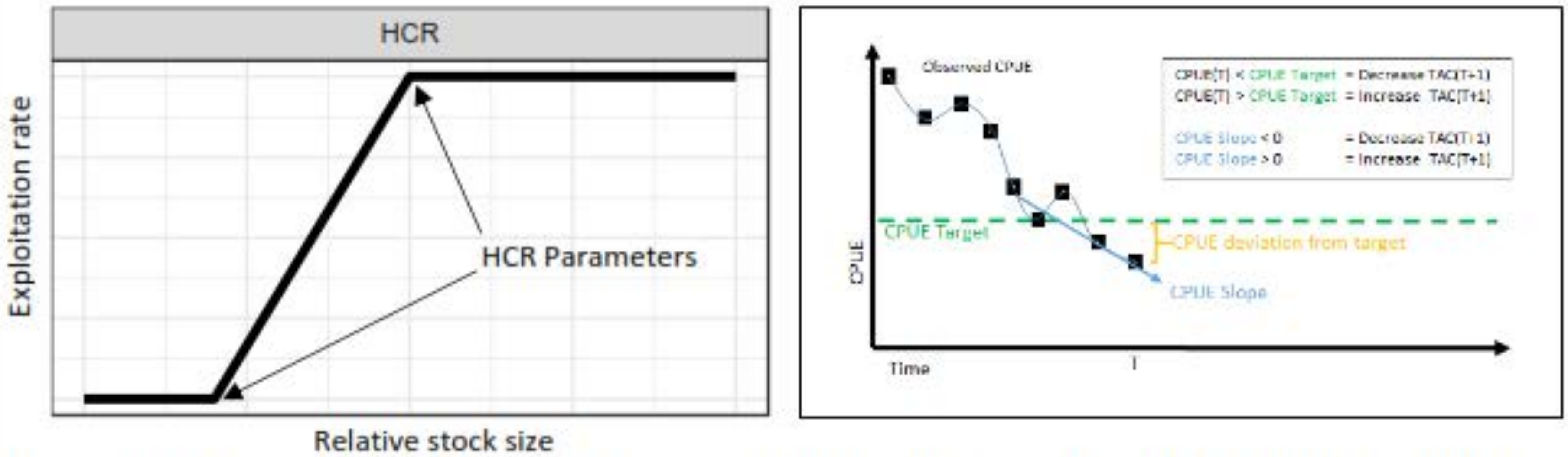
Proposal for presenting MSE results

1. **Illustrate the MPs** that have been evaluated in a figure and/or briefly define them in text.
2. Present the results for the performance of each MP in:
   a. **Boxplots** for a representative subset of performance measures
   b. **Trade-off plots** for a representative subset of performance measures
   c. **A summary table** that ranks the performance of each MP against a subset of performance measures
   d. **A Kobe plot** for the B/B_{MSY} and F/F_{MSY} performance measures
   e. **Time series plots** for stock size and fishing intensity performance measures.
3. Provide a clear and **succinct summary** of the performance of each MP.
4. Provide the numerical results for each MP across all 16 performance measures endorsed by the SC in a table in an appendix.

1. Illustrate candidate MPs or HCRs

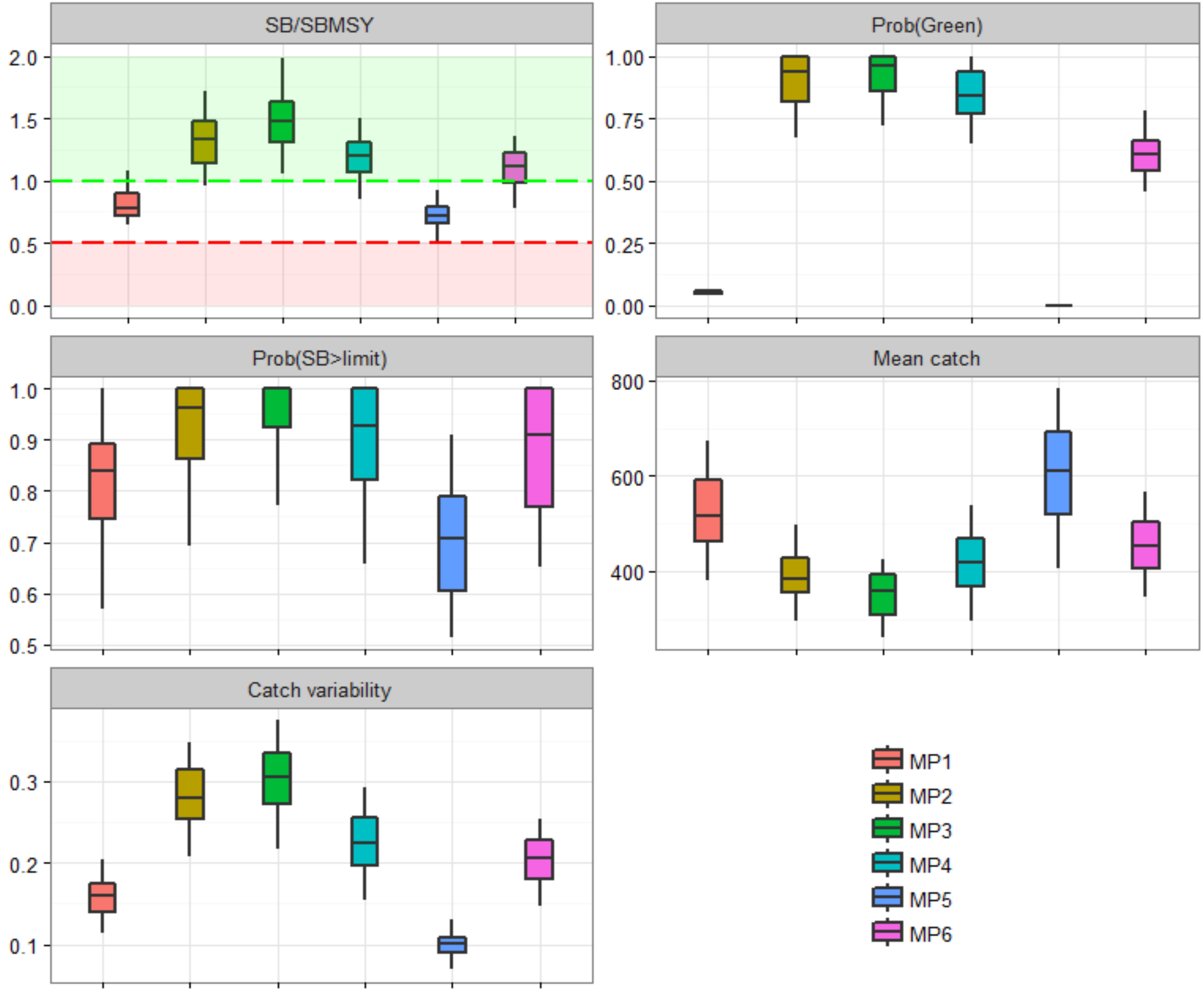
Harvest Control Rule (HCR)



Examples of two different types of harvest control rules: Biomass-based HCR relating exploitation rate to relative stock size (left), and cpue-based HCR relating observed cpue to a target level cpue. (right).

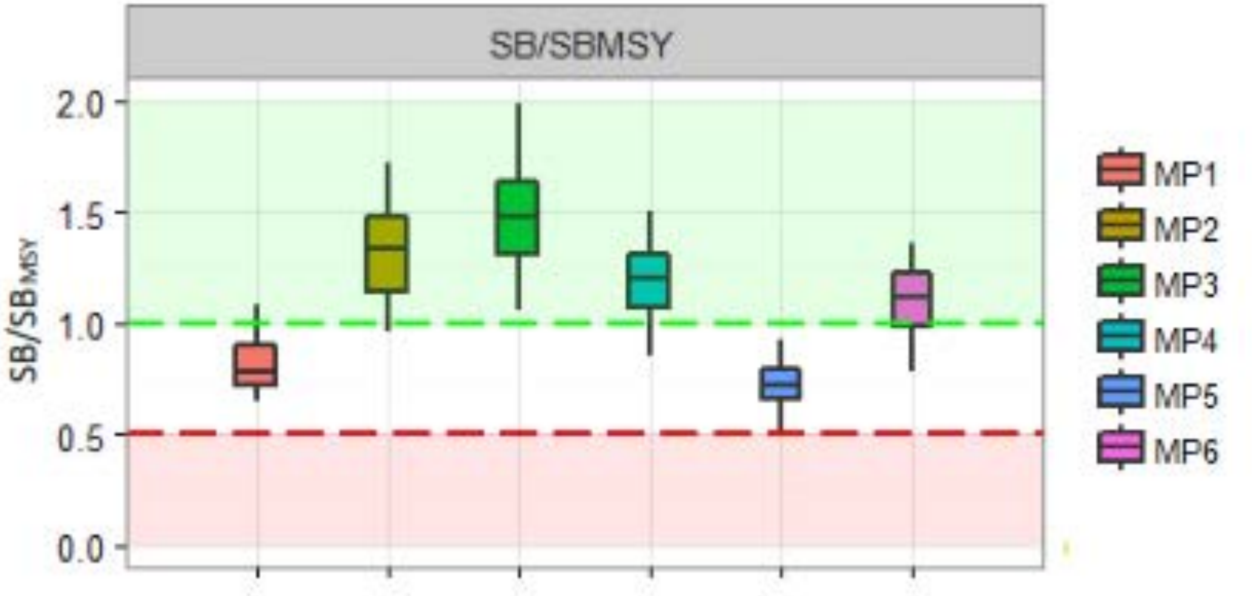
It will be important that decision makers have a clear understanding of the MPs (or HCRs) that have been evaluated. **To achieve this, a clear description of each MP (or HCR) should be presented prior to the MSE results**, along with an explanation of the relevant decision steps involved.

2. Performance of MPs – (a) Box plots



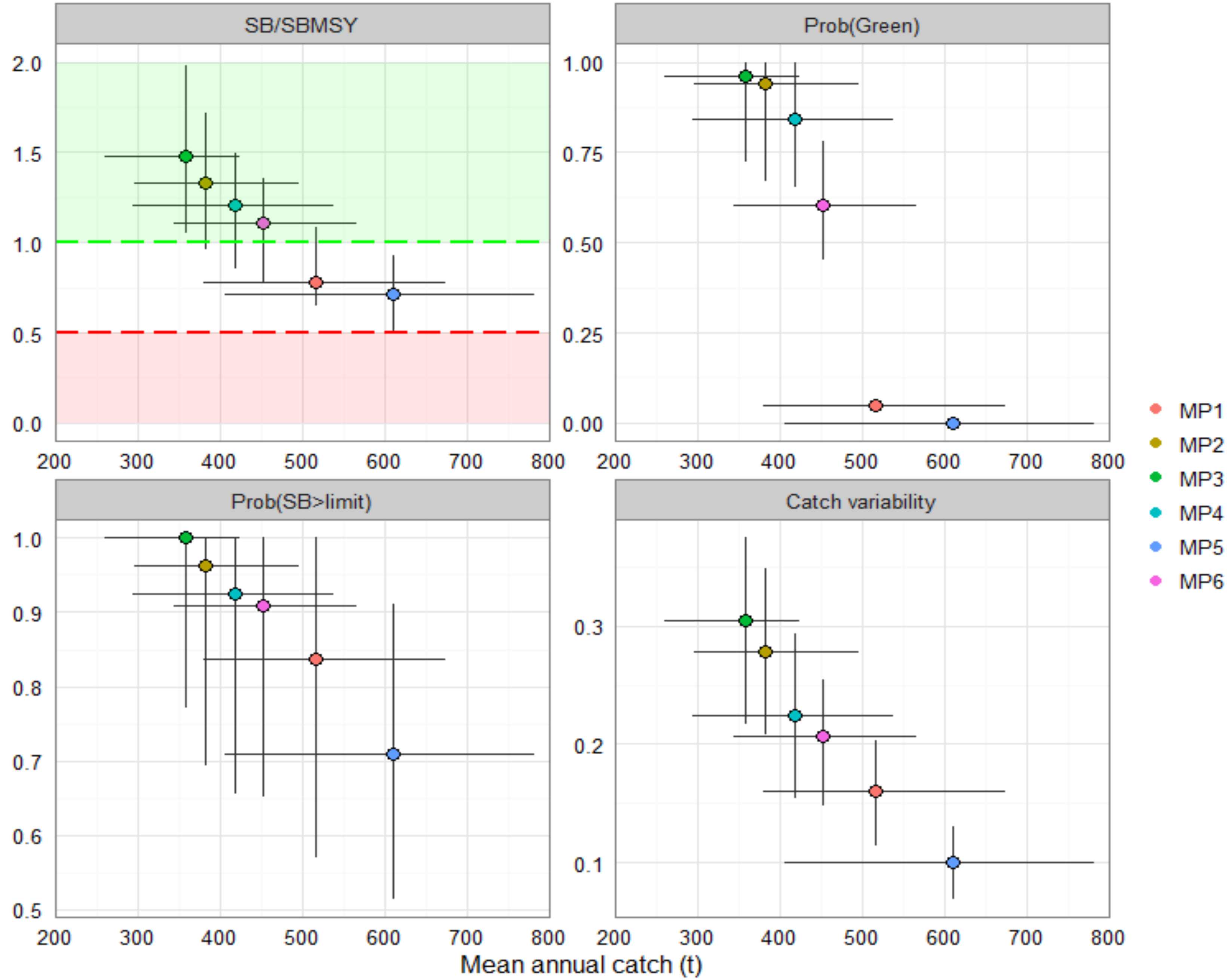
2. Performance of MPs – Box plots

Boxplot comparing performance of Management Procedures (MPs)



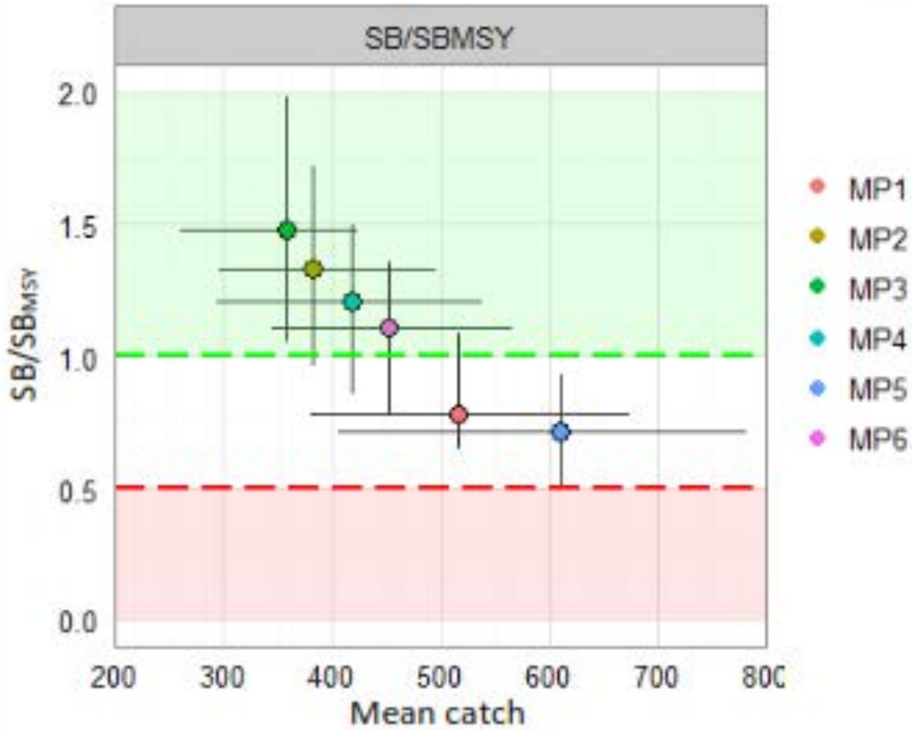
This example boxplot compares the performance of 6 MPs against SB/SB$_{MSY}$. Each data point represents the median over 20 years of simulation in the projection period as the horizontal line, 25th - 75th percentiles as coloured bars, and 10th - 90th percentiles as thin lines. Limit and target reference points are indicated by red and green dashed lines respectively.

2. Performance of MPs – (b) Trade-off plots



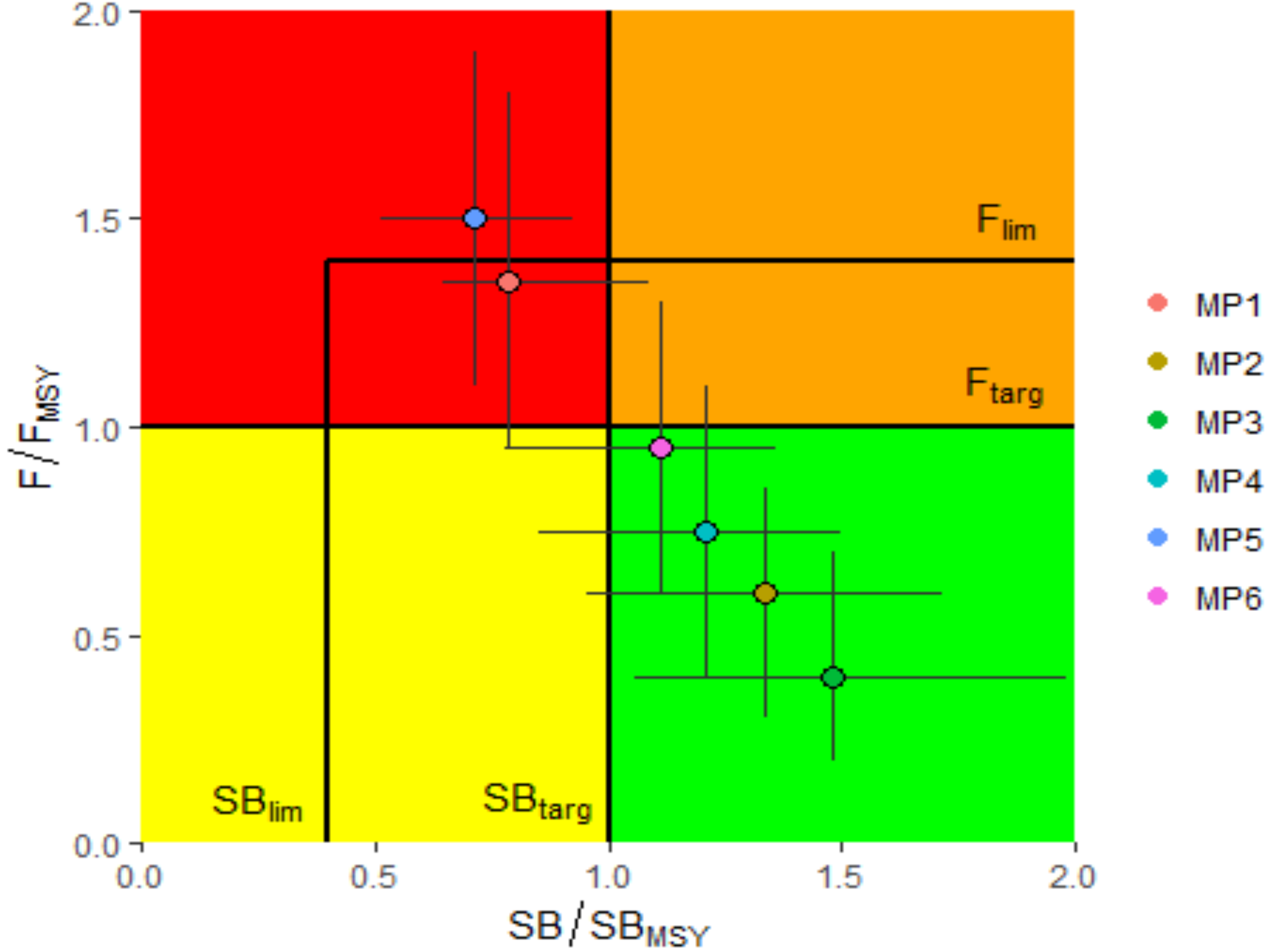
2. Performance of MPs – (b) Trade-off plots

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.

2. Performance of MPs – (d) Kobe plot

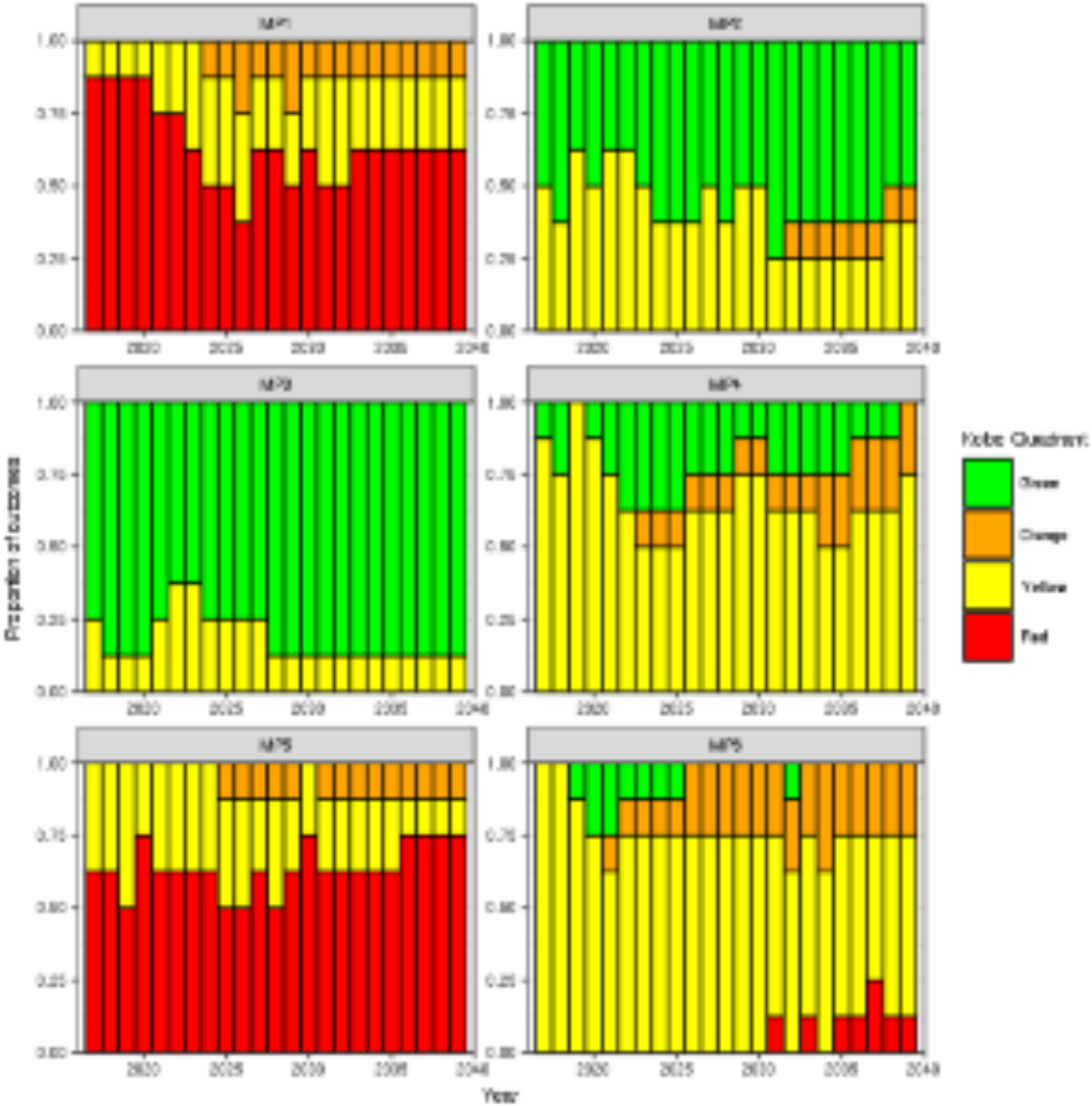


2. Performance of MPs – (c) summary table

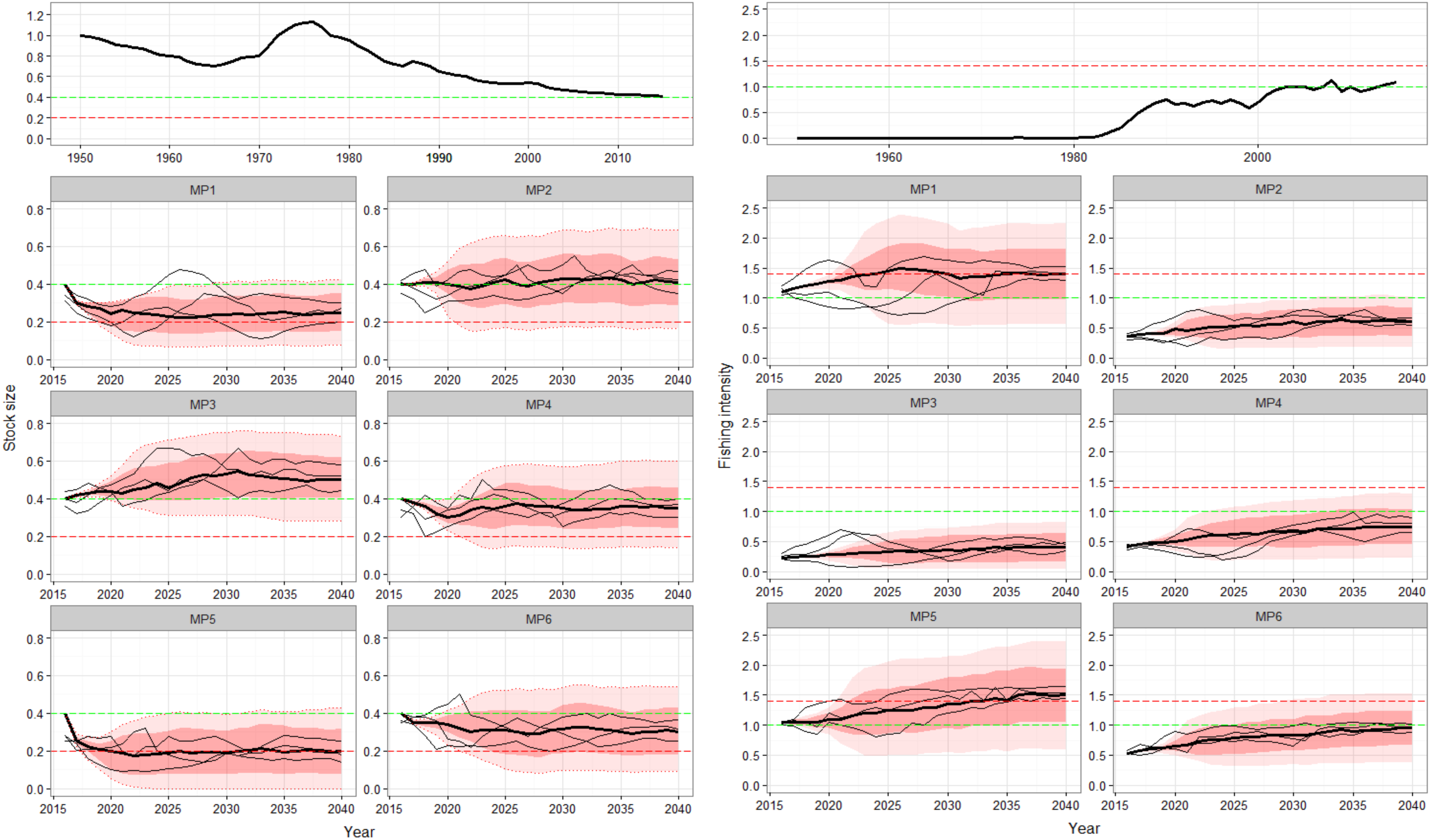
Management Procedure	Performance Measure				
	SB/SB_{MSY}	Prob(Green)	Prob(SB>limit)	Mean Catch	Catch variability
MP1	0.78	0.05	0.84	516	0.16
MP2	1.33	0.94	0.96	383	0.28
MP3	1.48	0.96	1	358	0.3
MP4	1.21	0.84	0.93	419	0.22
MP5	0.72	0	0.71	611	0.1
MP6	1.11	0.61	0.91	452	0.21

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).

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

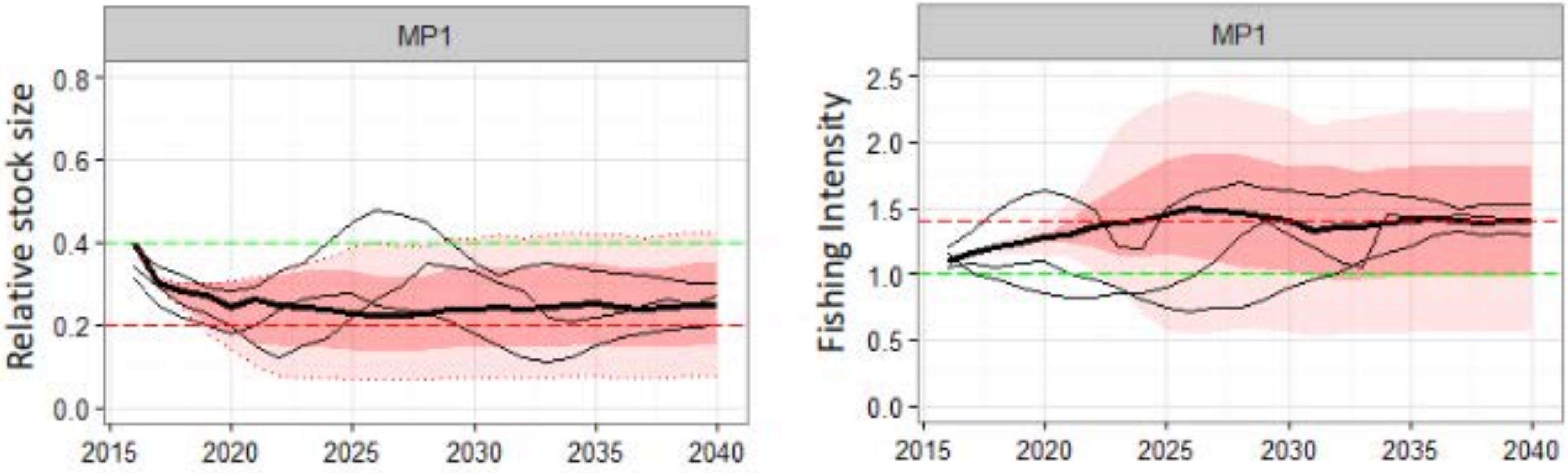


2. Performance of MPs – (e) Time series plots



2. 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.

3. Summary performance of MPs

- **MP1** MP1 achieved the second highest catches, and second lowest level of catch variability. There was a 5% chance that MP1 would be at or above the biomass target reference point and 2% chance it would be at or below the fishing mortality target reference point. There is a 25% risk that MP1 will cause the spawning biomass to fall below the limit reference point and a 50% risk that MP1 will cause the fishing mortality to exceed the limit reference point over the next 20 years.
- **MP2** performed ...
- **MP3** performed ...
- **MP4** performed ...
- **MP5** performed ...
- **MP6** performed ...

4. Details of performance of MPs across all indicators

Status : maximize stock status		1 year						5 years					
		MP1	MP2	MP3	MP4	MP5	MP6	MP1	MP2	MP3	MP4	MP5	MP6
1. Mean spawner biomass relative to pristine	*SB/SB*0	0.5	0.8	0.9	0.7	0.4	0.6	0.5	0.8	1.0	0.7	0.4	0.6
2. Minimum spawner biomass relative to pristine	*SB/SB*0	0.3	0.6	0.6	0.5	0.2	0.4	0.3	0.5	0.6	0.5	0.2	0.4
3. Mean spawner biomass relative to SB_{MSY}	*SB/SBMSY*	0.8	1.3	1.4	1.2	0.7	1.1	0.9	1.2	1.3	1.1	0.7	1.2
4. Mean fishing mortality relative to target	*F/Ftar*	1.4	0.6	0.4	0.8	1.5	0.9	1.4	0.6	0.4	0.8	1.5	0.9
5. Mean fishing mortality relative to *Fmsy*	*F/FMSY*	1.4	0.6	0.4	0.8	1.5	0.9	1.5	0.5	0.4	0.8	1.6	0.9
6. Probability of being in Kobe green quadrant	*SB,F*	0.5	0.9	1	0.8	0.3	0.7	0.5	0.9	0.9	0.8	0.3	0.7
7. Probability of being in Kobe red quadrant	*SB,F*	0.3	0.1	0	0.1	0.5	0.2	0.3	0.1	0.0	0.1	0.5	0.2
Safety : *maximize the probability of remaining above low stock status (i.e. minimize risk)*													
8. Probability of spawner biomass being above 20% of *SB0*	*SB*	0.8	0.9	0.9	0.8	0.7	0.8	0.8	0.8	0.9	0.8	0.7	0.8
9. Probability of spawner biomass being above *B*Lim	*SB*	0.8	1.0	1.0	0.9	0.7	0.9	0.8	1.0	1.0	0.9	0.7	0.8
Yield : maximize catches across regions and gears													
10. Mean catch (1'000 t)	*C*	520	390	350	430	600	460	551	417	378	434	600	460
11. Mean catch by region and/or gear (1'000 t)	*C*	250	200	180	210	310	220	248	194	176	229	335	218
12. Mean catch relative to MSY	*C/MSY*	1.1	0.7	0.6	0.8	1.2	0.9	1.2	0.6	0.6	0.8	1.3	1.0
Abundance: maximize catch rates to enhance fishery profitability													
13. Mean catch rates (by region and gear) (for fisheries with meaningful catch-effort relationship)	*I*	3.2	3.8	3.9	2.7	2.5	2.6	3.0	3.8	4.0	2.6	2.3	2.8
Stability: maximize stability in catches to reduce commercial uncertainty													
14. Mean absolute proportional change in catch	*C*	0.2	0.3	0.3	0.2	0.1	0.2	0.2	0.3	0.3	0.2	0.1	0.2
15. % Catch co-efficient of variation	*C*	20	25	24	18	12	21	19.4	27.3	26.2	17.6	11.5	21.0
16. Probability of shutdown	*C*	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

4. Details of performance of MPs across all indicators

Status : maximize stock status		10 years						20 years					
		MP1	MP2	MP3	MP4	MP5	MP6	MP1	MP2	MP3	MP4	MP5	MP6
1. Mean spawner biomass relative to pristine	*SB/SB*0	0.5	0.8	0.9	0.7	0.4	0.6	0.5	0.8	1.0	0.7	0.4	0.6
2. Minimum spawner biomass relative to pristine	*SB/SB*0	0.3	0.6	0.6	0.5	0.2	0.4	0.3	0.5	0.6	0.5	0.2	0.4
3. Mean spawner biomass relative to SB_{MSY}	*SB/SBMSY*	0.8	1.3	1.4	1.2	0.7	1.1	0.9	1.2	1.3	1.1	0.7	1.2
4. Mean fishing mortality relative to target	*F/Ftar*	1.4	0.6	0.4	0.8	1.5	0.9	1.4	0.6	0.4	0.8	1.5	0.9
5. Mean fishing mortality relative to *Fmsy*	*F/FMSY*	1.4	0.6	0.4	0.8	1.5	0.9	1.5	0.5	0.4	0.8	1.6	0.9
6. Probability of being in Kobe green quadrant	*SB,F*	0.5	0.9	1	0.8	0.3	0.7	0.5	0.9	0.9	0.8	0.3	0.7
7. Probability of being in Kobe red quadrant	*SB,F*	0.3	0.1	0	0.1	0.5	0.2	0.3	0.1	0.0	0.1	0.5	0.2
Safety : *maximize the probability of remaining above low stock status (i.e. minimize risk)*													
8. Probability of spawner biomass being above 20% of *SB0*	*SB*	0.8	0.9	0.9	0.8	0.7	0.8	0.8	0.8	0.9	0.8	0.7	0.8
9. Probability of spawner biomass being above *B*Lim	*SB*	0.8	1.0	1.0	0.9	0.7	0.9	0.8	1.0	1.0	0.9	0.7	0.8
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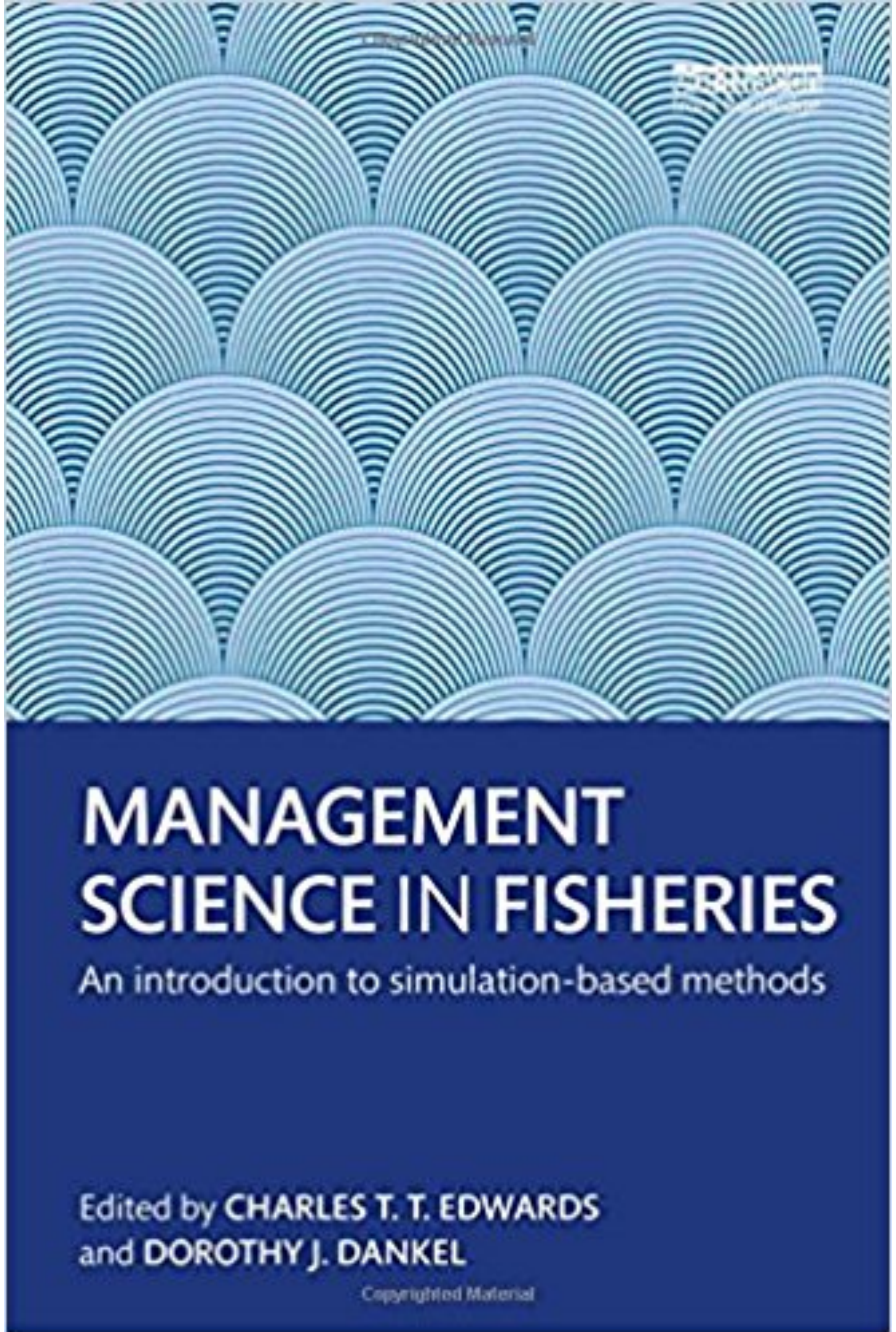
15. % Catch co-efficient of variation	*C*	20	25	24	18	12	21	19.4	27.3	26.2	17.6	11.5	21.0
16. Probability of shutdown	*C*	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01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MANAGEMENT SCIENCE IN FISHERIES
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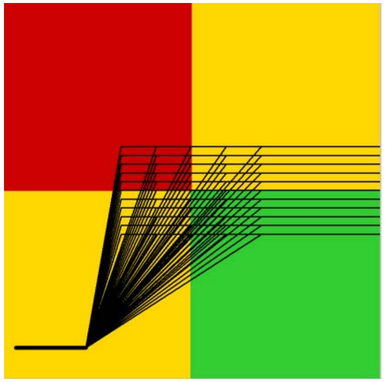
Introduction to Management Strategy Evaluation with TunaMSE: Stock assessment vs MPs

Dan Fu (IOTC)

Busan, Republic of Korea, 19-20 February 2020

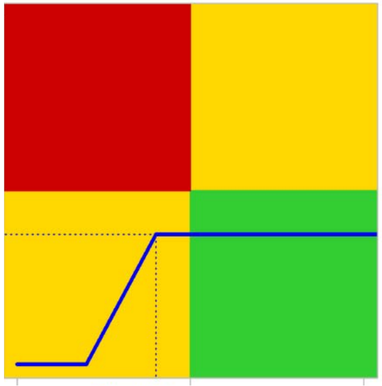
Management strategy evaluation

Candidate management procedures



MSE

Agreed management procedures



- Management objectives
- Operating models
- Simulation testing
- Performance measures

Management Strategy Evaluation

- Assess the performance of a potential MP
  - Meet management objectives ?
- Compare amongst MPs
  - Considering many possibilities – we don’t know what future/reality is
  - Considering trade-off among objectives – we cannot get everything,

A hypothetic MSE example (Smith A.D.M.)

- Select amongst 4 MP
  - Constant catch (high and/or low)
  - Constant harvest rate
  - Constant biomass strategy
- Against three objectives
  - Maximise the catch
  - Minimise year-to-year catch variability
  - Minimise the risks of stock falling below a threshold

A hypothetic MSE example

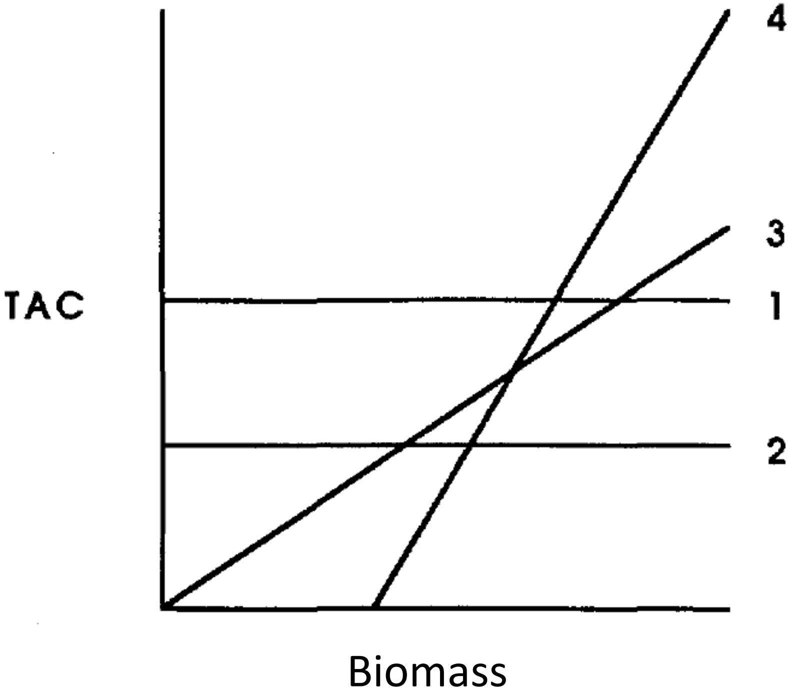
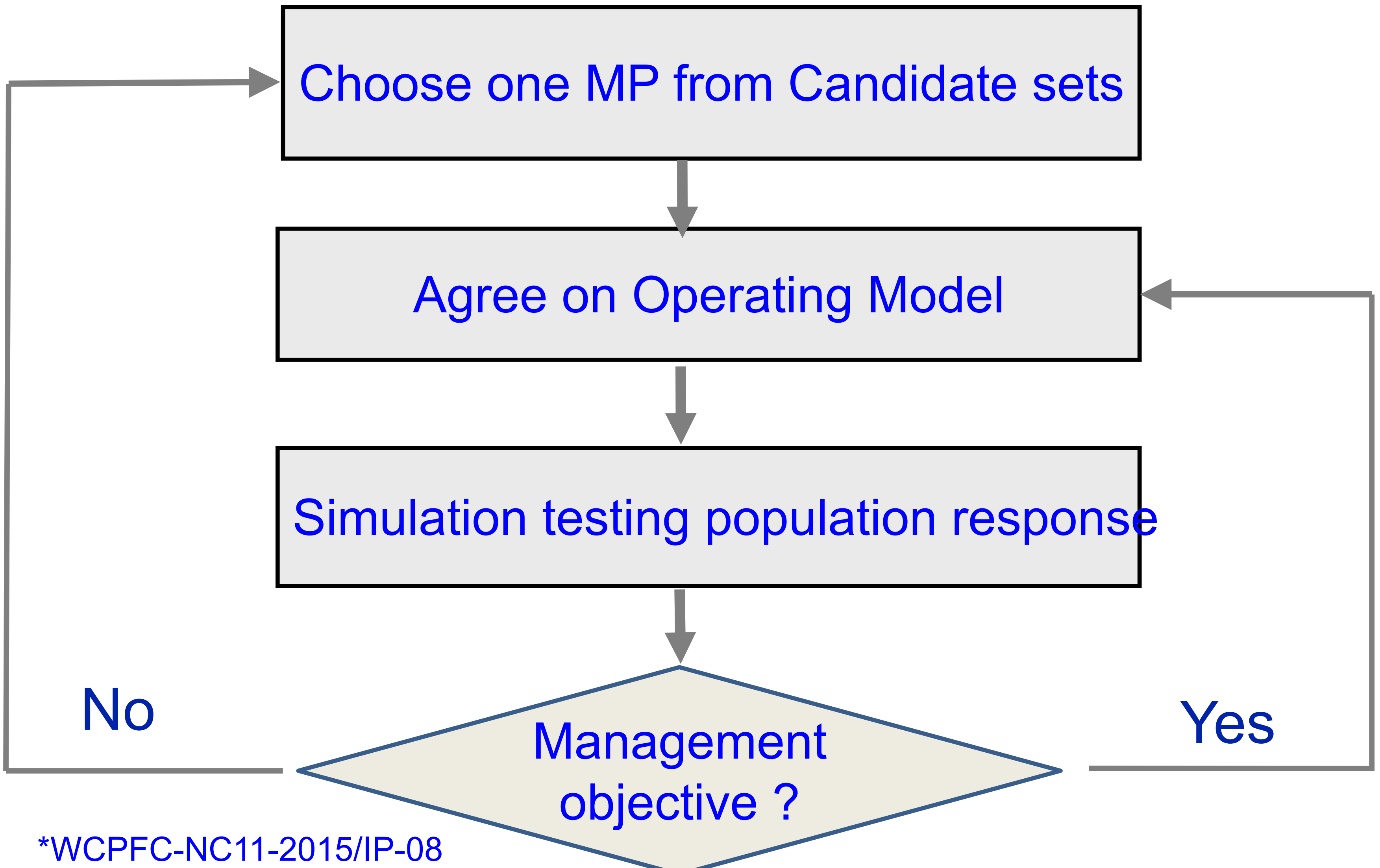


Table 1. Performance of strategies against objectives.

	OBJECTIVE		
	Maximize catch	Minimize variability	Minimize risk
STRATEGY			
Constant high catch	Moderate	Moderate	Poor
Constant low catch	Poor	Good	Moderate
Constant harvest rate	Moderate	Moderate	Moderate
Constant biomass	Good	Poor	Good

Management Strategy evaluation*



*WCPFC-NC11-2015/IP-08

What are we evaluating?

- MSE evaluates management procedure
  - a set of rules that determine TAC from the data

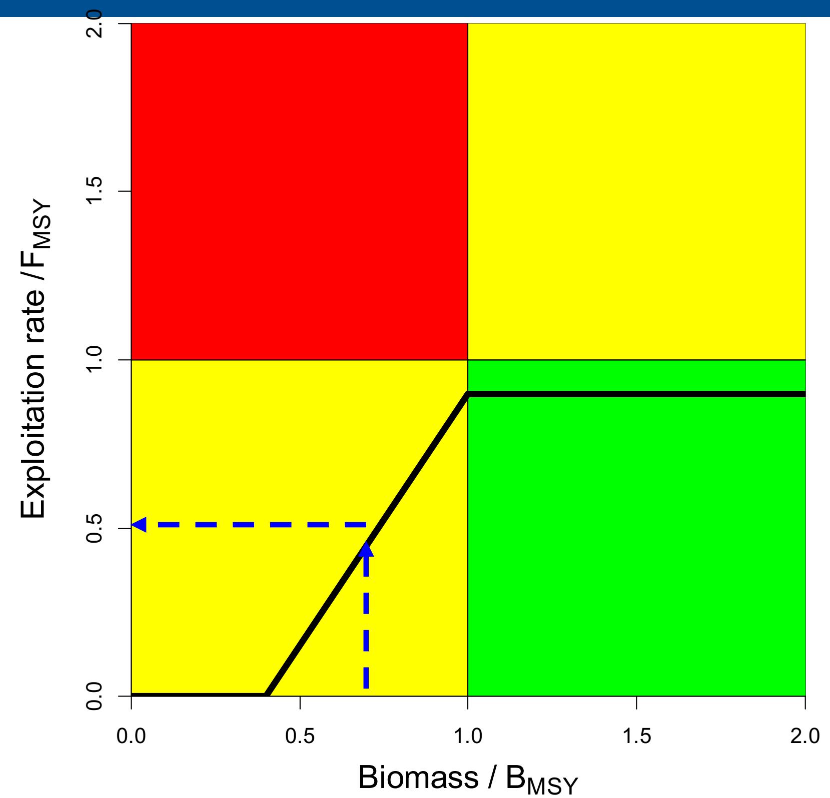
Data + analysis + Harvest control rule

Harvest control rules

- Constant catch or exploitation rate
- CPUE-based rules
- Thresh-hold rules
  - Triggered when stock status approach reference points

Threshold rule example

Output – exploitation rate or catch

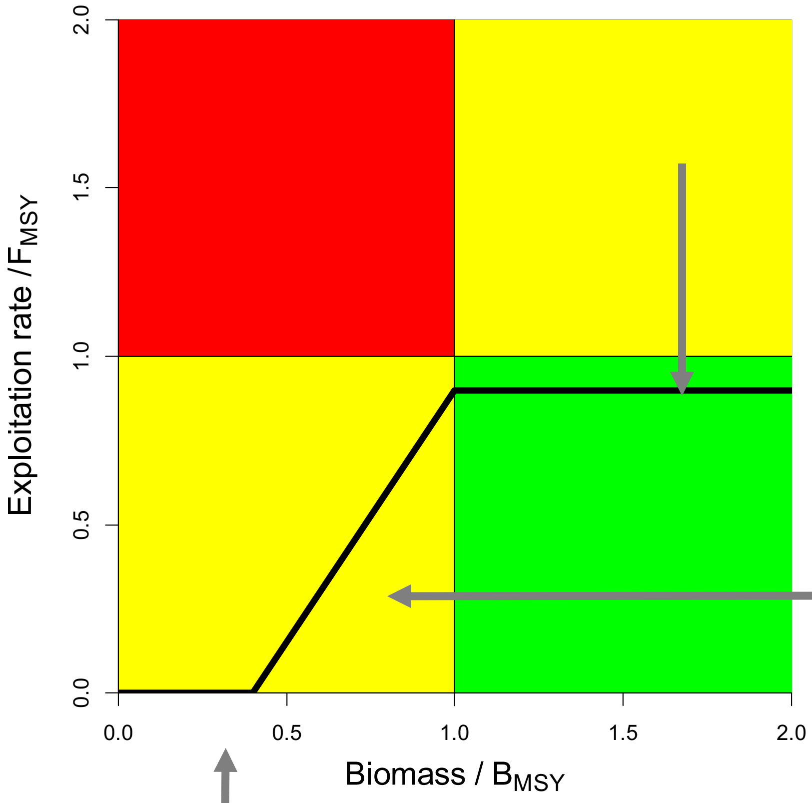


If stock status is 70% Bmsy

Then set F = 50% Fmsy

Input – stock status

Threshold rule example

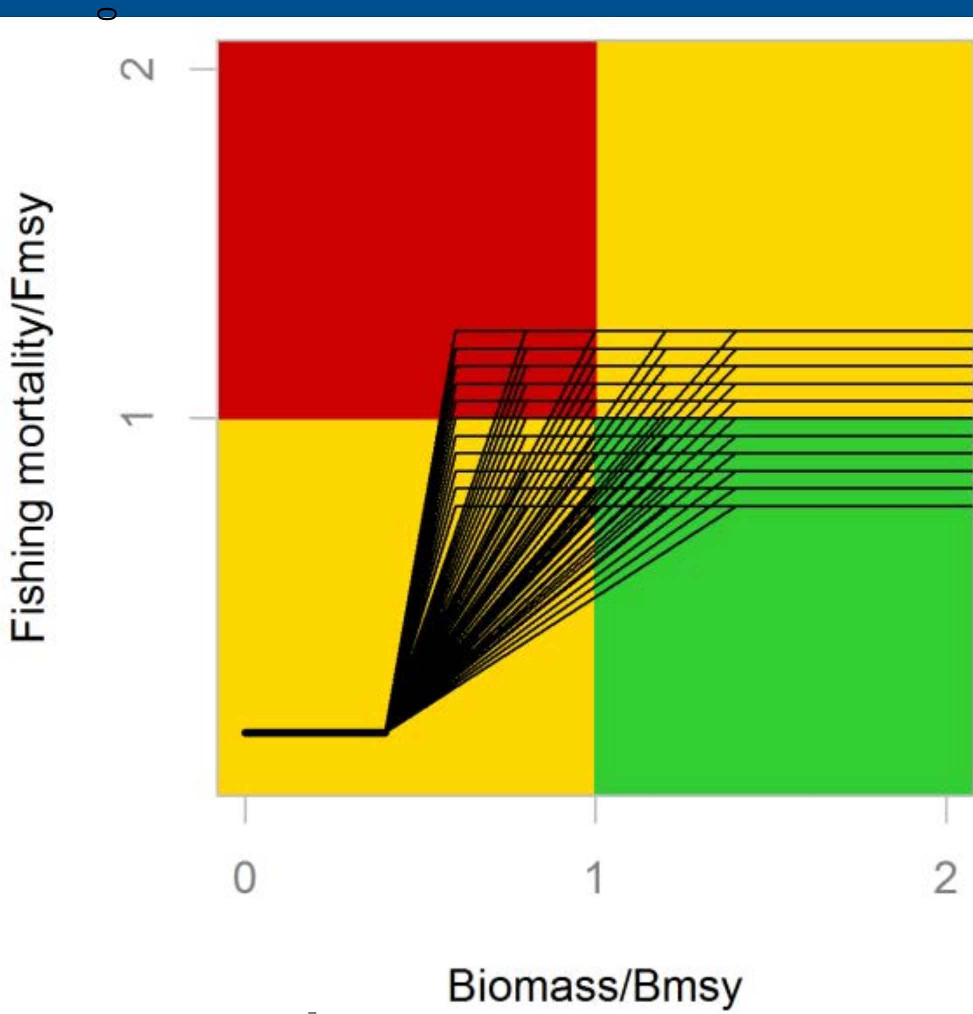


Fishing at maximum F if biomass is above Bmsy

Reduce fishing if biomass is below Bmsy

Stop fishing if biomass is below 40% Bmsy

Threshold rule – control parameters



ıt's the maximum F

When to reduce

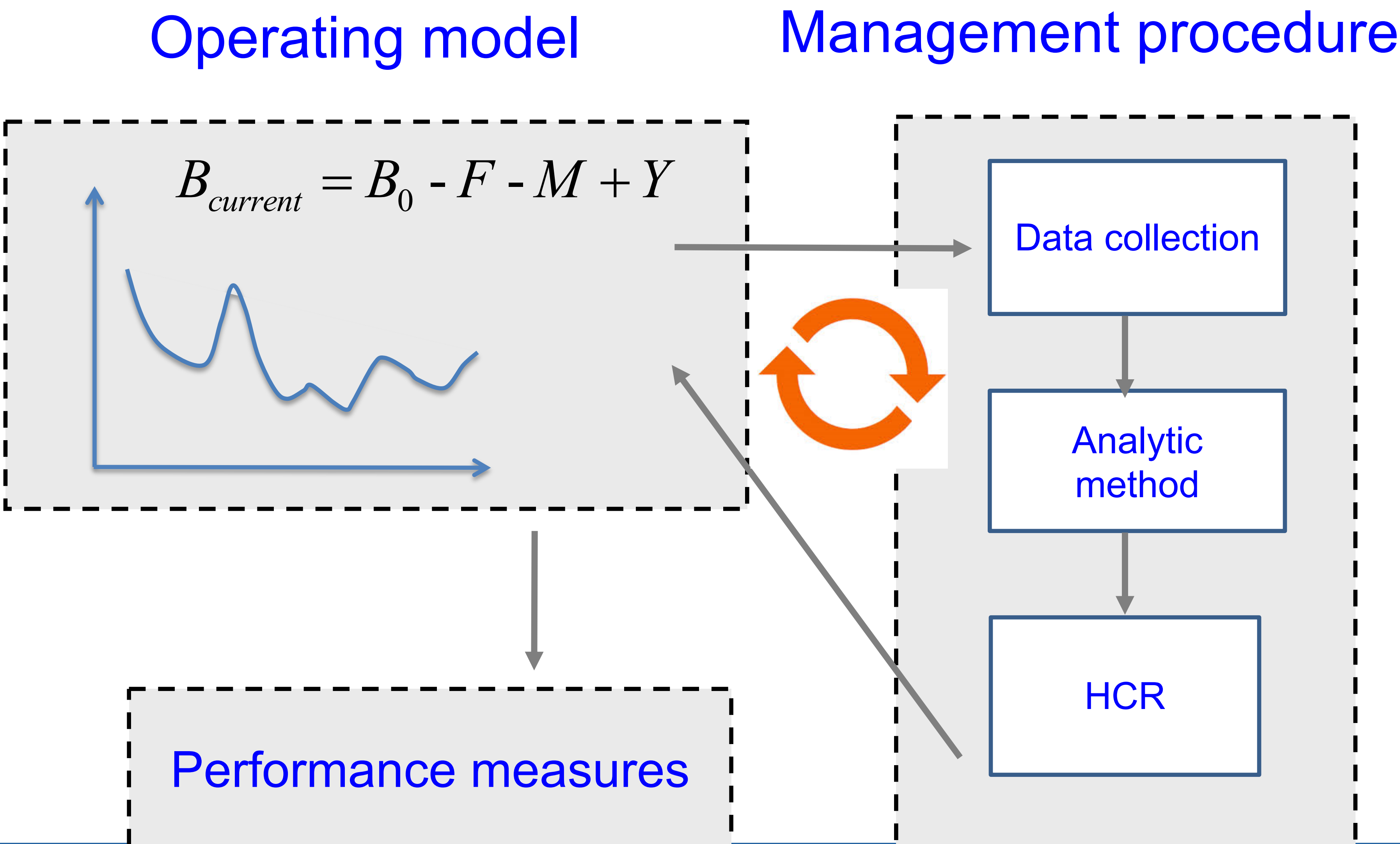
- How quickly to reduce?

- When to stop

Why HCR needs to be tested

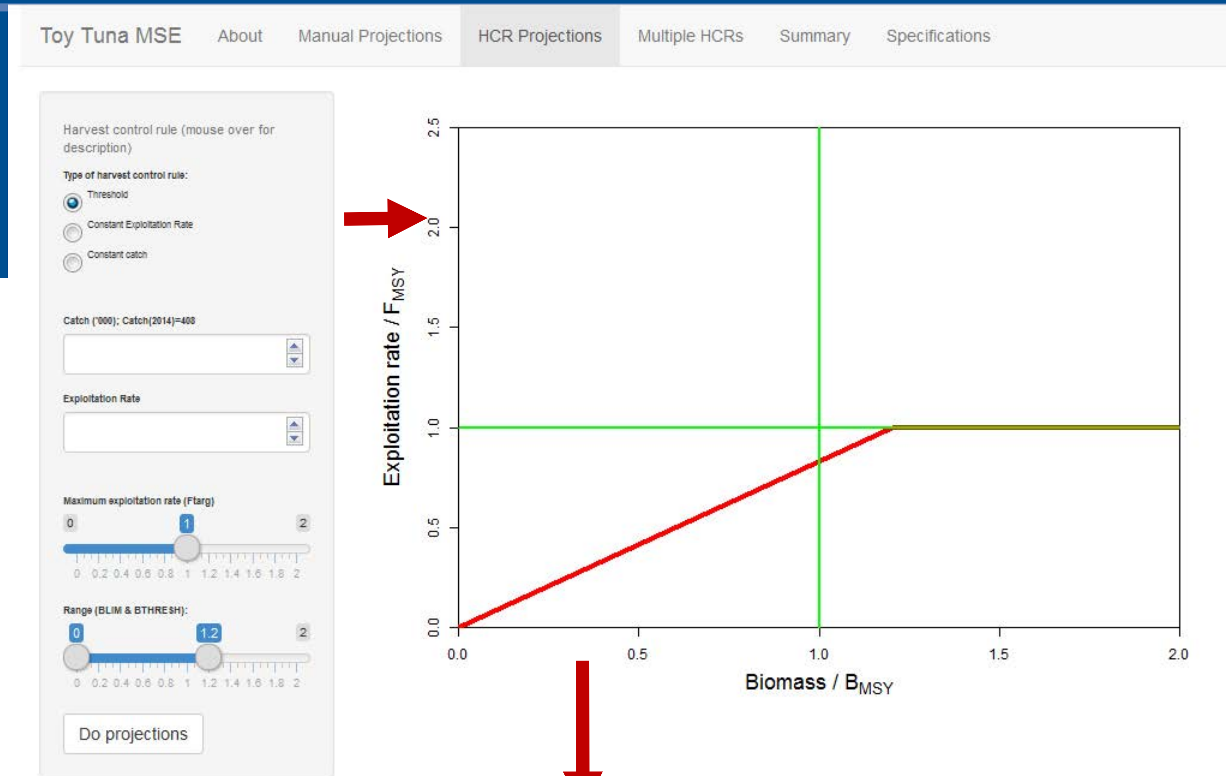
- Performance of a HCR may depend on
  - fishery dynamics
  - Stock productivity
  - Random (recruitment) variability
- Trade-offs in management objectives

Management Strategy evaluation



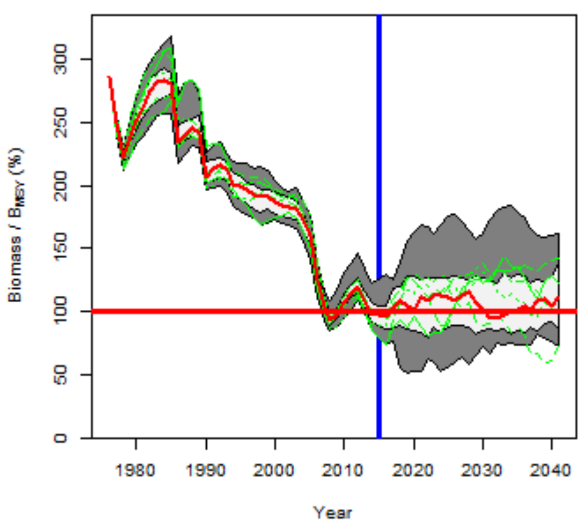
HCR

Control parameter

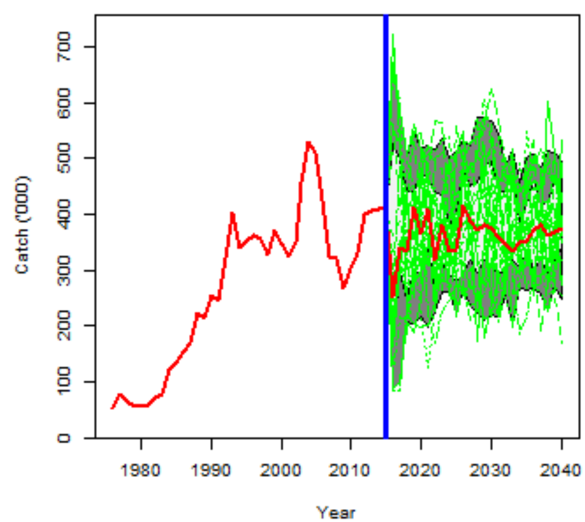


MP output

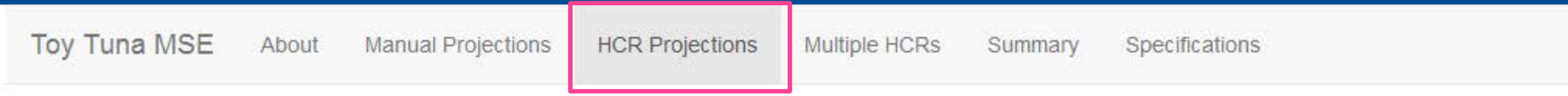
Stock status

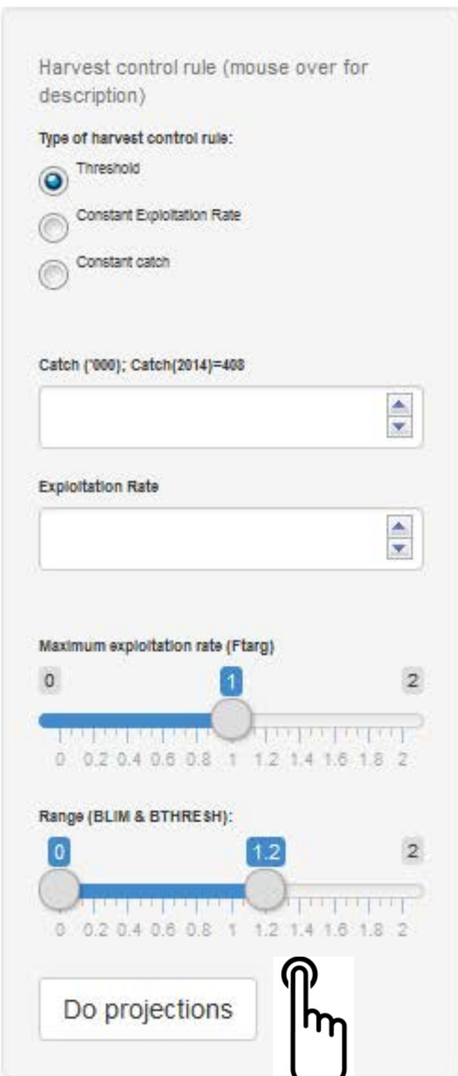


Catch



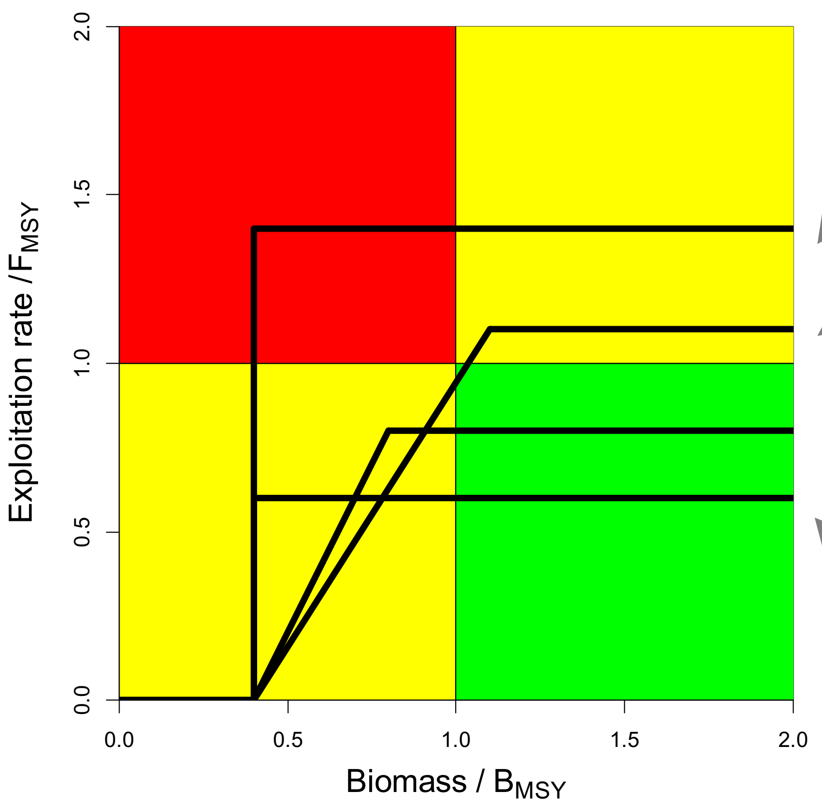
‘Tuna MSE’ – Process





1. OM runs from 1950 to 2016
2. Year 2017:
   1. CPUE (1950-2016) collected
   2. stock status estimated
   3. Catch for 2017 calculated
   4. Catch removed from the population
3. Year 2018,… repeat!

HCR examples

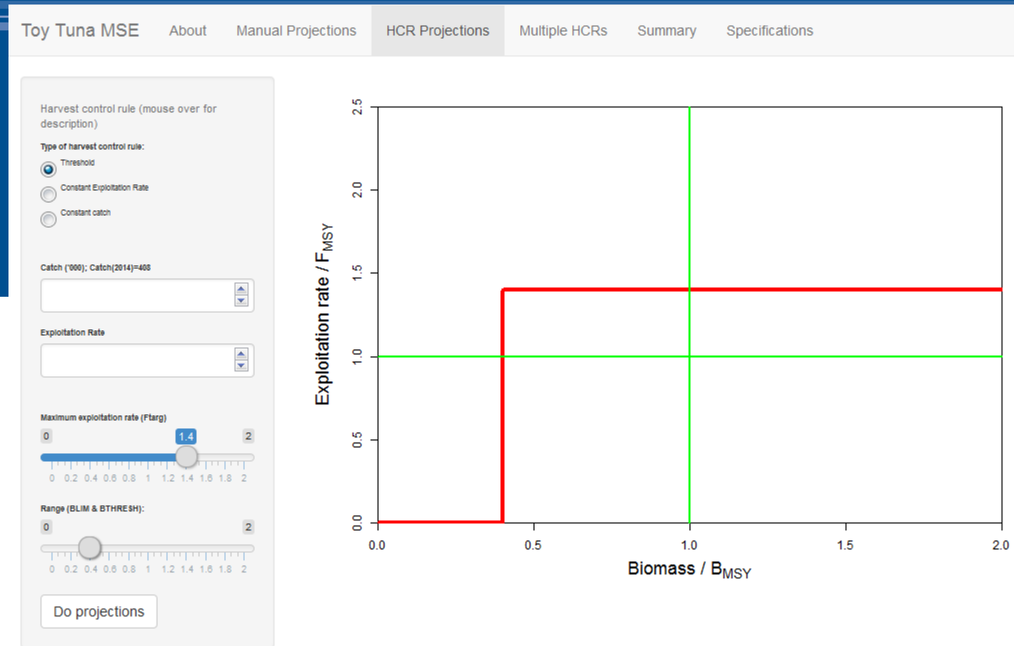


Very Aggressive –
F = 1.4Fmsy

Aggressive –
High F at healthy stocks but quick reaction when stocks start to decline

Conservative –
low F, with less action when stocks start to decline

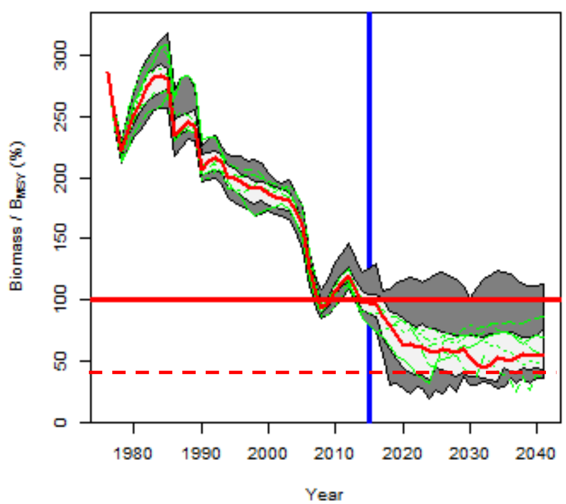
Very conservative –
F = 0.6 Fmsy

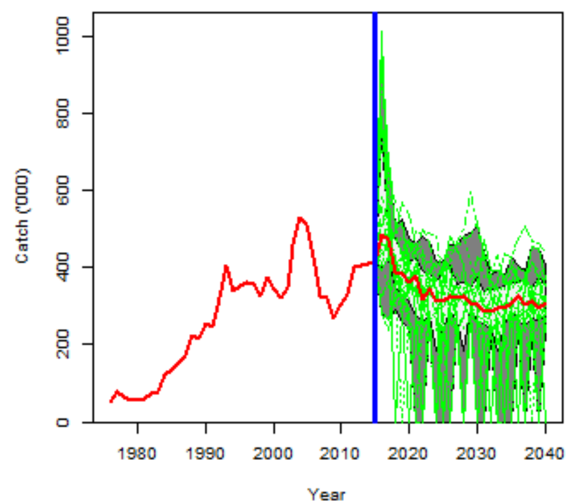


Very Aggressive

Stock status

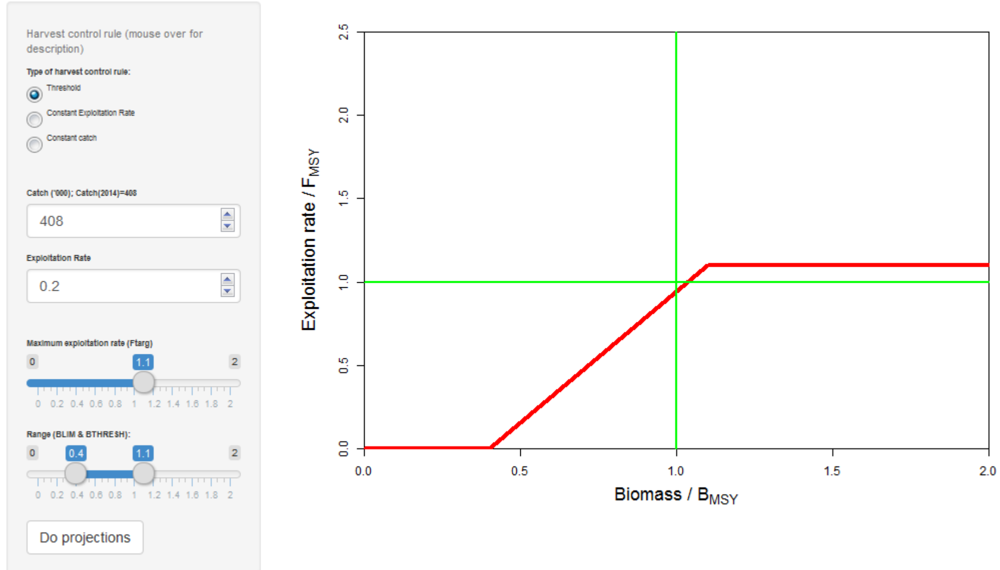
Catch





Biomass well below the target

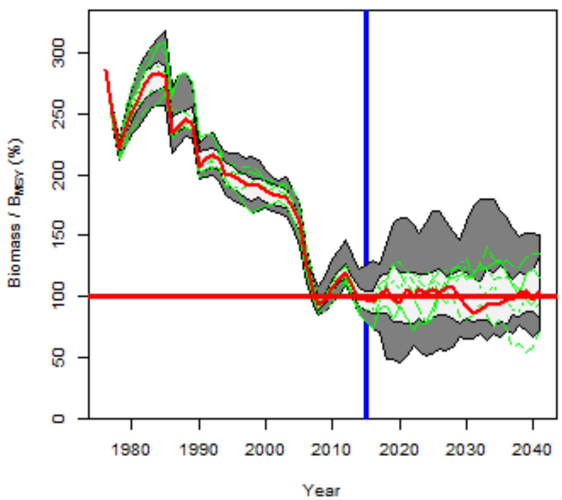
Catch also decline

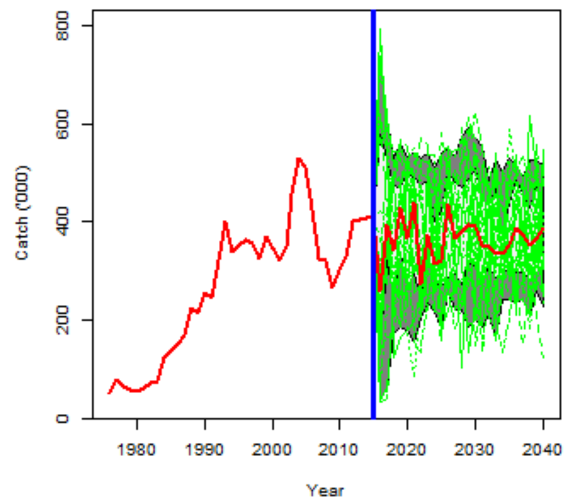


Aggressive

Stock status

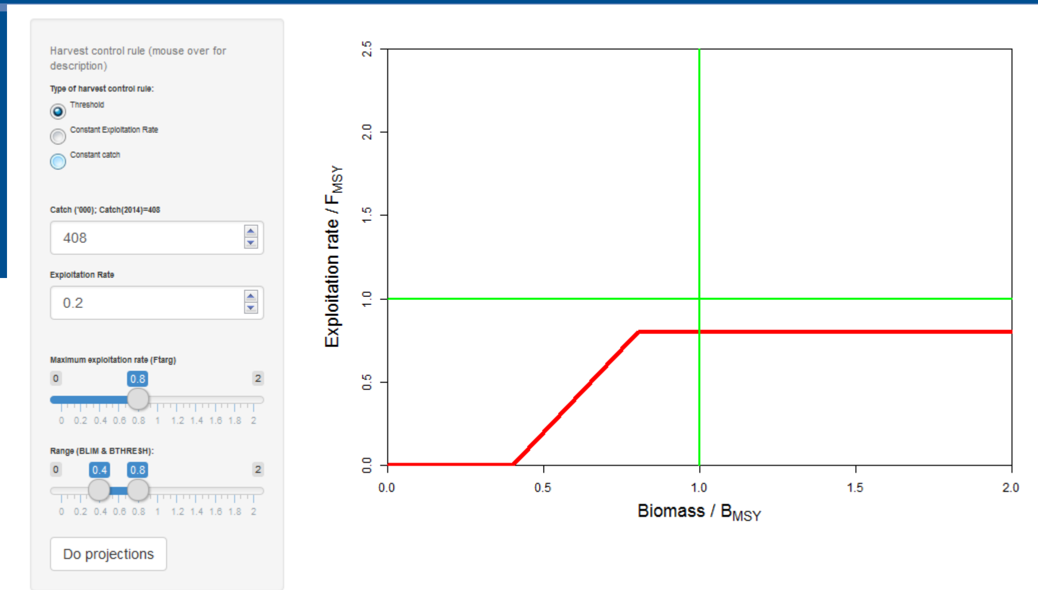
Catch





Biomass below target
for some years

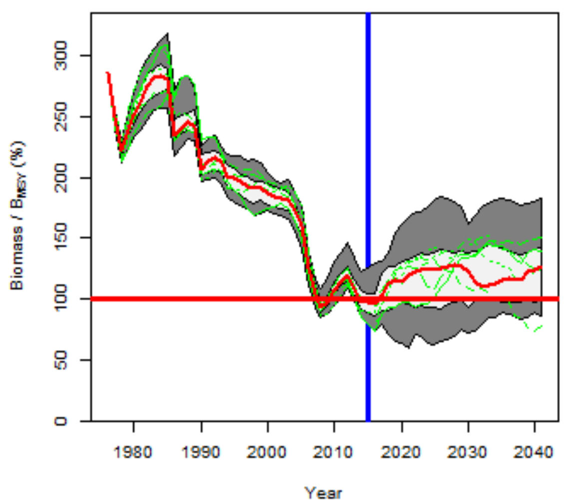
Catch very variable

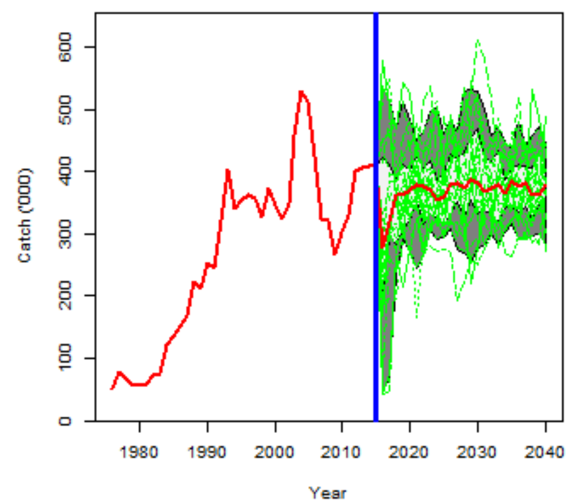


Conservative

Stock status

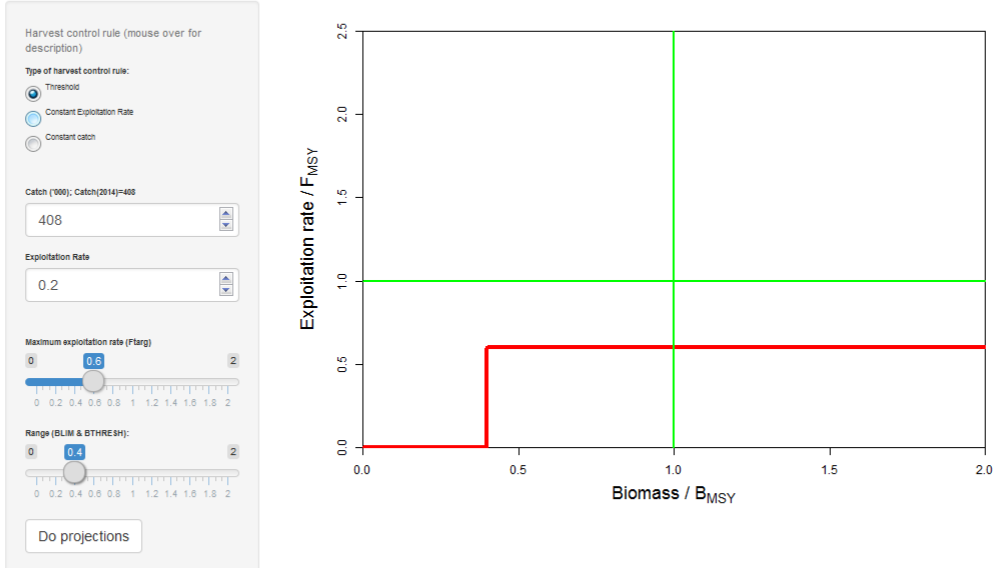
Catch





Biomass above the target on average

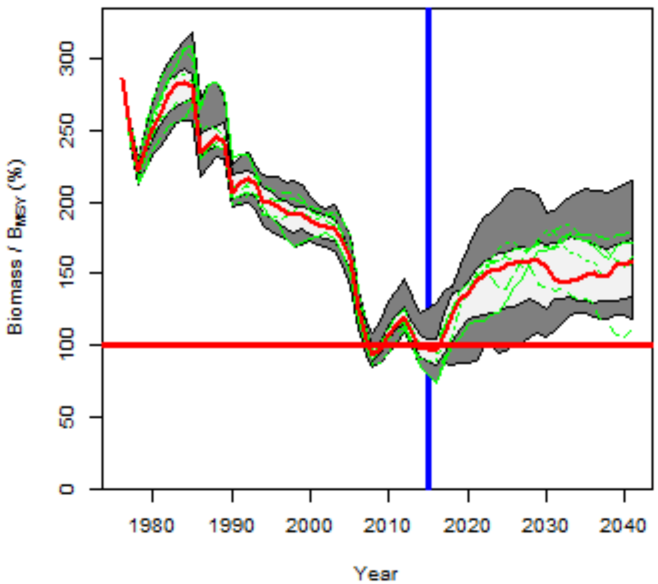
catch less variable

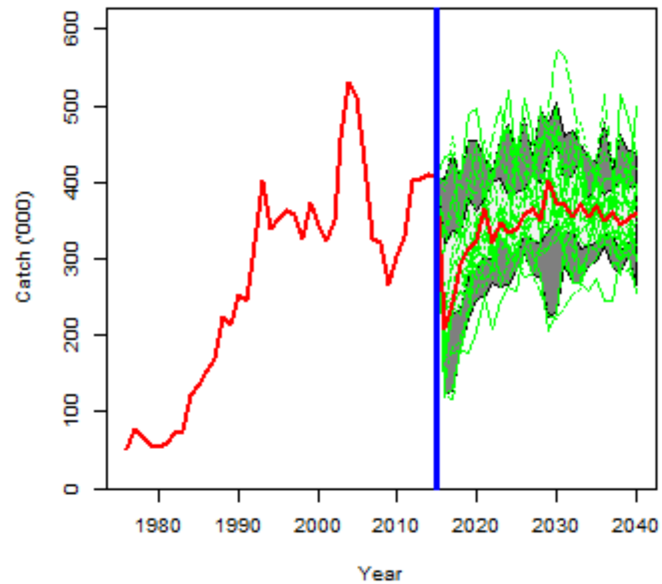


Very conservative

Stock status

Catch

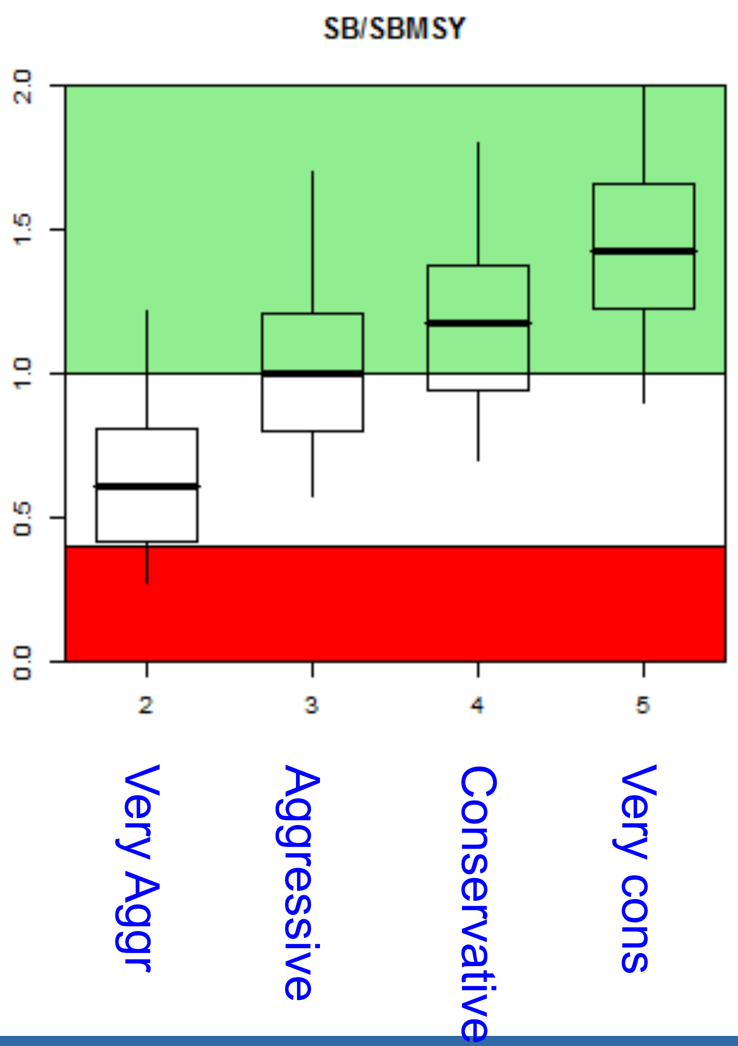


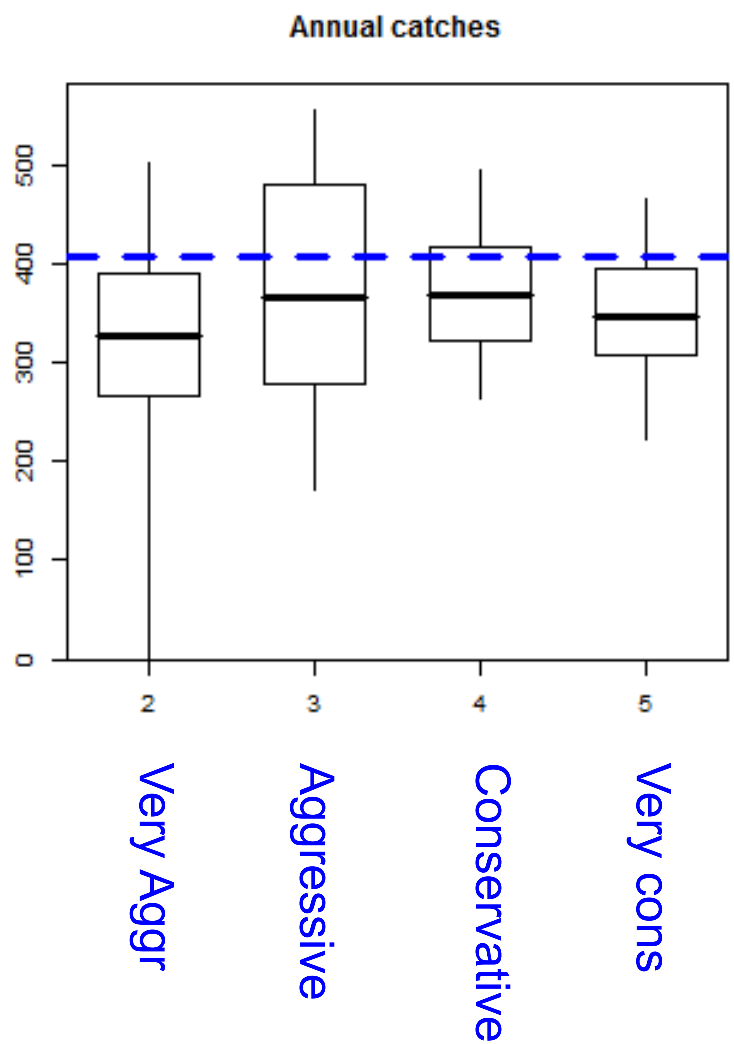


Biomass above target

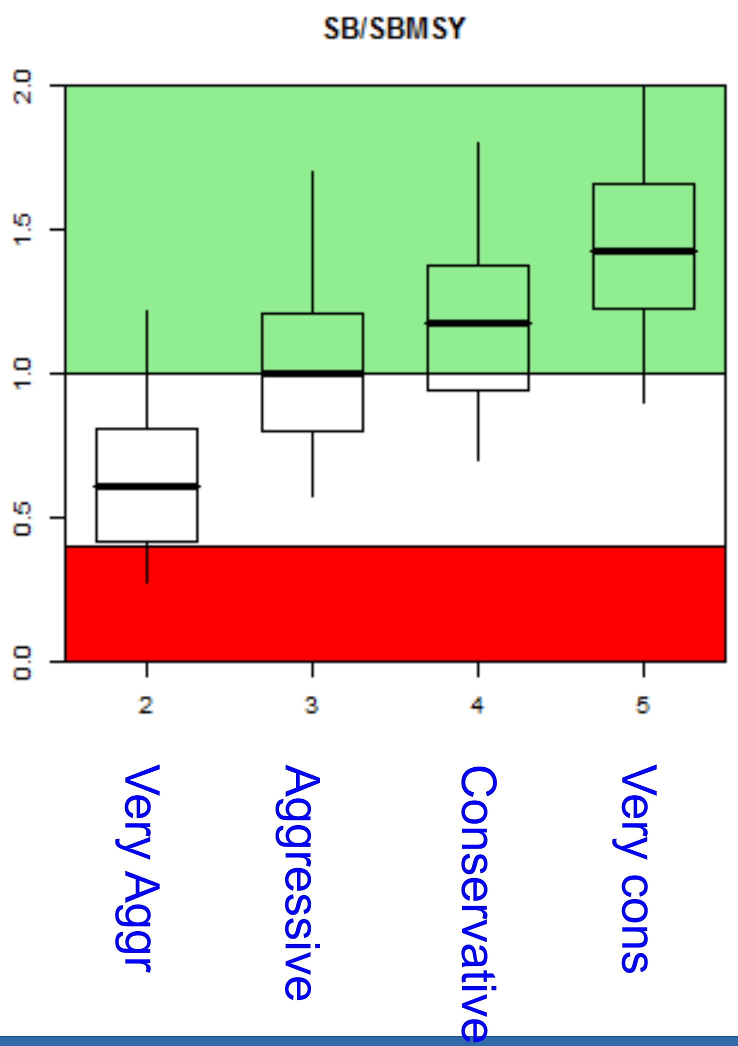
Catch low and variable

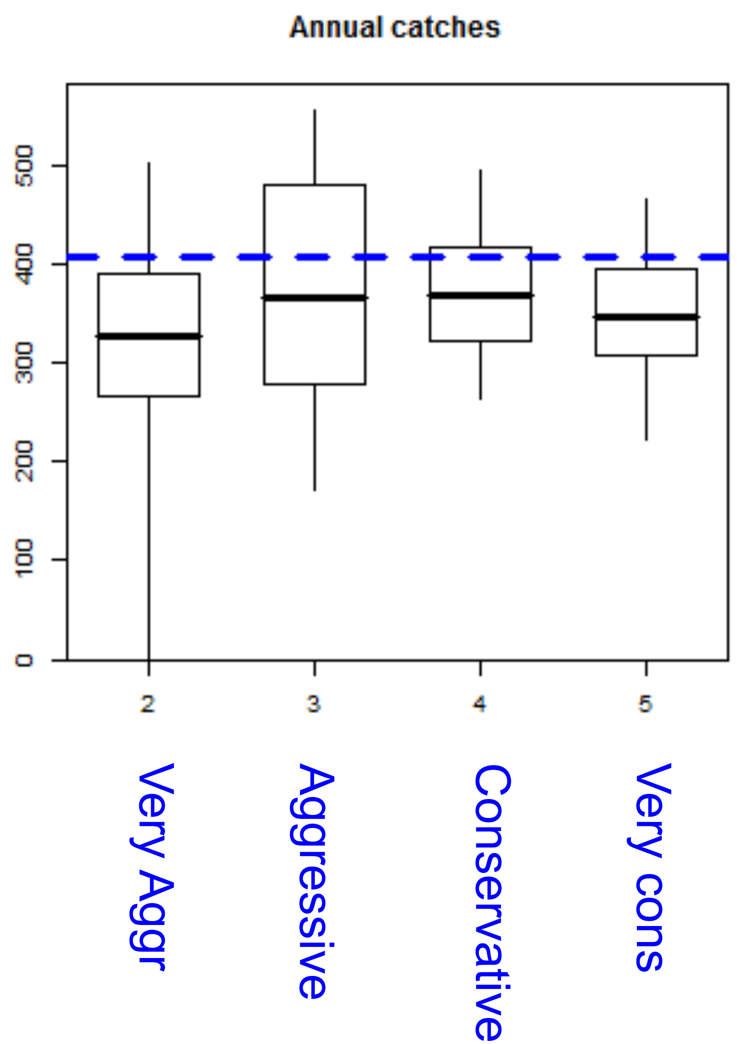
Performance measures





Performance measures





Introduction to Management Strategy Evaluation with TunaMSE: Tuna Shiny App

Dan Fu (IOTC)

Busan, Republic of Korea, 19-20 February 2020

Start the tool

- https://puntapps.shinyapps.io/tunamse/
- Go to the location of the HSDTool folder on your computer and double-click on run

Stock projection

Toy Tuna MSE | Ex 1. Manual Management | Ex 2. HCR Management | Ex 3. HCR selection | Settings

Manage the fishery 'manually' by changing the catch limit each year.

Each time you change the catch limit, discuss amongst the group why you are making the change. Your aim is to get the highest overall catch while maintaining stock status, avoiding overfishing and keeping catch variation low.

Catch limit ('000t)

180

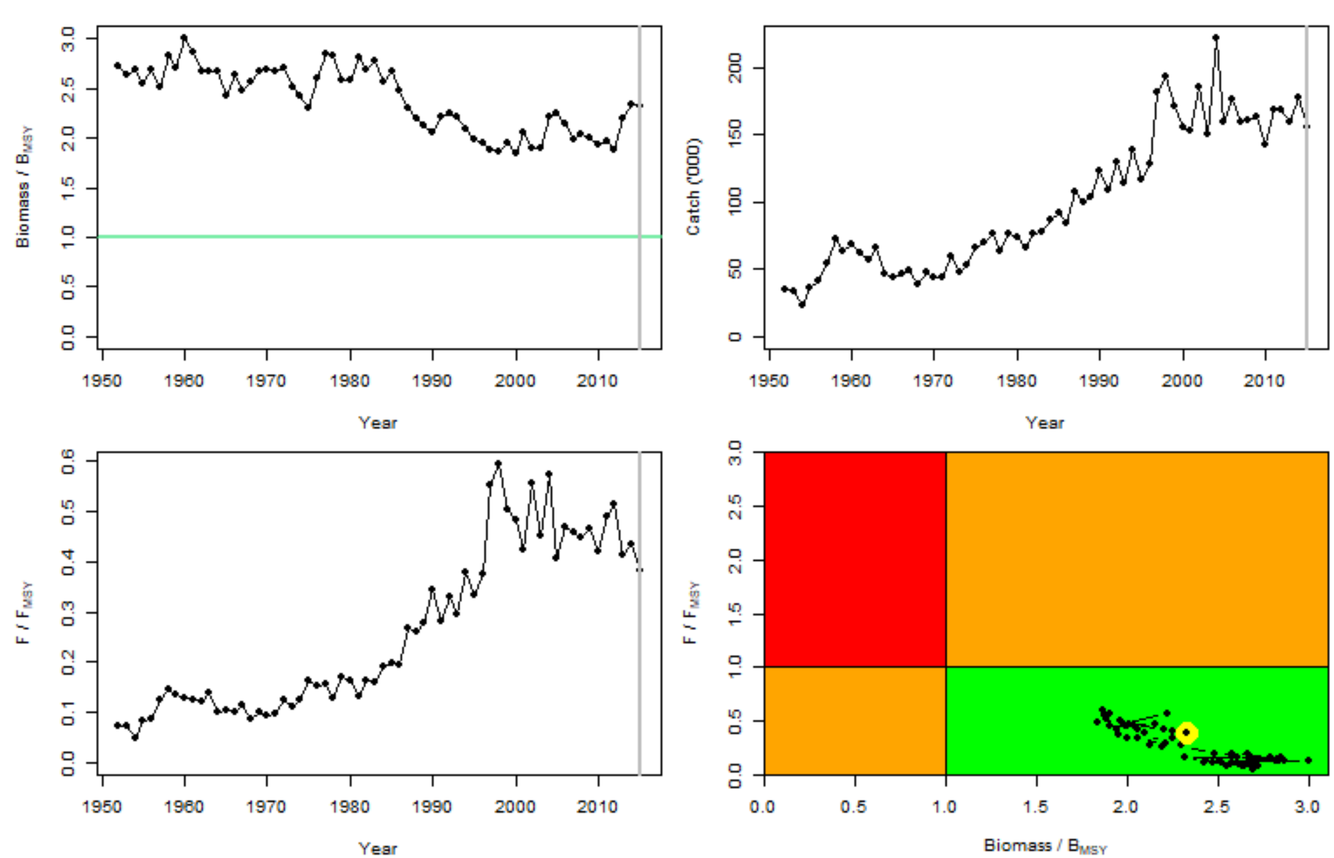
Catch limit duration (yrs)

3

Apply management | Restart

This tool was originally developed by André Punt and funded via WWF under the GEF/FAO ABNJ project and subsequently developed by several others.

Performance indicators: plots



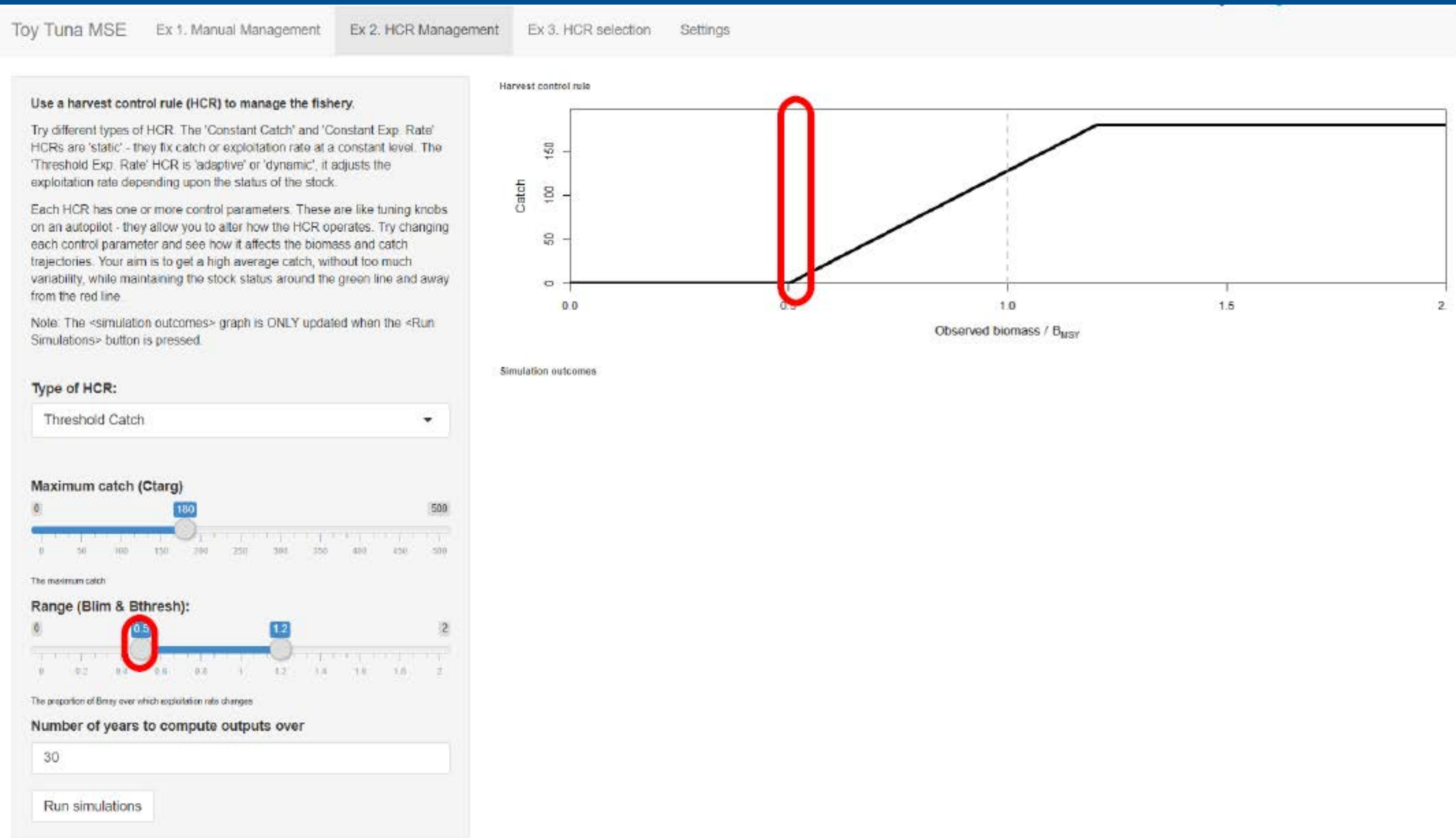
Exercise 1

Find the maximum catch that can allow the stock be in the Kobe green in 10 years (**Prob. Green =1**)

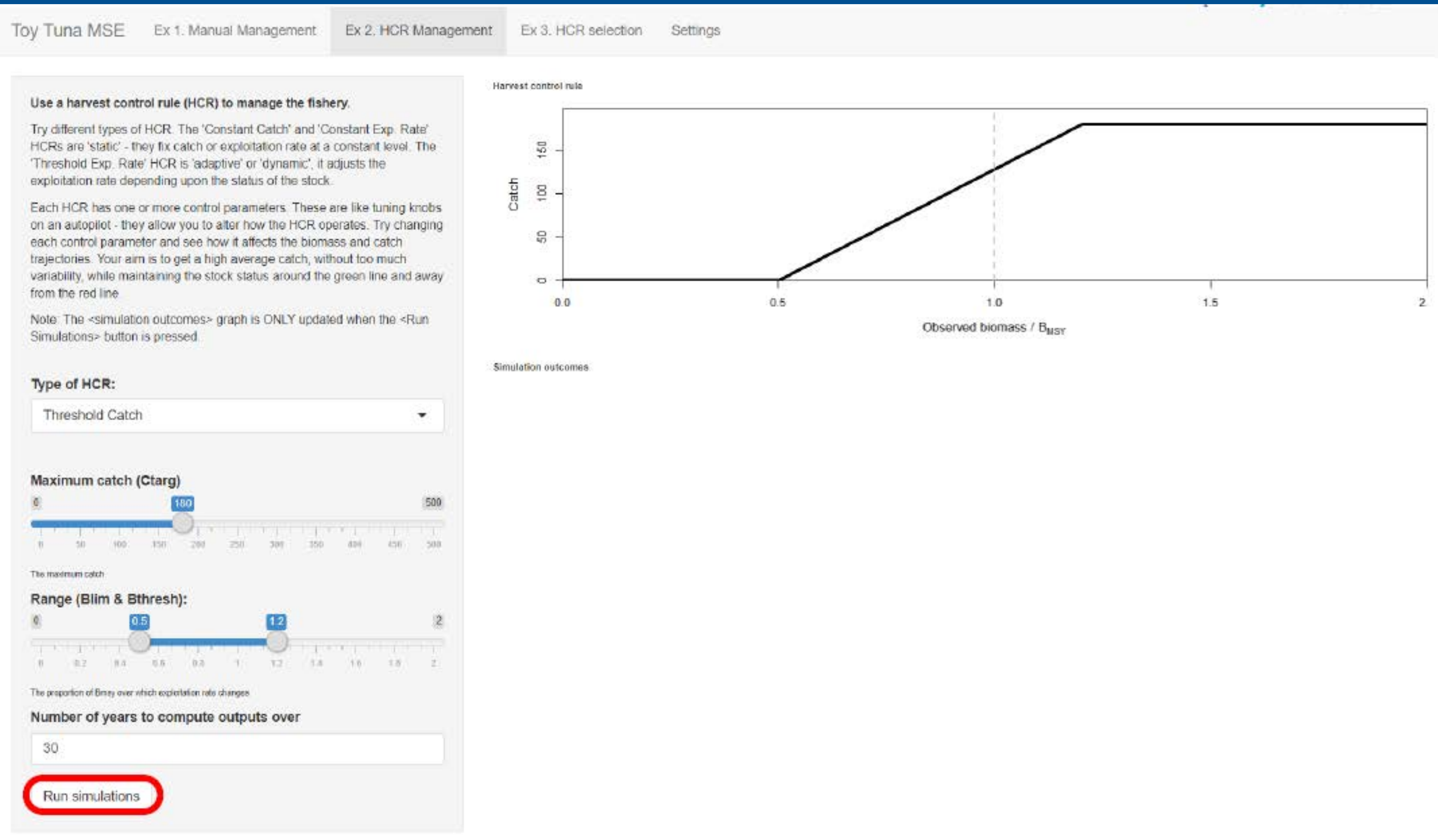
A test harvest control rule

- Blim = 0.5
- Bthresh = 1.2
- Ctarg = 180

HCR 1.1 Set the Blim slider to 0.5



HCR 1.2 Press the Run Simulations button



HCR 1.3 What happened?

Toy Tuna MSE | Ex 1. Manual Management | Ex 2. HCR Management | Ex 3. HCR selection | Settings

Use a harvest control rule (HCR) to manage the fishery.

Try different types of HCR. The 'Constant Catch' and 'Constant Exp. Rate' HCRs are 'static' - they fix catch or exploitation rate at a constant level. The 'Threshold Exp. Rate' HCR is 'adaptive' or 'dynamic', it adjusts the exploitation rate depending upon the status of the stock.

Each HCR has one or more control parameters. These are like tuning knobs on an autopilot - they allow you to alter how the HCR operates. Try changing each control parameter and see how it affects the biomass and catch trajectories. Your aim is to get a high average catch, without too much variability, while maintaining the stock status around the green line and away from the red line.

Note: The <simulation outcomes> graph is ONLY updated when the <Run Simulations> button is pressed.

Type of HCR:

Threshold Catch

Maximum catch (Ctarg)

0 180 500

The maximum catch

Range (Blim & Bthresh):

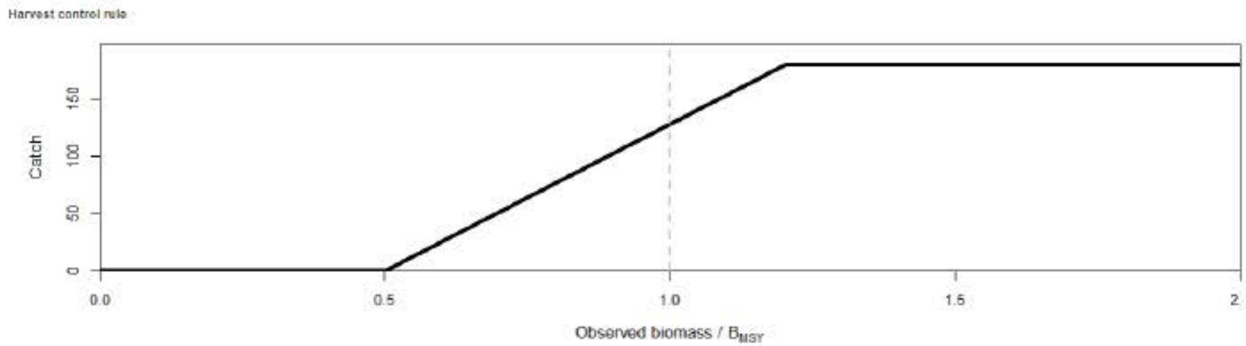
0 0.5 1.2 2

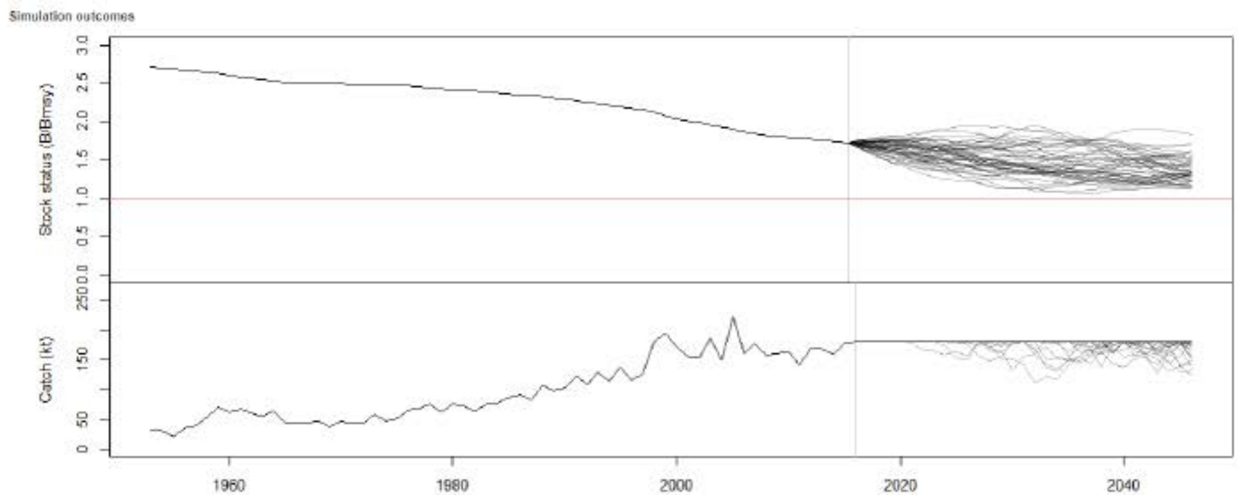
The proportion of Bmsy over which exploitation rate changes

Number of years to compute outputs over

30

Run simulations





HCR 1.3 What happened?

Toy Tuna MSE | Ex 1. Manual Management | Ex 2. HCR Management | Ex 3. HCR selection | Settings

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Type of HCR:

Threshold Catch

Maximum catch (Ctarg)

0 — 180 — 500

The maximum catch

Range (Blim & Bthresh):

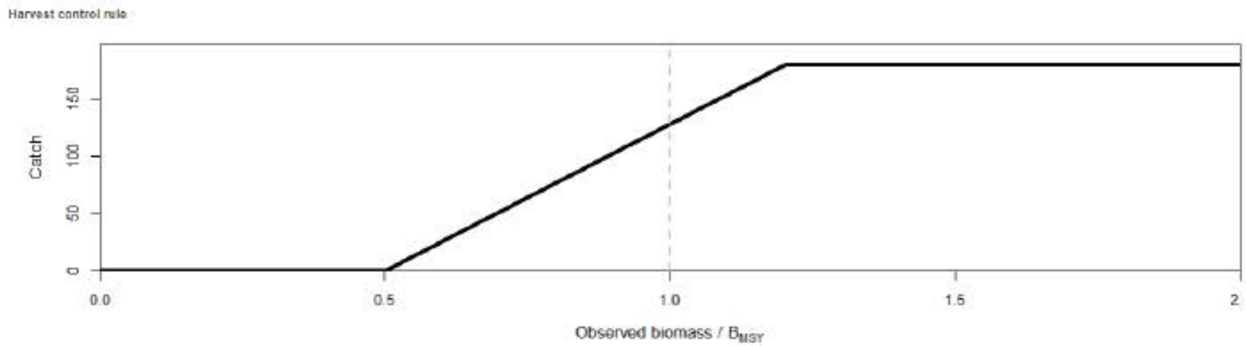
0 — 0.5 — 1.2 — 2

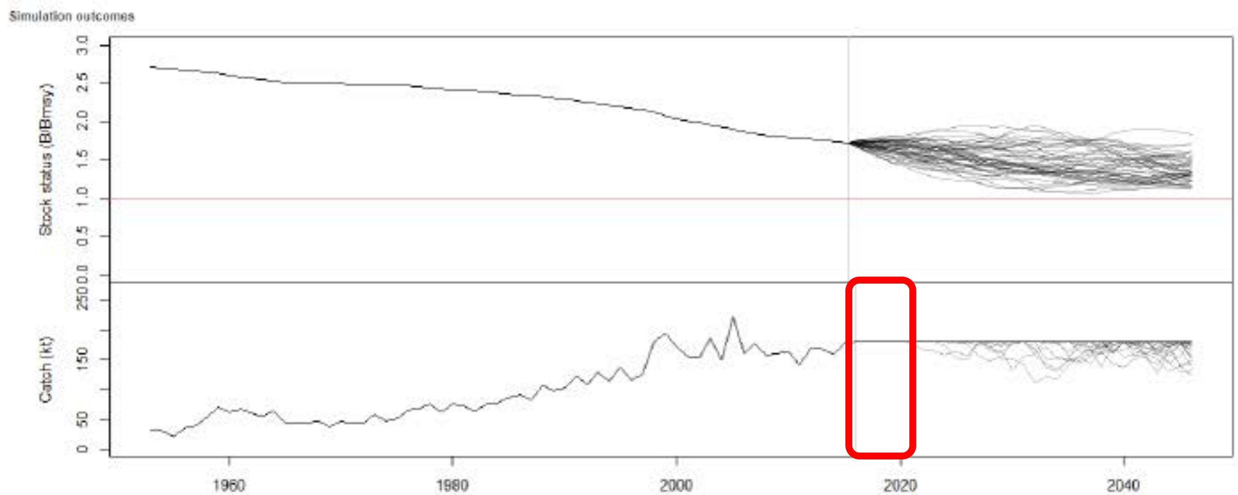
The proportion of Bmsy over which exploitation rate changes

Number of years to compute outputs over

30

Run simulations





HCR 1.6 When B/BMSY > Bthresh (1.2), catches = Ctarg

Toy Tuna MSE | Ex 1. Manual Management | Ex 2. HCR Management | Ex 3. HCR selection | Settings

Use a harvest control rule (HCR) to manage the fishery.

Try different types of HCR. The 'Constant Catch' and 'Constant Exp. Rate' HCRs are 'static' - they fix catch or exploitation rate at a constant level. The 'Threshold Exp. Rate' HCR is 'adaptive' or 'dynamic', it adjusts the exploitation rate depending upon the status of the stock.

Each HCR has one or more control parameters. These are like tuning knobs on an autopilot - they allow you to alter how the HCR operates. Try changing each control parameter and see how it affects the biomass and catch trajectories. Your aim is to get a high average catch, without too much variability, while maintaining the stock status around the green line and away from the red line.

Note: The <simulation outcomes> graph is ONLY updated when the <Run Simulations> button is pressed.

Type of HCR:

Threshold Catch

Maximum catch (Ctarg)

0 — 180 — 500

The maximum catch

Range (Blim & Bthresh):

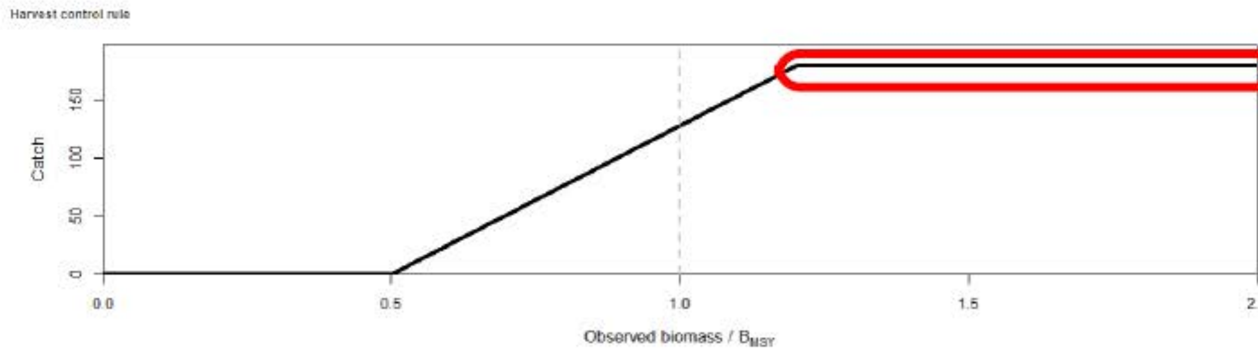
0 — 0.5 — 1.2 — 2

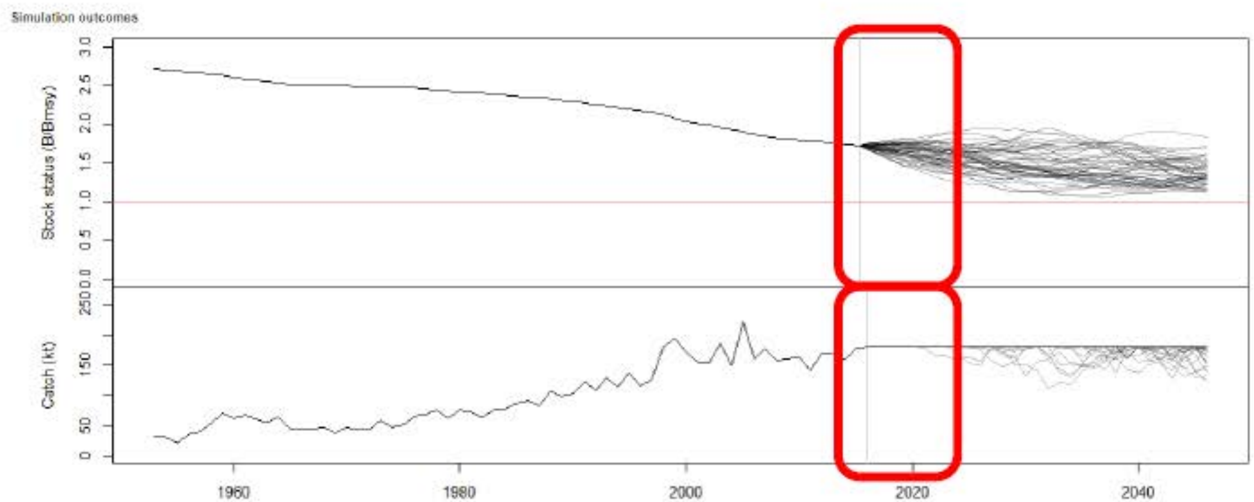
The proportion of Bmsy over which exploitation rate changes

Number of years to compute outputs over

30

Run simulations





HCR 1.3 What happened?

Toy Tuna MSE | Ex 1. Manual Management | Ex 2. HCR Management | Ex 3. HCR selection | Settings

Use a harvest control rule (HCR) to manage the fishery.

Try different types of HCR. The 'Constant Catch' and 'Constant Exp. Rate' HCRs are 'static' - they fix catch or exploitation rate at a constant level. The 'Threshold Exp. Rate' HCR is 'adaptive' or 'dynamic', it adjusts the exploitation rate depending upon the status of the stock.

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Note: The <simulation outcomes> graph is ONLY updated when the <Run Simulations> button is pressed.

Type of HCR:

Threshold Catch

Maximum catch (Ctarg)

0 — 180 — 500

The maximum catch

Range (Blim & Bthresh):

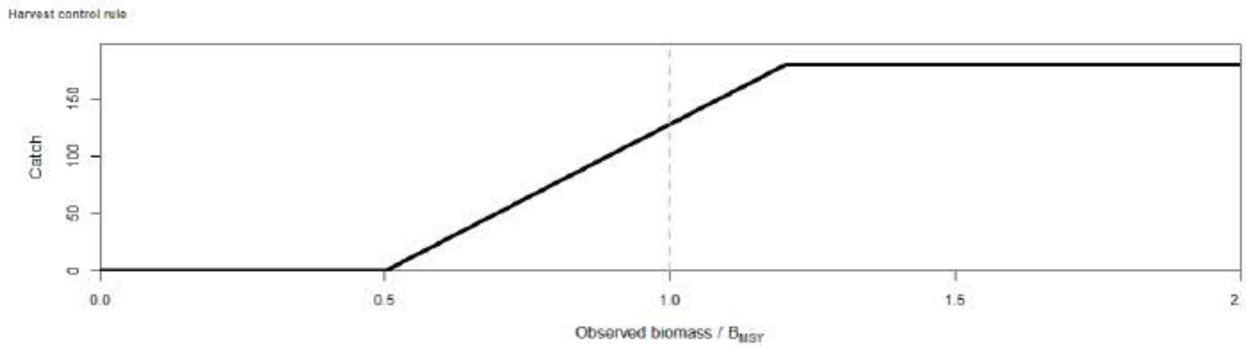
0 — 0.5 — 1.2 — 2

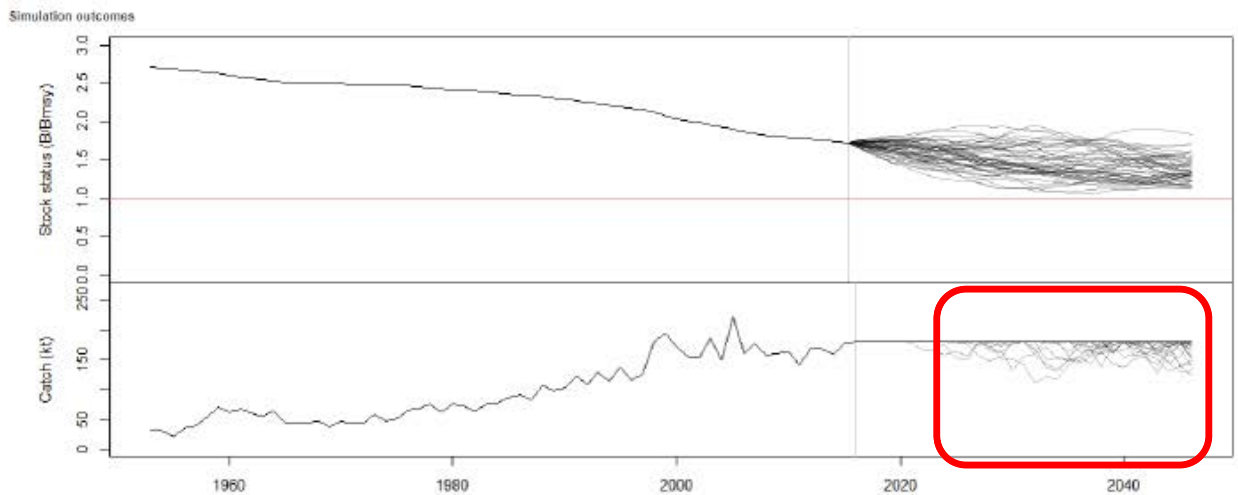
The proportion of Bmsy over which exploitation rate changes

Number of years to compute outputs over

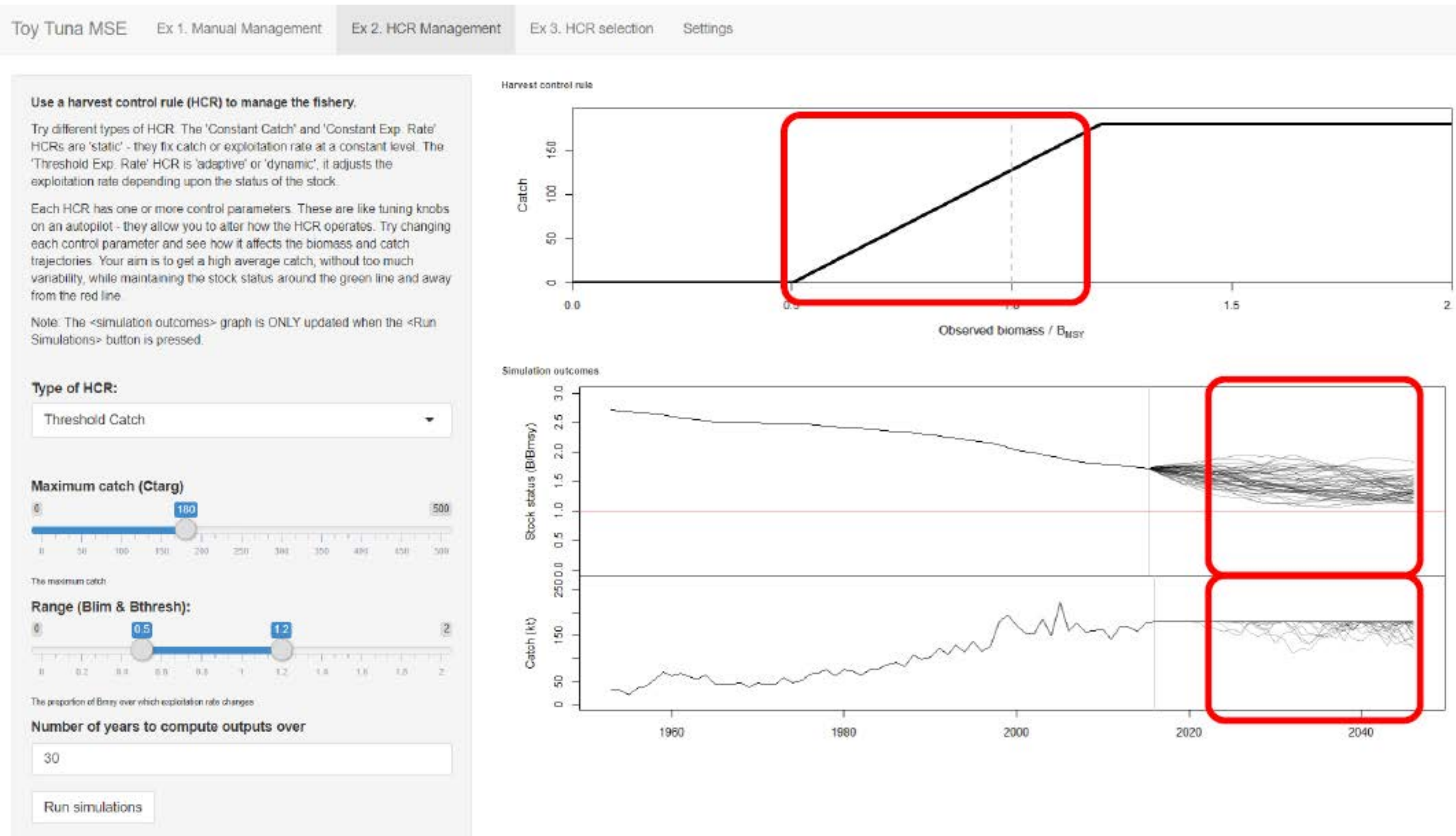
30

Run simulations





HCR 1.7 When B/BMSY drops below Bthresh, catches are reduced



HCR 1.9 Performance Indicators

Toy Tuna MSE | Ex 1. Manual Management | Ex 2. HCR Management | Ex 3. HCR selection | Settings

Select the HCR that best acheives your management objectives.

The performance indicators have been recorded for each of the HCR's that you tested during Excercise 2. Select one HCR that you think has the best tradeoffs amongst the performance indicators. You can go back to Excercise 2 and evaluate more HCRs to try and find a HCR with even better performance.

Plot trajectories for which HCR?

1

Use this to choose which HCR to plot trajectories for.

Type of plot:

Kobe

Use this to choose between a Kobe and Majuro plot. Note that these plots show the results in the final year of the projection.

Key

HCR control parameters

Catch is the constant catch.

*Exp. rate is the constant exploitation rate.

Ftarg and Ctarg define the maximum output of the threshold HCRs.

Blim and Bthresh are the input limits of the HCR. If an threshold exploitation rate HCR is used they are biomass relative to Bmsy. If a threshold catch HCR is used they are biomass relative to BF0

Performance indicators

Median depletion (%) : Median of B/unfished B.

*Prob. green : probability of being above B > BMSY and F < FMSY.

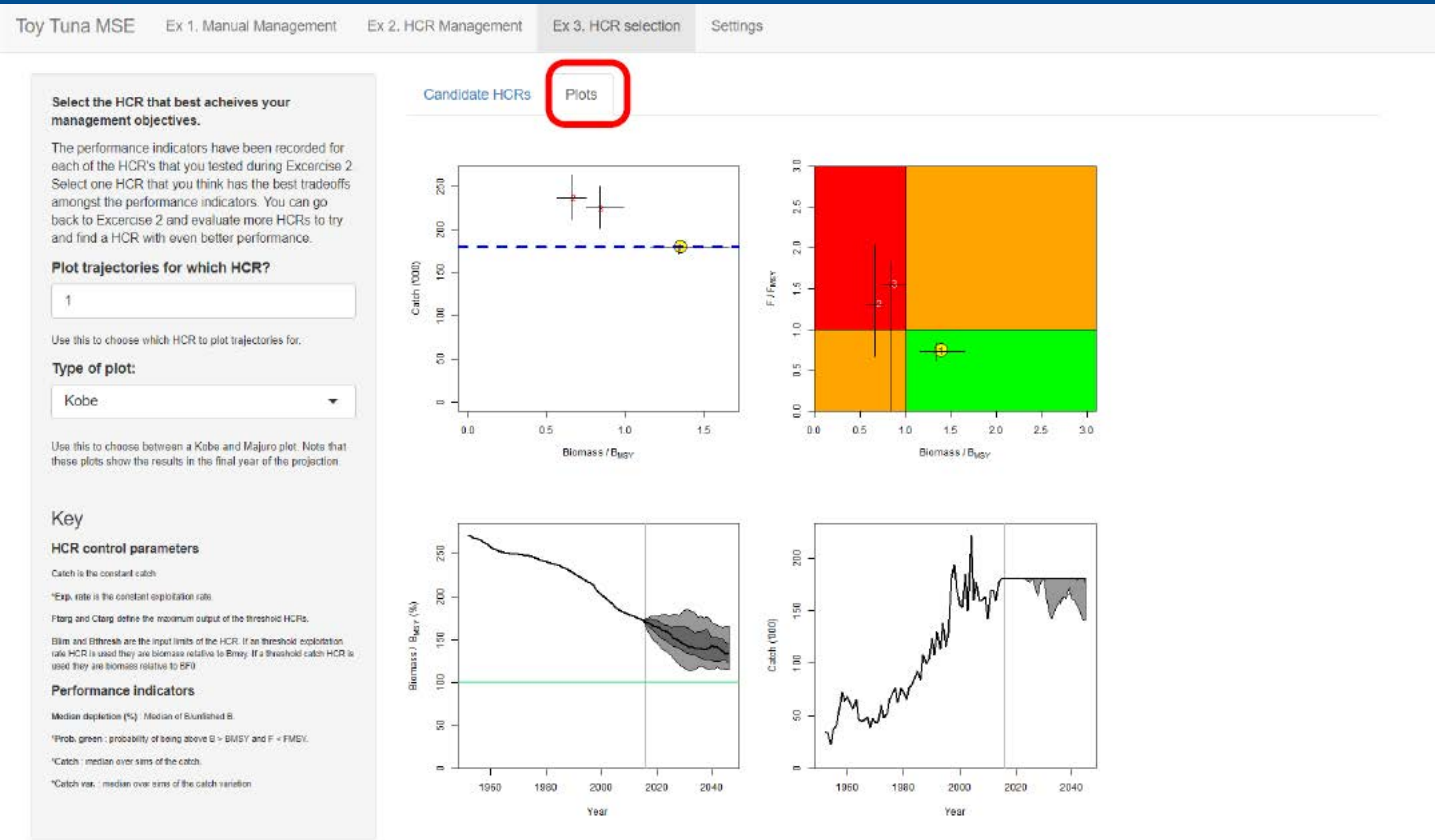
*Catch : median over sims of the catch.

*Catch var. : median over sims of the catch variation

Candidate HCRs | Plots

HCR	Type	Catch	Exp. rate	Fmult	Cmax	Blim	Bthresh	Median B/BMSY	*Prob. green	*Catch	*Catch var.	No. yrs average
1	Threshold Catch	NA	NA	NA	180	0.5	1.2	1.48	1	179.8	0.009	30

Plotting the HCRs 1



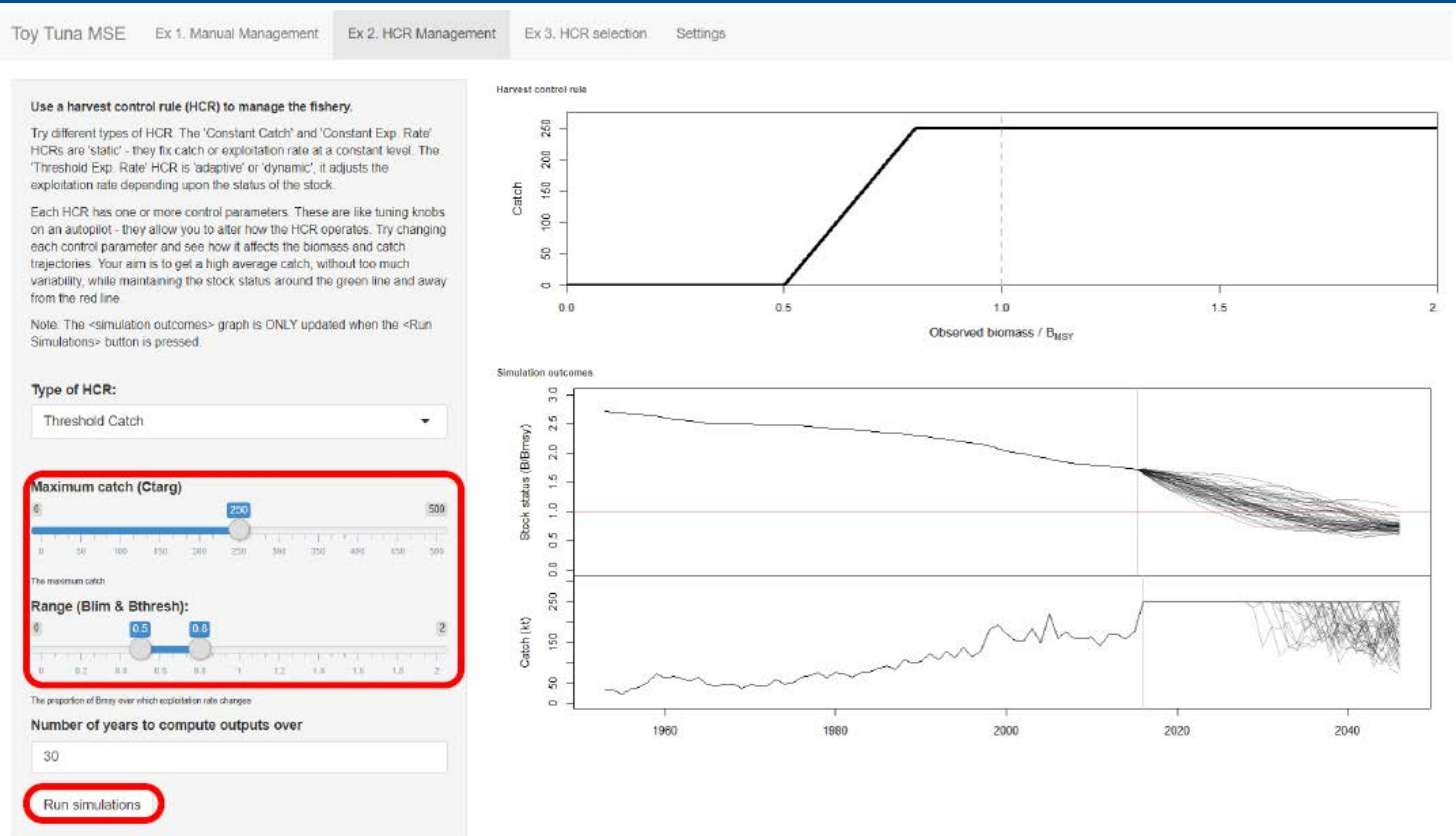
Another Harvest Control Rule

Let's set up another Harvest Control Rule.

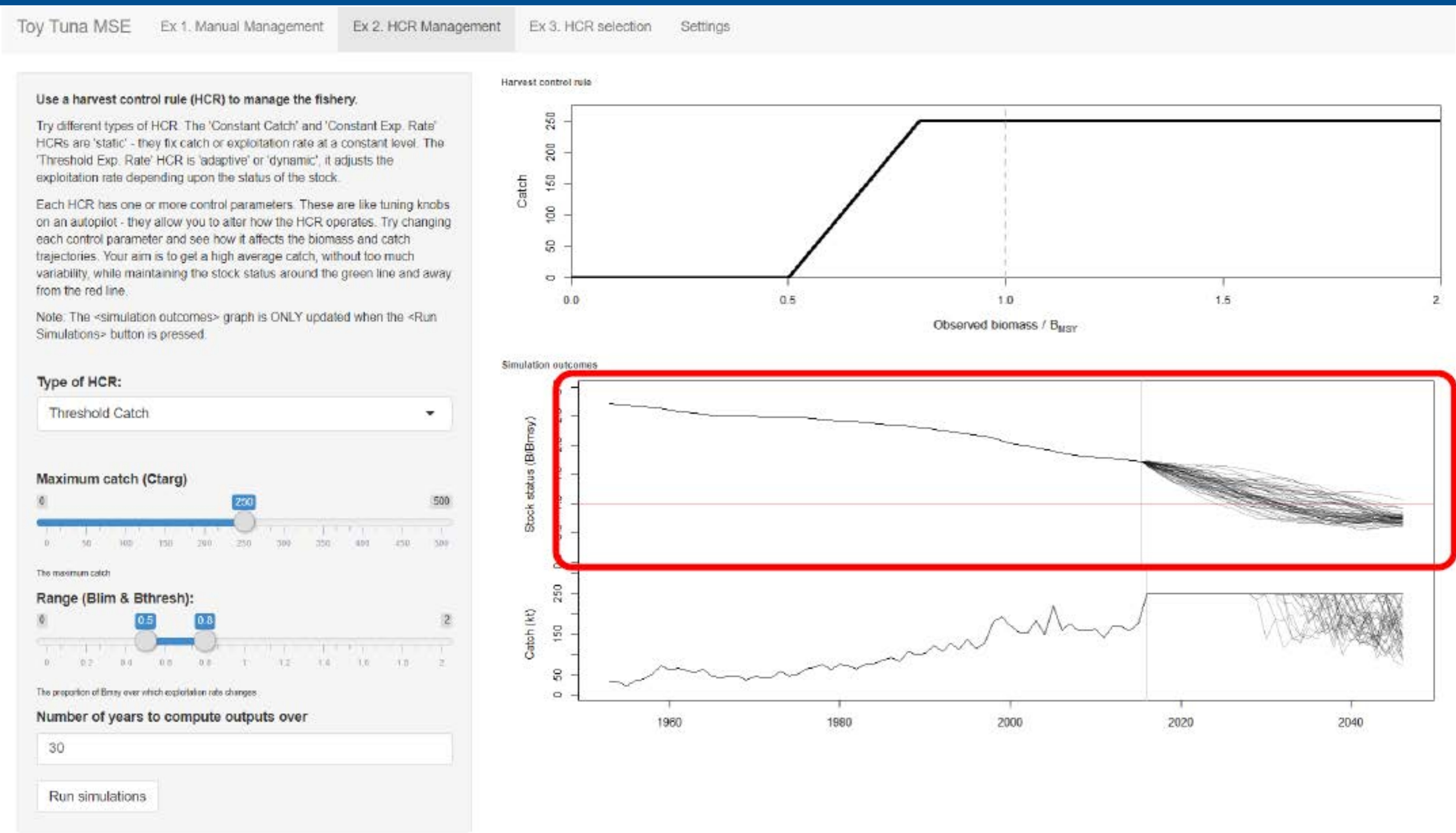
Can we improve performance?

- Blim = 0.5
- Bthresh = 0.8
- Ctarg = 250

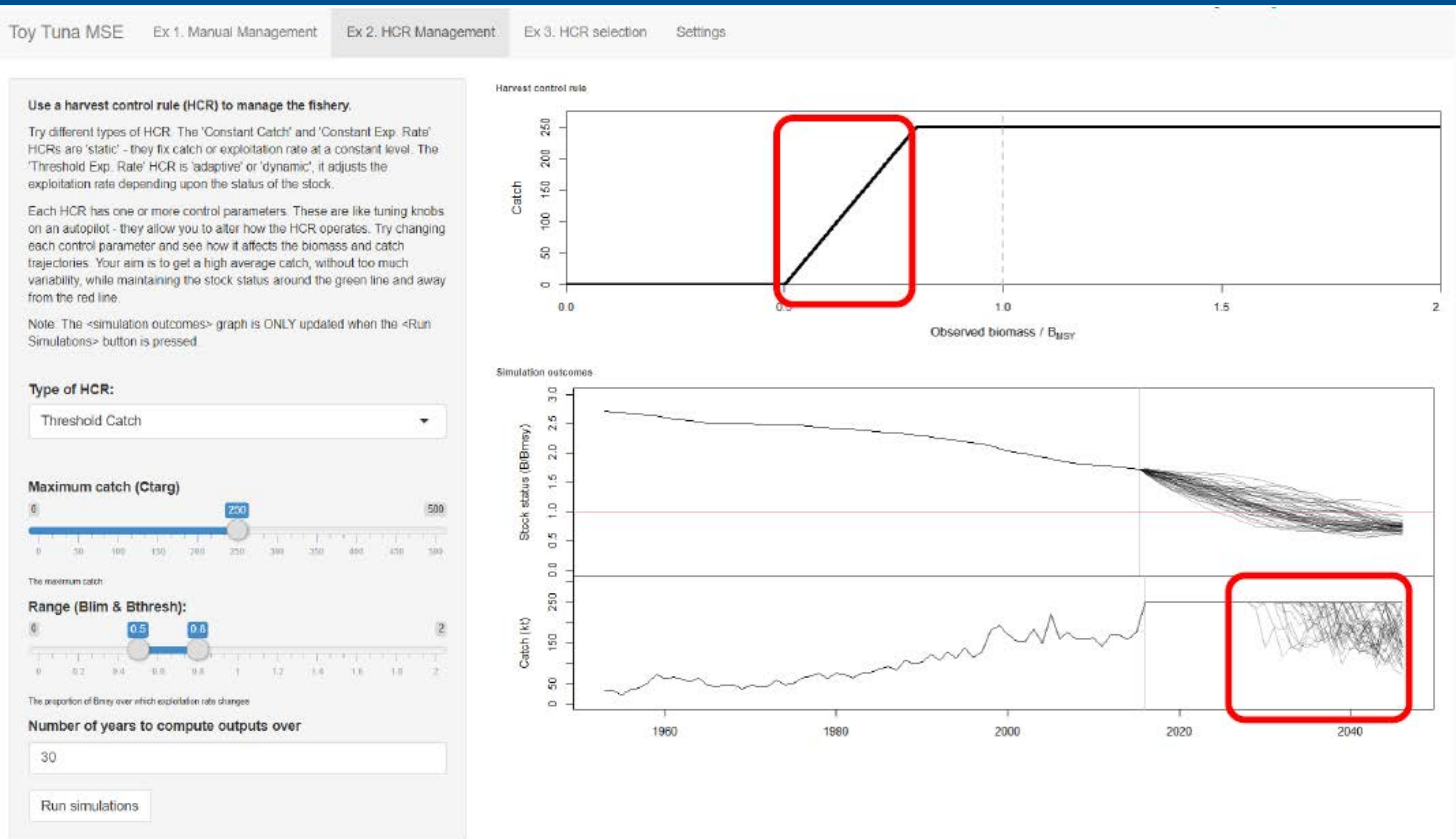
HCR 2.1 Blim=0.5, Bthresh=0.8, Ctarg=250



HCR 2.2 What happened? Biomass starts to declines below BMSY...



HCR 2.3 ...but catches not cut until B/BMSY < Bthresh (0.8)



HCR 2.5 Compare the HCRs

Toy Tuna MSE | Ex 1. Manual Management | Ex 2. HCR Management | Ex 3. HCR selection | Settings

Select the HCR that best acheives your management objectives.

The performance indicators have been recorded for each of the HCR's that you tested during Excercise 2. Select one HCR that you think has the best tradeoffs amongst the performance indicators. You can go back to Excercise 2 and evaluate more HCRs to try and find a HCR with even better performance.

Plot trajectories for which HCR?

1

Use this to choose which HCR to plot trajectories for.

Type of plot:

Kobe

Use this to choose between a Kobe and Majuro plot. Note that these plots show the results in the final year of the projection

Key

HCR control parameters

Catch is the constant catch

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Performance indicators

Median depletion (%) : Median of B/unfished B

*Prob. green : probability of being above B > BMSY and F < FMSY.

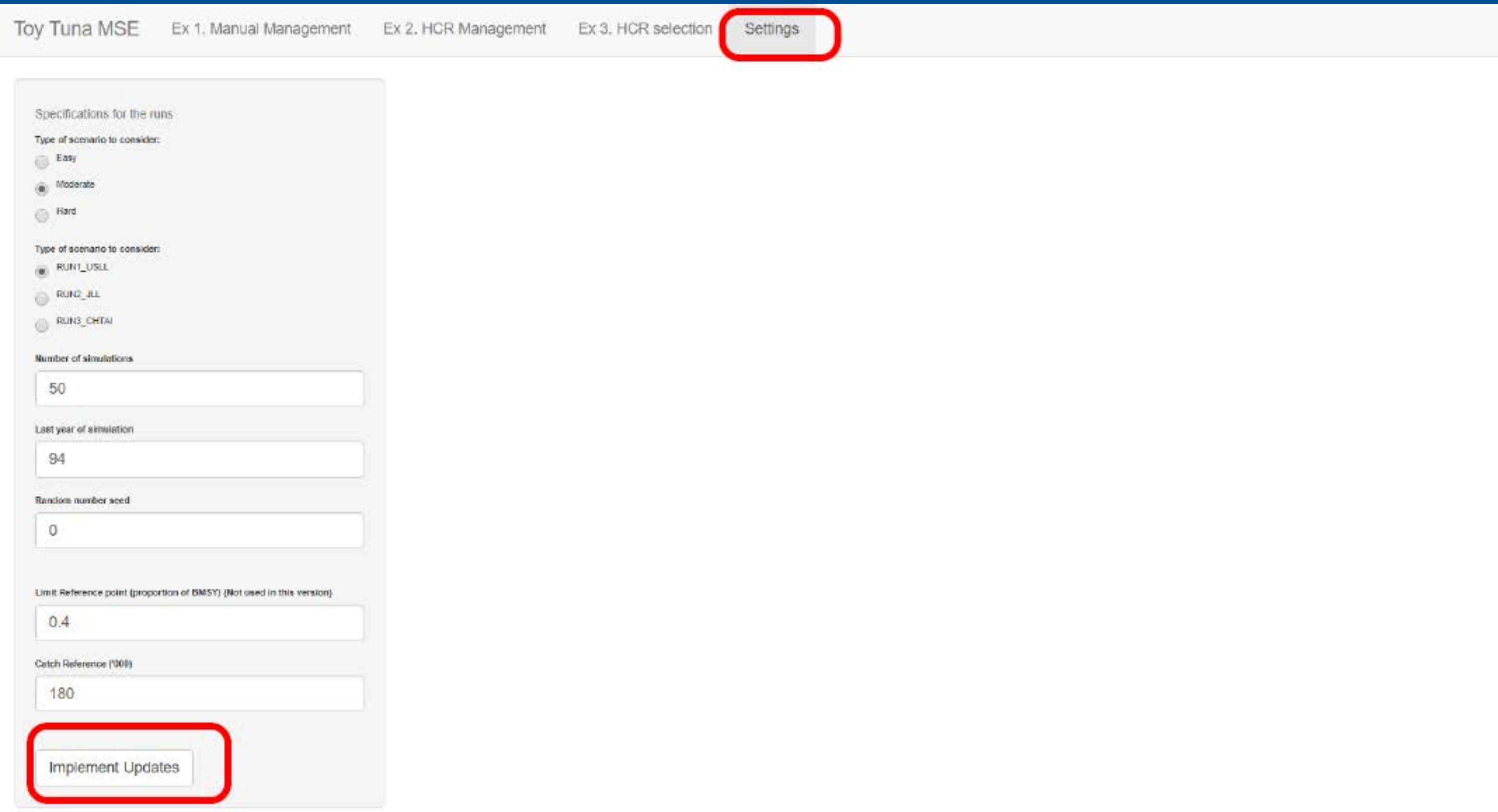
*Catch : median over sims of the catch.

*Catch var. : median over sims of the catch variation

Candidate HCRs | Plots

HCR	Type	Catch	Exp. rate	Fmult	Cmax	Blim	Bthresh	Median B/BMSY	*Prob. green	*Catch	*Catch var.	No. yrs average
1	Threshold Catch	NA	NA	NA	180	0.5	1.2	1.48	1	179.8	0.009	30
2	Threshold Catch	NA	NA	NA	250	0.5	0.8	1.07	0.219	234.7	0.036	30

Clearing HCRs



Now you try. Competition time!

OBJECTIVES

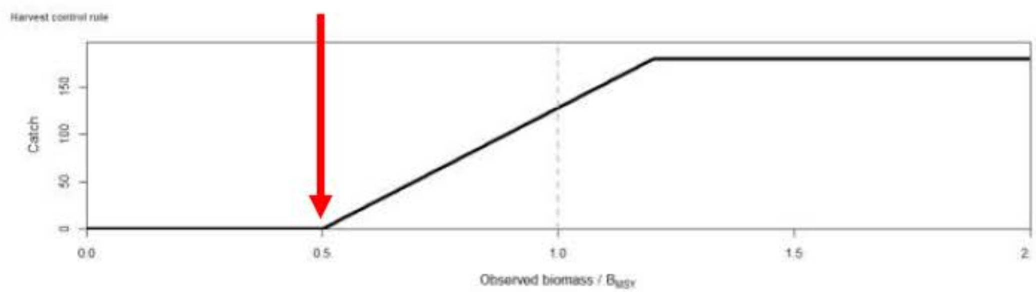
- $SB/SB_{msy} = 1$
- Maximise catch

CONSTRAINTS

- Use threshold catch HCR (the one we have been using
- Fix B_{lim} at 0.5 SB/SB_{msy}

MANAGEMENT

- Find combination of B_{thresh} and C_{targ} that achieves objectives



Now you try. Competition time!

OBJECTIVES

- High catches
- Biological sustainability

CONSTRAINTS

- Use threshold catch HCR (the one we have been using
- Fix B_{lim} at 0.5 SB/SB_{msy}

MANAGEMENT

- Find combination of B_{thresh} and C_{targ} that:
  - Gives highest catches
  - But probability of being in the green zone of the Kobe plot must be greater than or equal to 0.7

CURRENT STATUS OF IOTC MANAGEMENT STRATEGY EVALUATIONS

Bigeye Tuna

Dale Kolody & Paavo Jumppanen – CSIRO
With guidance from the IOTC MSE Task Force

TCMP-02 (2018) : 3 Tuning Objectives

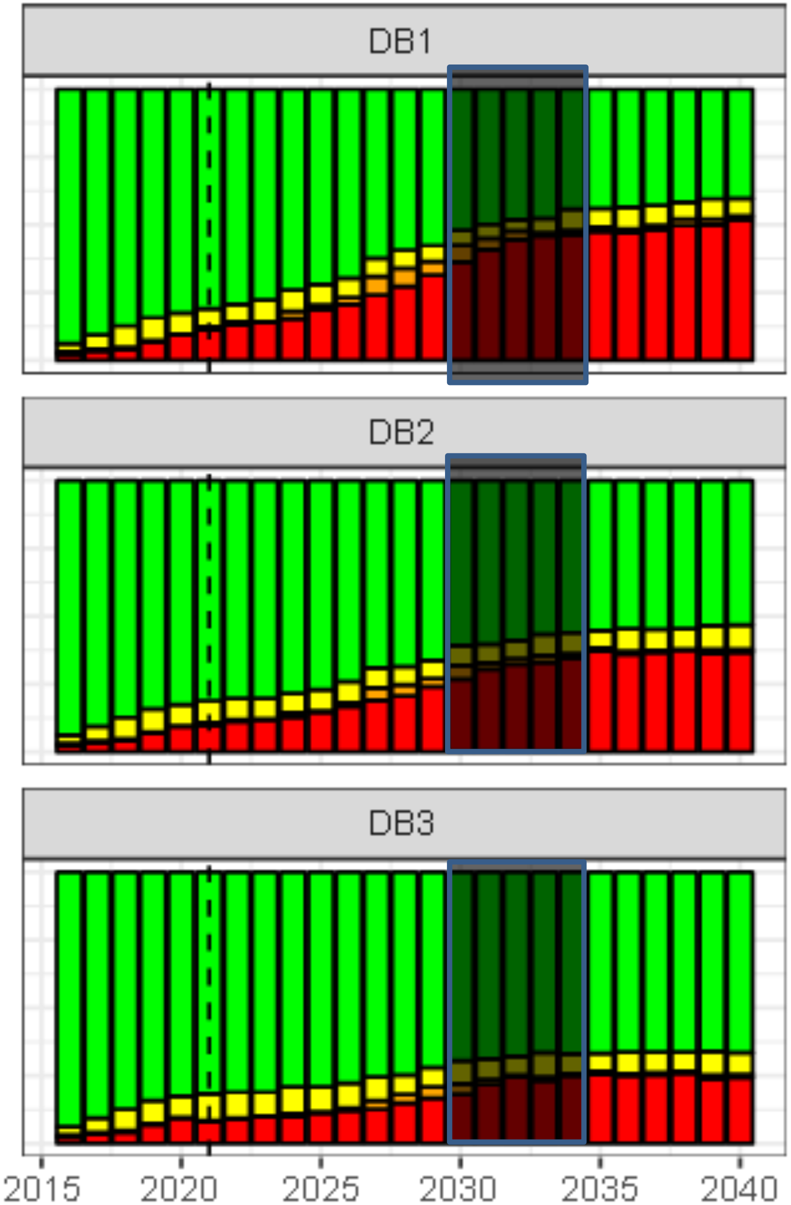
B1: Pr(Kobe green zone 2030:2034) = **0.5**

B2: Pr(Kobe green zone 2030:2034) = **0.6**

B3: Pr(Kobe green zone 2030:2034) = **0.7**

The stock status is in the Kobe green quadrant over the period 2030:2034 exactly 50, 60 or 70 % of the time (averaged over all simulations).

Visualizing the Tuning Objectives: Time series of Kobe quadrant probabilities



B1: 50% **K**obe green zone

B2: 60% **K**obe green zone

B3: 70% **K**obe green zone

TCMP-01 Initial MP development guidance

Other MP implementation constraints:

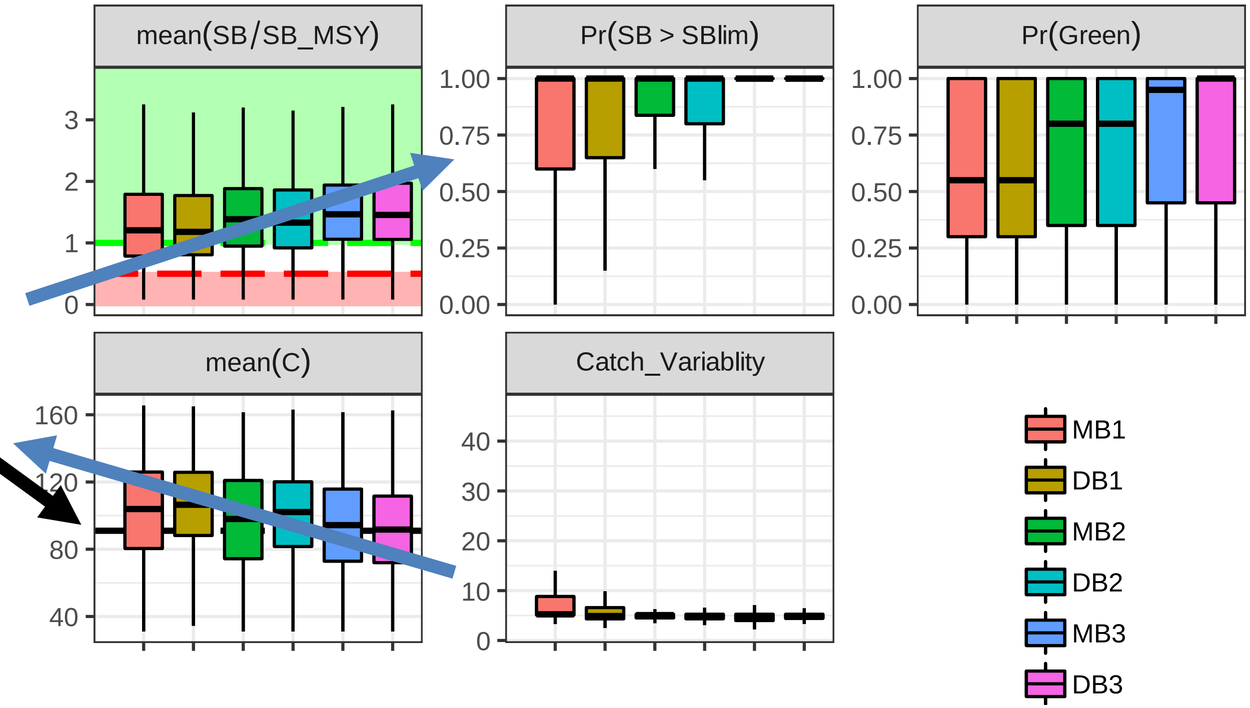
- Frequency of quota setting
  - First MP setting: 2021
  - Then every 3 years
- TAC change constraints
  - Maximum 15% change (increase or decrease)
  - (achievable for all BET tuning objectives)
- 2 year Implementation data lag
  - E.g. 2019 CPUE available for 2021 TAC setting

Fig. 3

2021-2040

performance summary

- All tuning levels likely to result in catch equal to or exceeding current catch



- Higher catch = higher risk

- i.e. no surprises

Fig. 4

2021-2040

performance summary

- All tuning levels likely to result in catch equal to or exceeding current catch

- Higher catch = higher risk

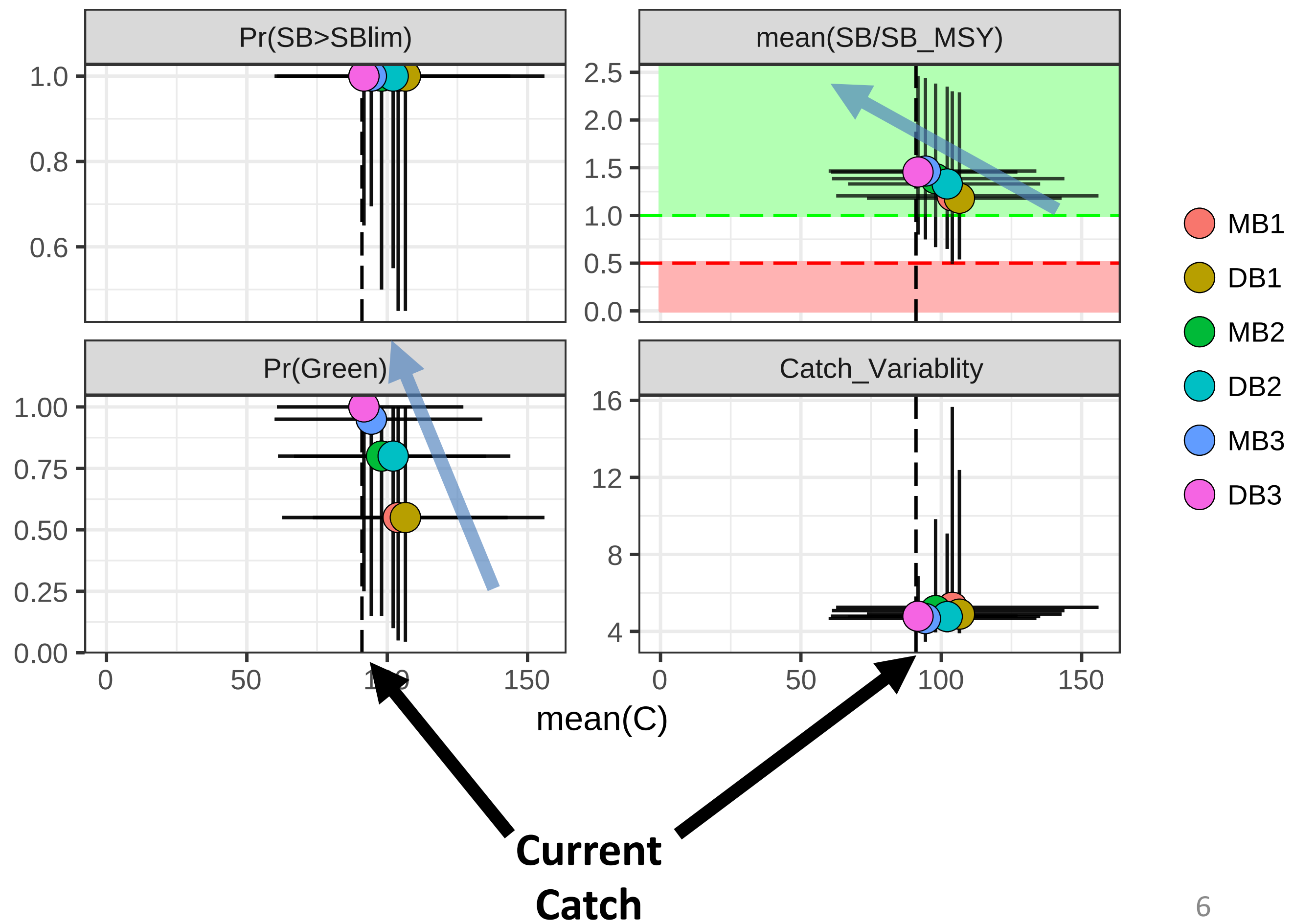


Fig.5

2021-2040

performance summary

- Tuning level more important than MP-Class
- 3 Tuning levels cover broad range of trade-off space

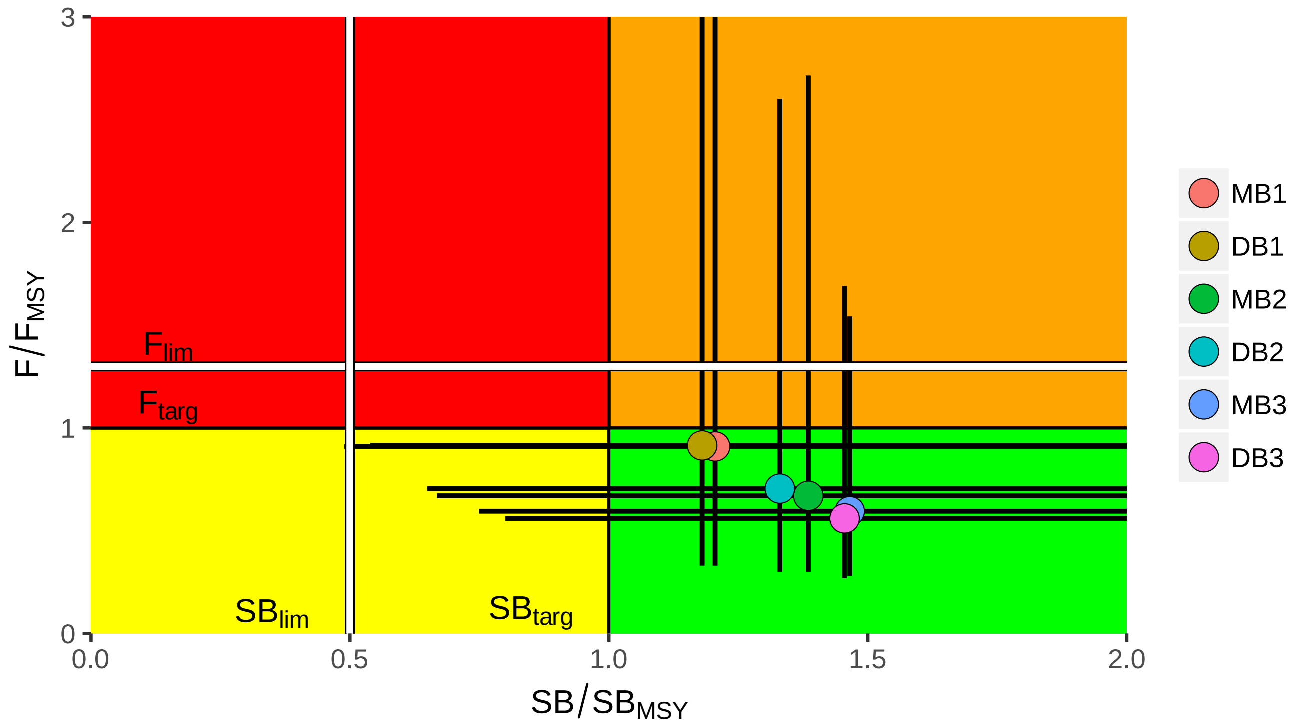
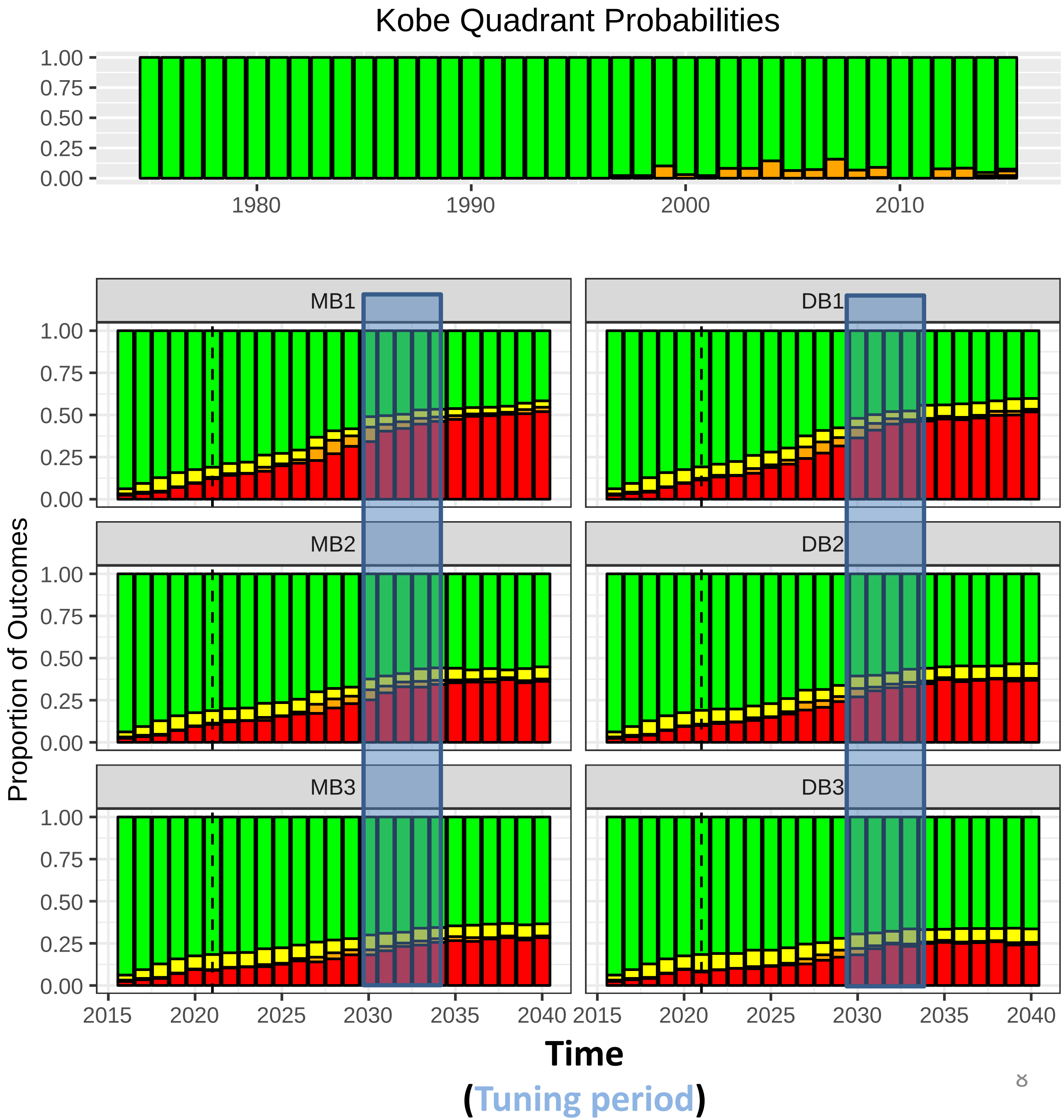


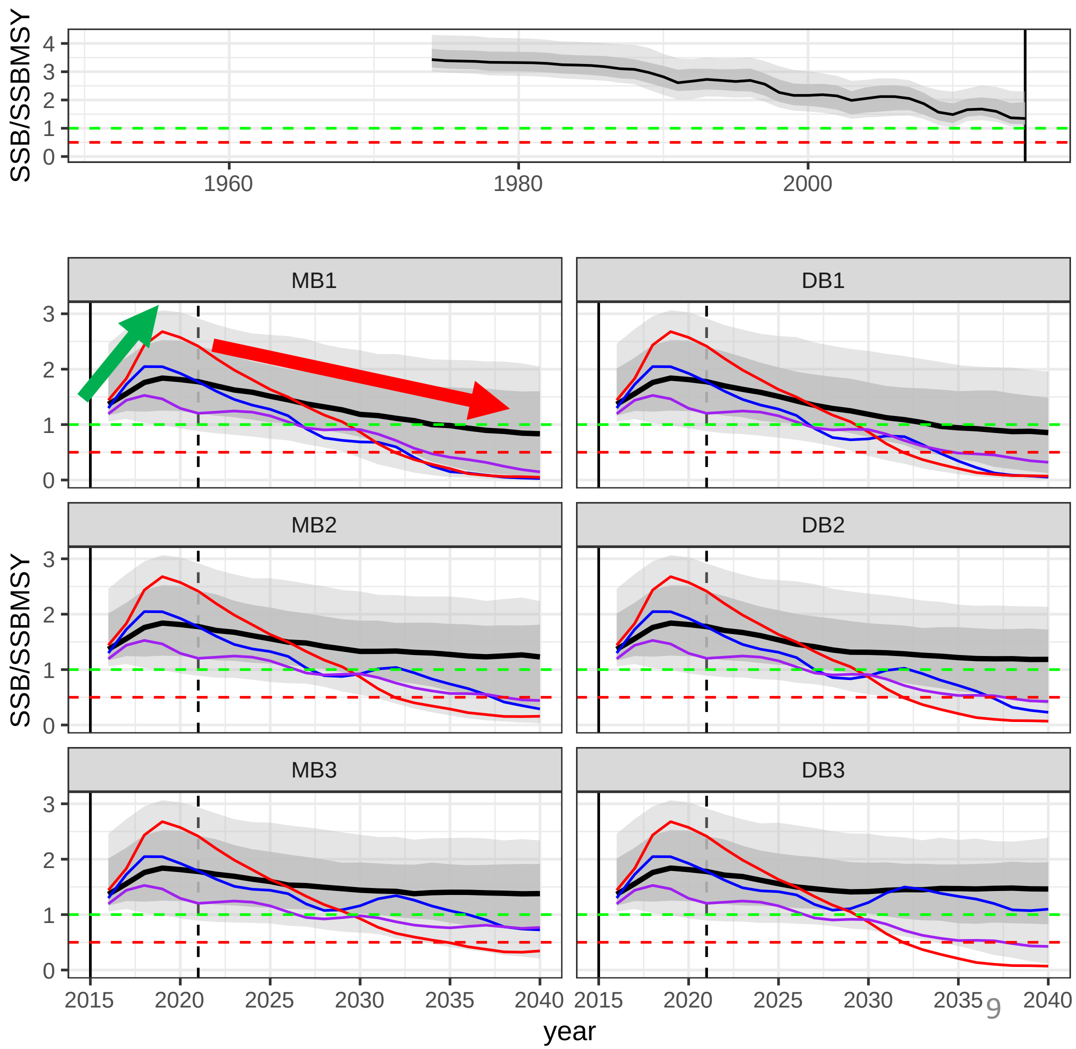
Fig. 6


Kobe Quadrant Probabilities
1.00
0.75
0.50
0.25
0.00
1980
1990
2000
2010
MB1
DB1
MB2
DB2
MB3
DB3
Proportion of Outcomes
2015
2020
2025
2030
2035
2040
Time
(Tuning period)

Key Results of Candidate MP Evaluations

- Fig. 7
- Current low catches cause Biomass rebuilding prior to first MP setting
- MP must cause biomass decline to meet defined tuning objectives
- B1 requires the biggest biomass decrease.

Spawning Biomass

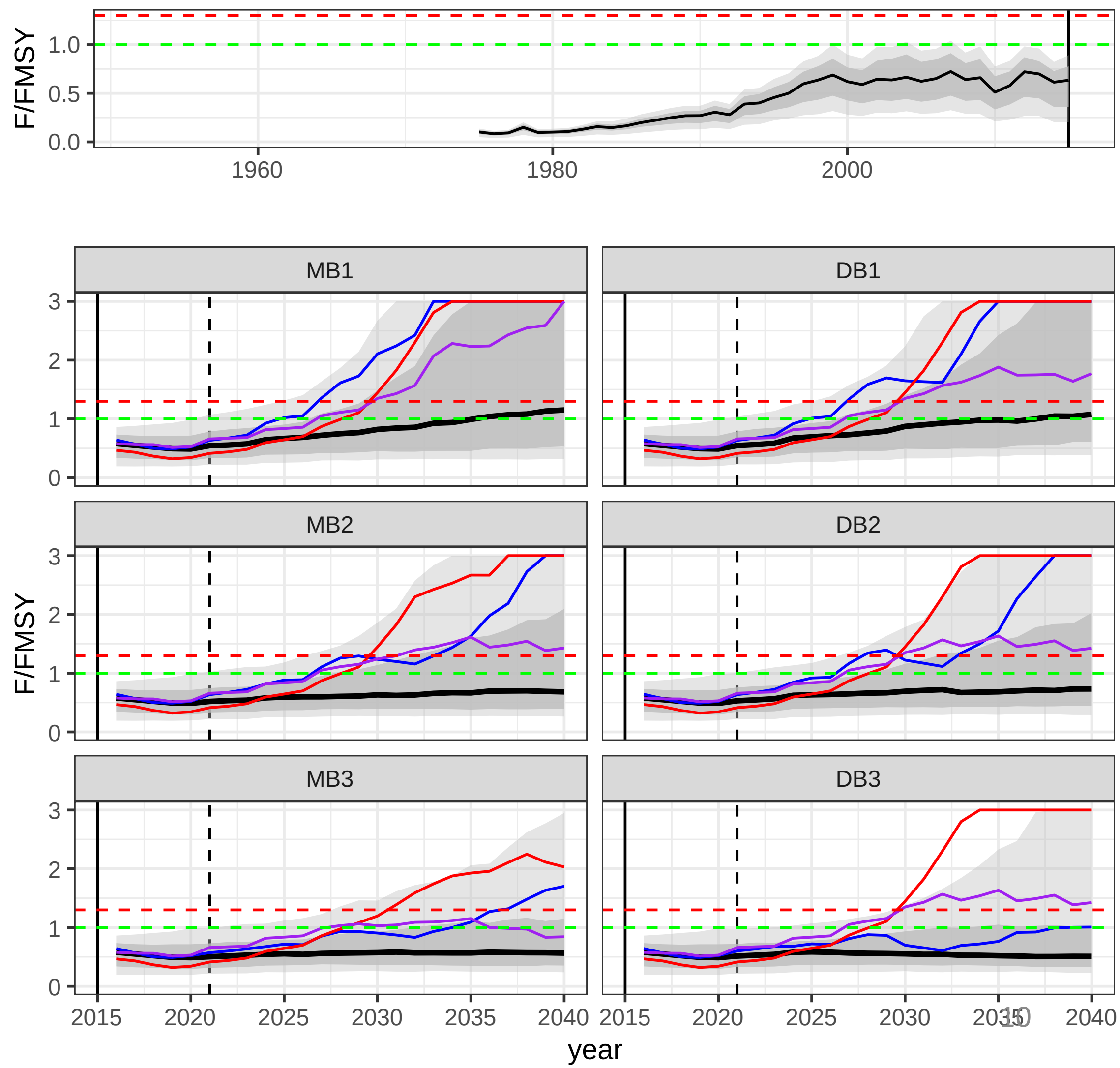


Key Results of Candidate MP Evaluations

Fig. 8

- F often very high post 2030

Fishing Intensity

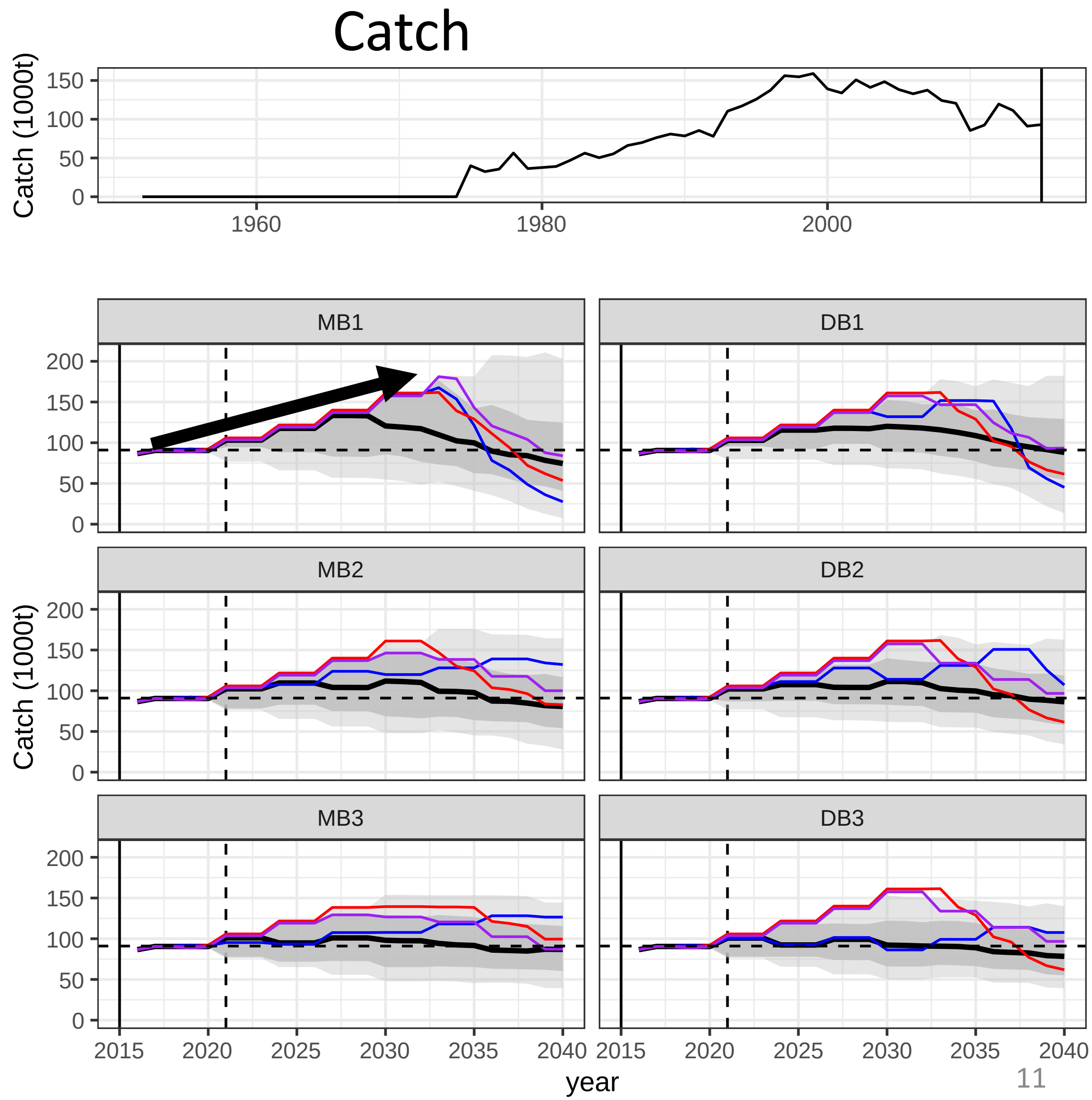


Key Results of Candidate MP Evaluations

Fig. 9

- Biomass decline achieved by increasing catch, mostly for B1

- B2, B3 fairly stable



Considerations for next iteration

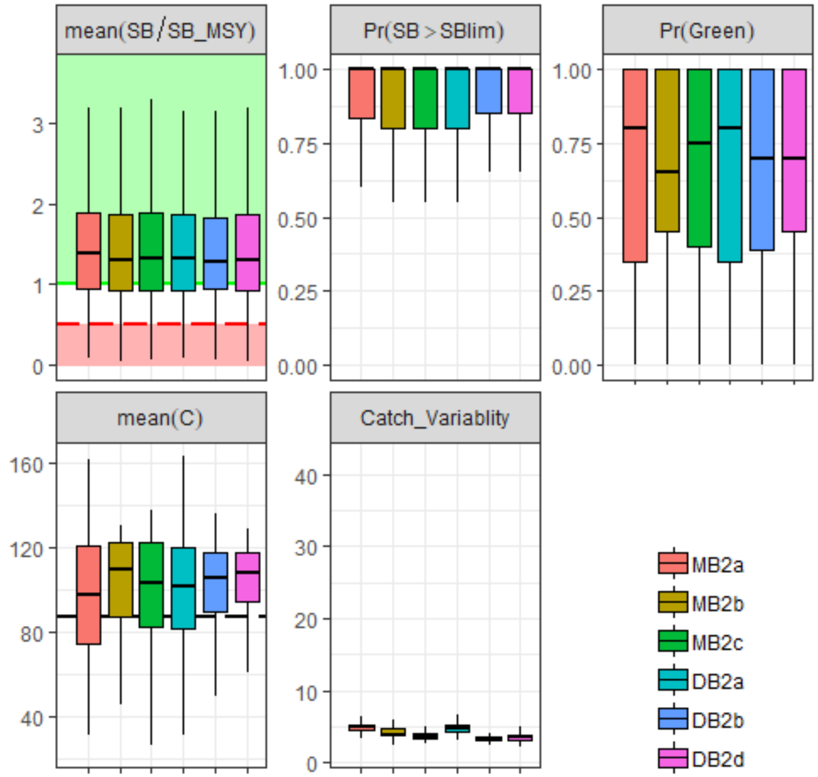
1) Current stock status is seemingly not over-exploited.

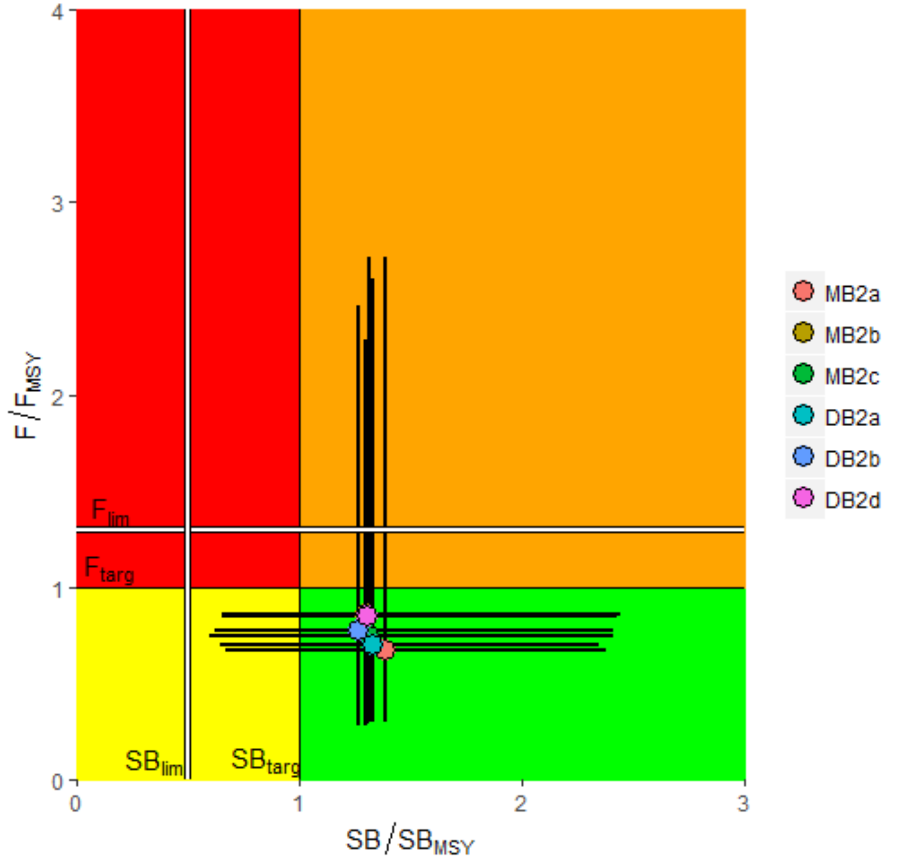
2) Catches have been declining in recent years.

3) Tuning objective B1 tends to require substantial catch increases.

4) There appears to be no incentive for industry to increase catches at this time.

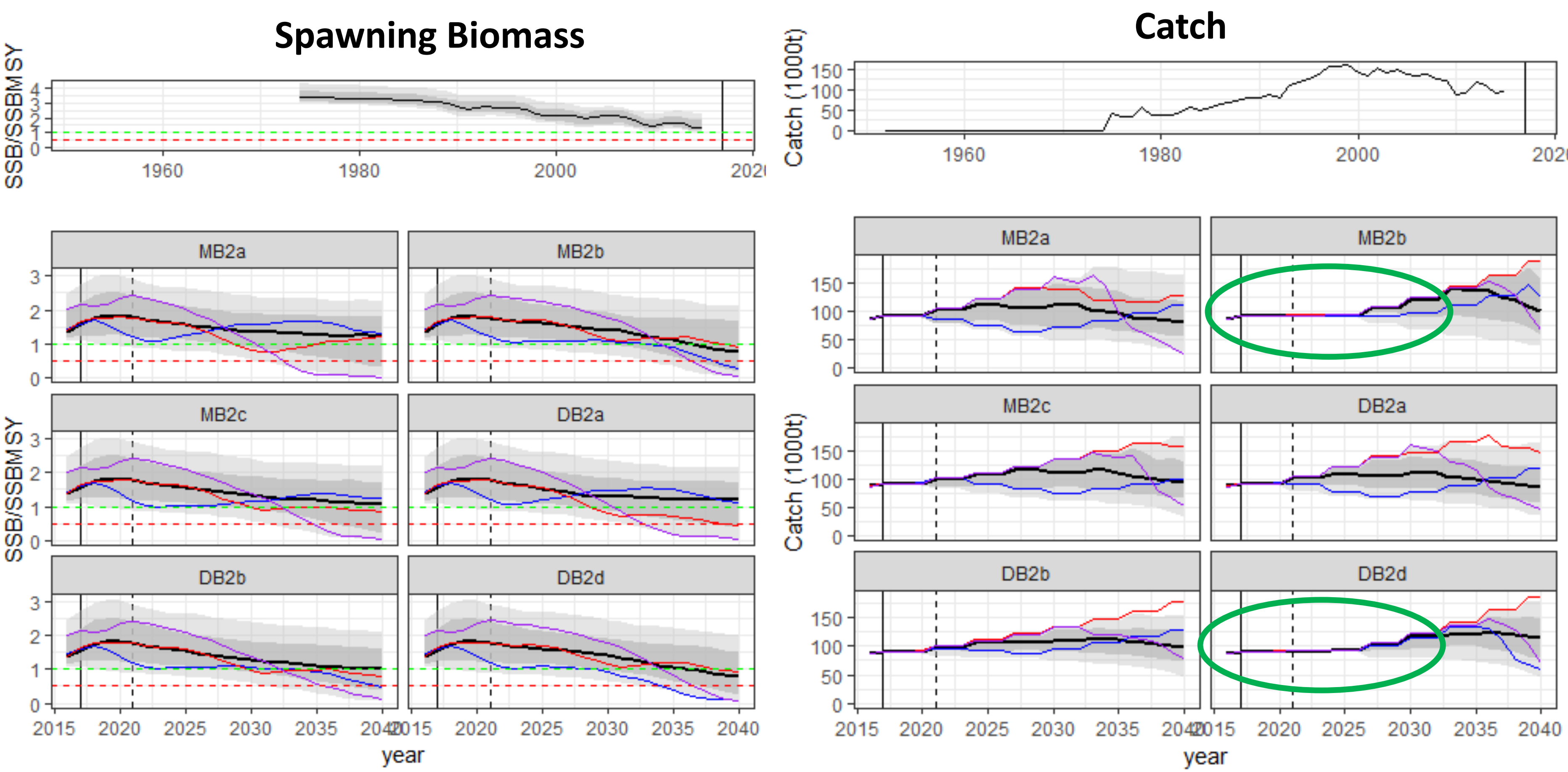
Given a single tuning objective(B2), how do 6 different MPs perform?





For the bigeye MPs tested, tuning objectives largely determine MP performance.

Given a single tuning objective(B2), how do 6 different MPs perform?



More time can be spent developing “smarter” MPs if managers can clearly describe what is desirable.

e.g. greater initial TAC stability

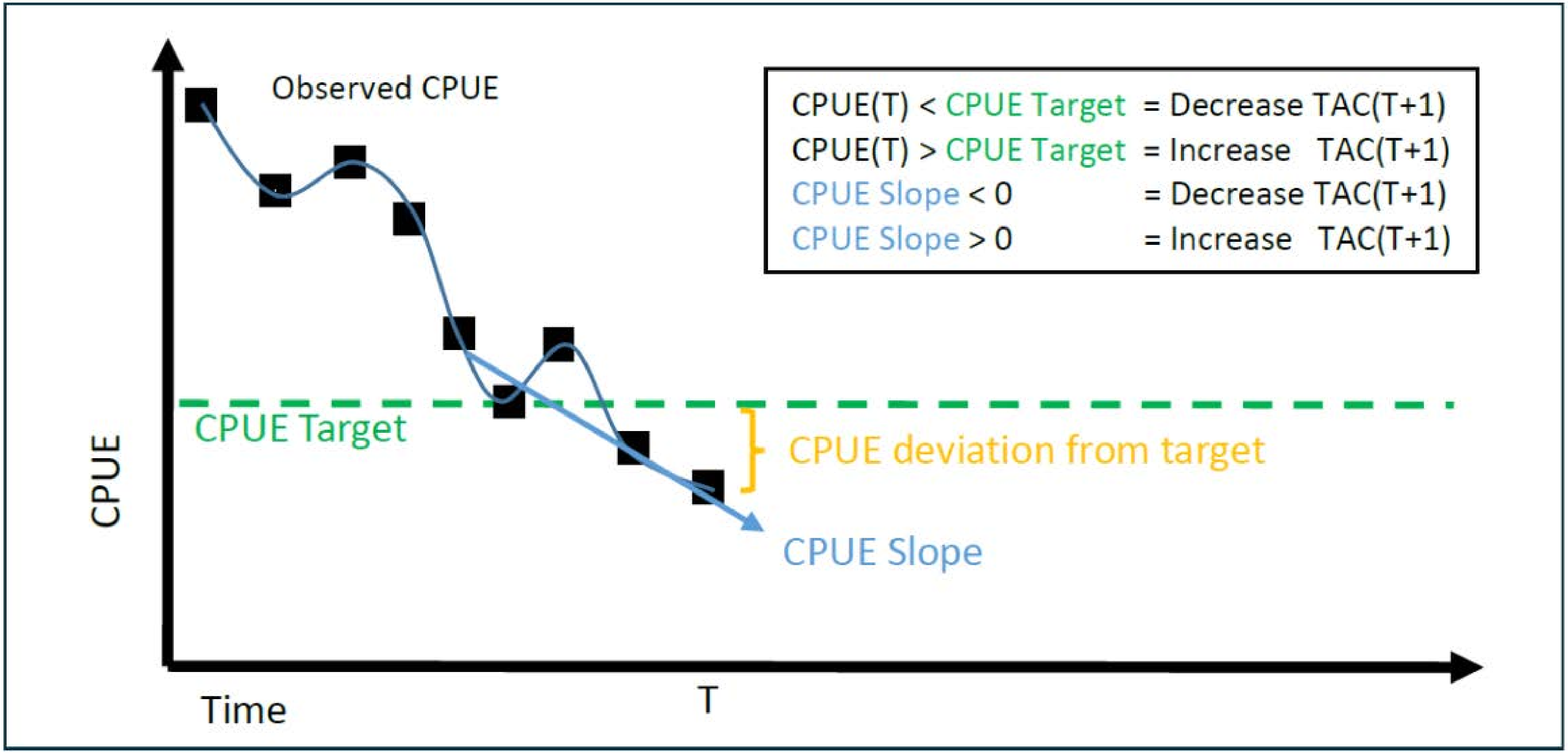
Questions for TCMP to advance bigeye MSE

1) Reduced set of tuning objectives for phase 2?
   - E.g. Is it worth retaining B1?
2) Frequency of quota setting?
   - First MP setting: 2021
   - Then every 3 years
3) TAC change constraints?
   - May be possible to increase initial stability
4) Implementation lag?
   - MP data (CPUE) available to 2019 for 2021 TAC

धन्यवाद
Merci
Thanks!

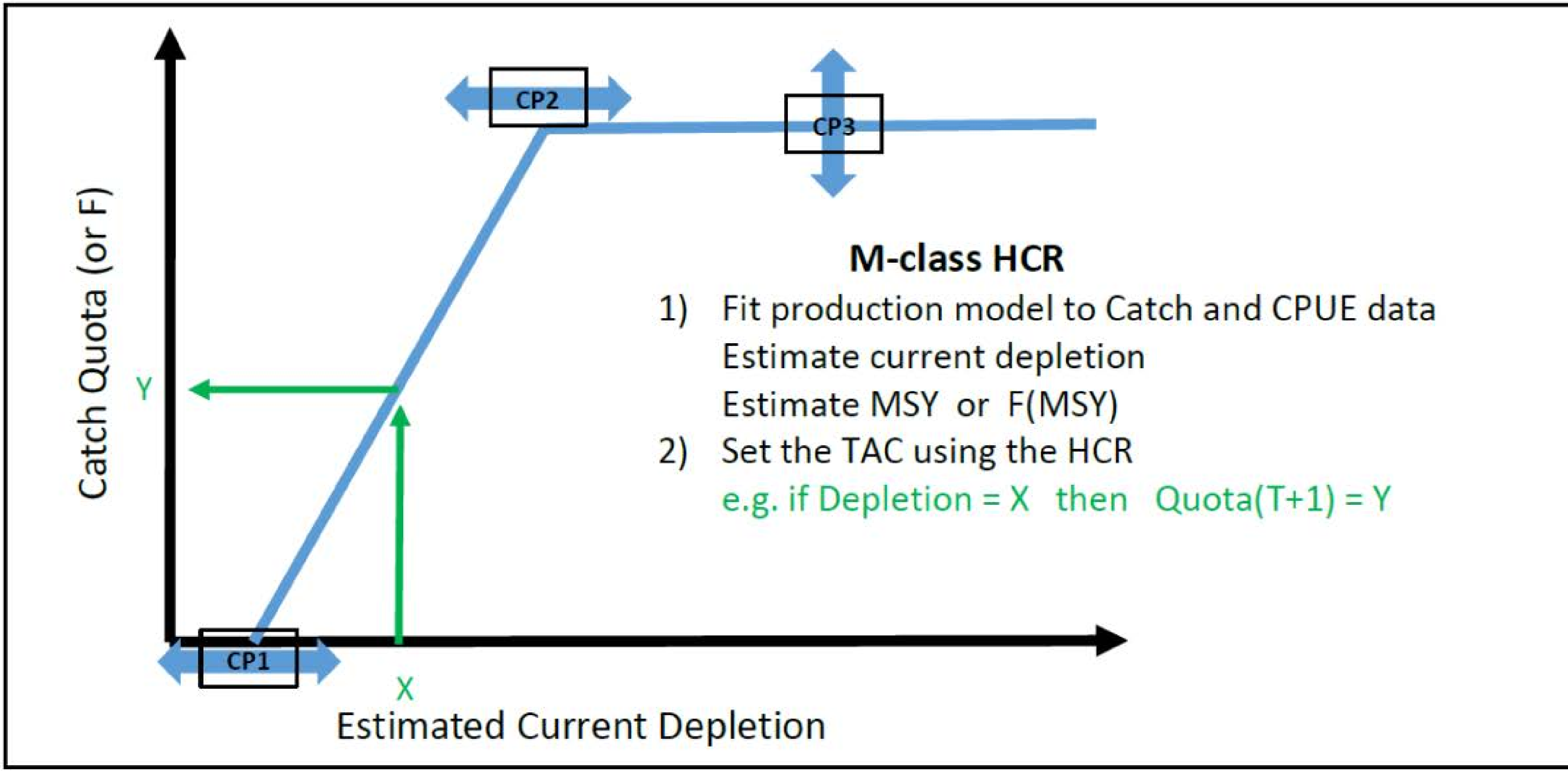
Empirical CPUE-based MP

"D" class (data-based) MPs



Model-based MP

"M" class (model-based) MPs



Korean Roundtable for Sustainable Tuna

Accelerating Tuna Sustainability via FIPs and MSC

Doohyun Park
Ocean Programme Officer, WWF-Korea

Areas Beyond National Jurisdiction (ABNJ) Tuna Management Workshop
19-20 February 2020
National Institute of Fisheries Sciences
Busan, Republic of Korea

NIFS Sea, the Future Sea, the Hope

ISSF INTERNATIONAL SEAFOOD SUSTAINABILITY FOUNDATION

Outline

- WWF – How we work
- Market Incentives – FIPs, MSC
- Korean Roundtable for Sustainable Tunas
- KORST – ISSUES
- Global FIP Alliance for Sustainable Tunas (G-FAST)

WWF in numbers

1961/2014

WWF was founded in 1961 and WWF-Korea was founded in 2014

+100

WWF is in over 100 countries, on 6 continents

+5M

WWF has over 5 million supporters

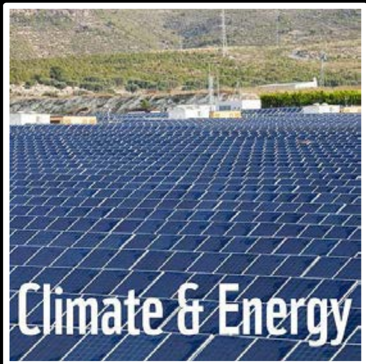
+5000

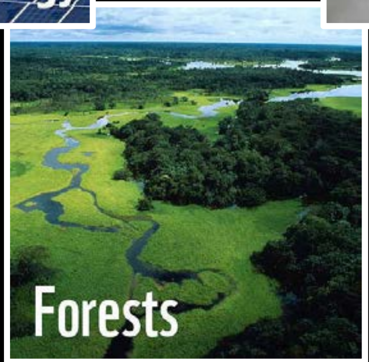
WWF has over 5,000 staff worldwide

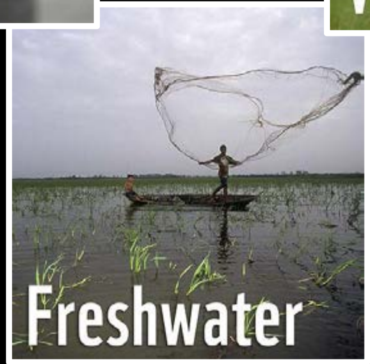
Our Mission

To stop the degradation of the planet's natural environment and to build a future in which people live in harmony with nature, by:

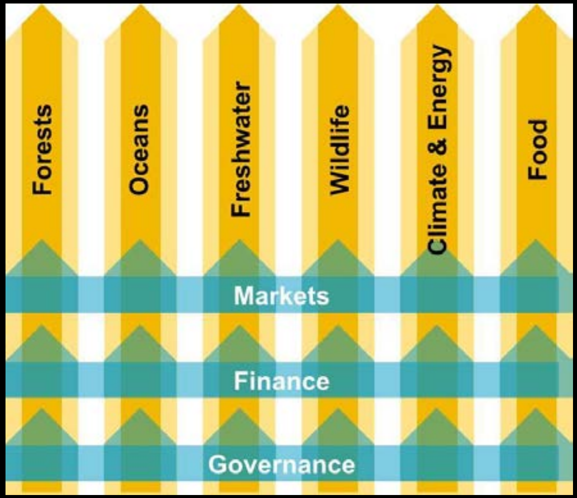
- Conserving the world's biological diversity
- Ensuring that the use of renewable natural resources is sustainable
- Promoting the reduction of pollution and wasteful consumption.







Tackling the Causes: Cross-cutting Drivers



Transforming international markets so goods and services are produced and consumed more sustainably.

Moving away from financial systems that favour short-term returns over long-term wealth creation that supports inclusive development and protection of natural assets.

Tackling the inequitable global governance system where the vast majority of people affected by environmental change remain voiceless and unable to influence change.

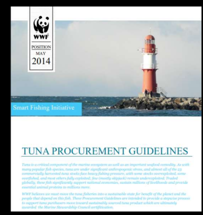
Markets want Sustainable Tunas!

Consumers

Demands for sustainable tuna

Communication/Awareness

Partnership w NGOs



- ✓ Financial support, if needed
- ✓ Procurement Preference/Agreement
- ✓ Other business deals that help FIPs

Supply Certified or from FIP fisheries

Fishery
Improvement
Project

세계자연기금

Tuna Vessel Owners

CERTIFIED SUSTAINABLE SEAFOOD MSC www.msc.org

WWF Global Seafood Charter

WHO?

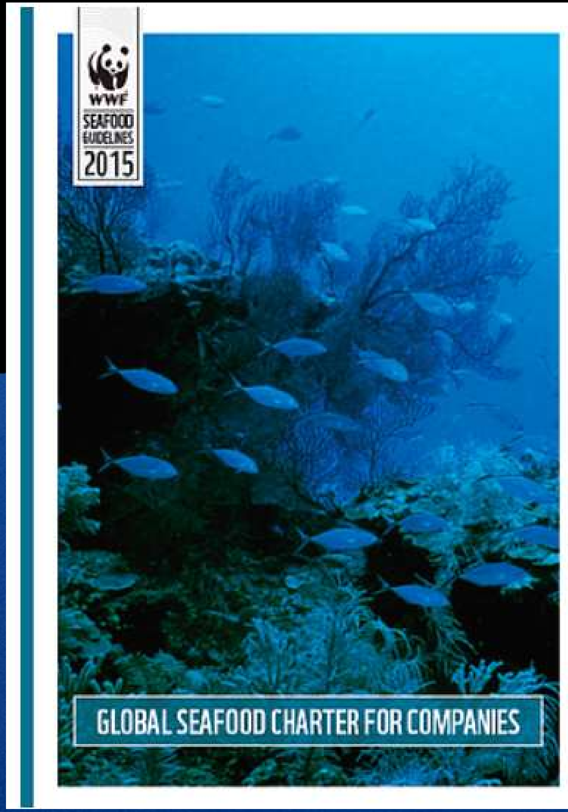
Consumer-facing retailers, brand owners, buyers, traders, processors, & vessel owners

HOW?

- ✓ Publicly announced "Sustainability Commitments"

  "By 20XX, XX% of all seafood... MSC/ASC-certified or from FIP fisheries"
- ✓ Invest in FIP & AIP
- ✓ Invest in Fishery Conservation Projects (FCP)
- ✓ Raise awareness

  educating their employees/consumers/partners about the benefits of the MSC & ASC



WWF Tuna Procurement Guidelines

WWF

POSITION

MAY

2014

Smart Fishing Initiative

TUNA PROCUREMENT GUIDELINES

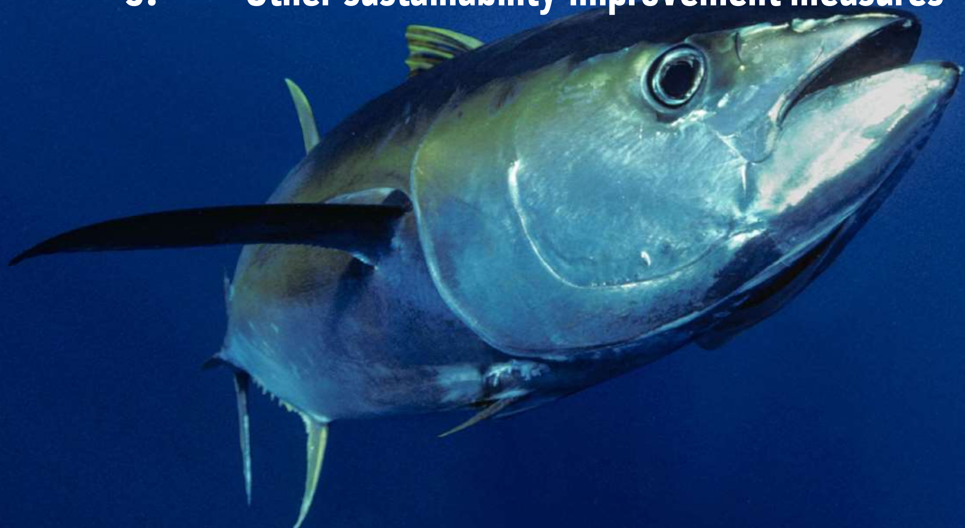
Tuna is a critical component of the marine ecosystem as well as an important seafood comodity. As with many popular fish species, tuna are under significant anthropogenic stress, and almost all of the 23 commercially harvested tuna stocks face heavy fishing pressure, with some stocks overexploited, some overfished, and most others fully exploited; few (mostly skipjack) remain underexploited. Traded globally, these fish significantly support national economies, sustain millions of livelihoods and provide essential animal proteins to millions more.

WWF believes we must move the tuna fisheries into a sustainable state for benefit of the planet and the people that depend on this fish. These Procurement Guidelines are intended to provide a stepwise process to support tuna purchasers move toward sustainably sourced tuna product which are ultimately awarded the Marine Stewardship Council certifitication.

Canned: SKJ, YFT, ALBC, BET

Fresh & Frozen: YFT, BET

1. MSC-certified tuna products – Chain of Custody, MSC Logo
2. Fishery Improvement Project
3. ISSF Participation
4. ISSF's Conservation and Management Measure, esp Proactive Vessel Register(PVR) Commitments
5. Other sustainability improvement measures



MSC Fisheries Standard

PRINCIPLE 1: Sustainable fish stocks

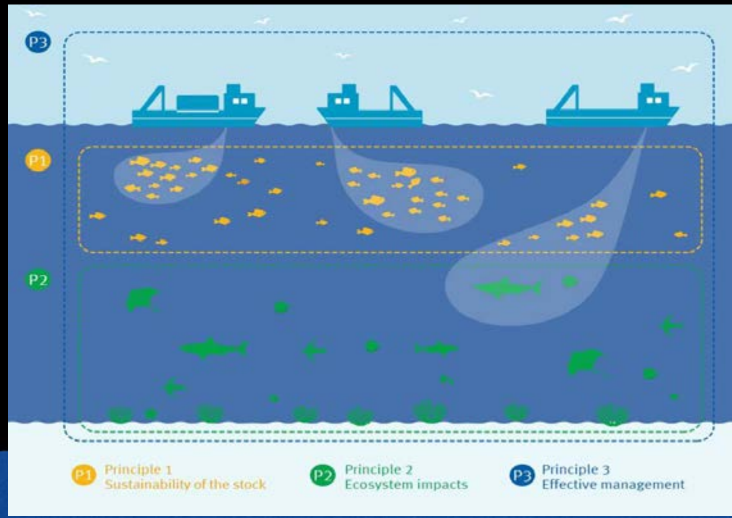
The fishery must operate so that fishing can continue indefinitely and is not overexploiting the resource.

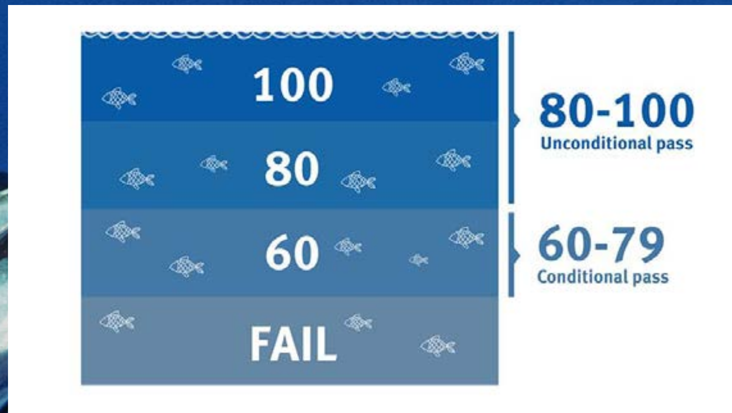
PRINCIPLE 2: Minimal environmental impact

Fishing operations should be managed to maintain the structure, productivity, function, and diversity of the ecosystem on which the fishery depends.

PRINCIPLE 3: Effective management

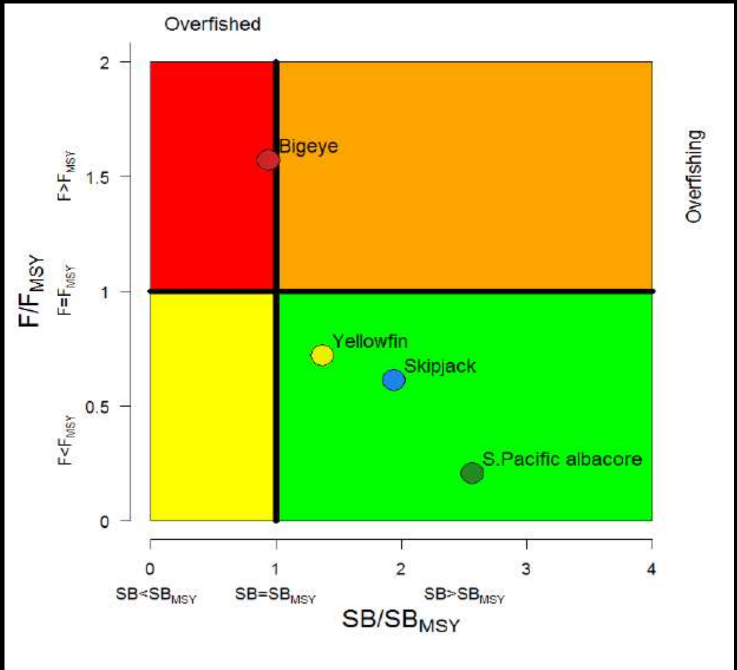
The fishery must meet all local, national, and international laws and must have a management system in place to respond to changing circumstances and maintain sustainability.



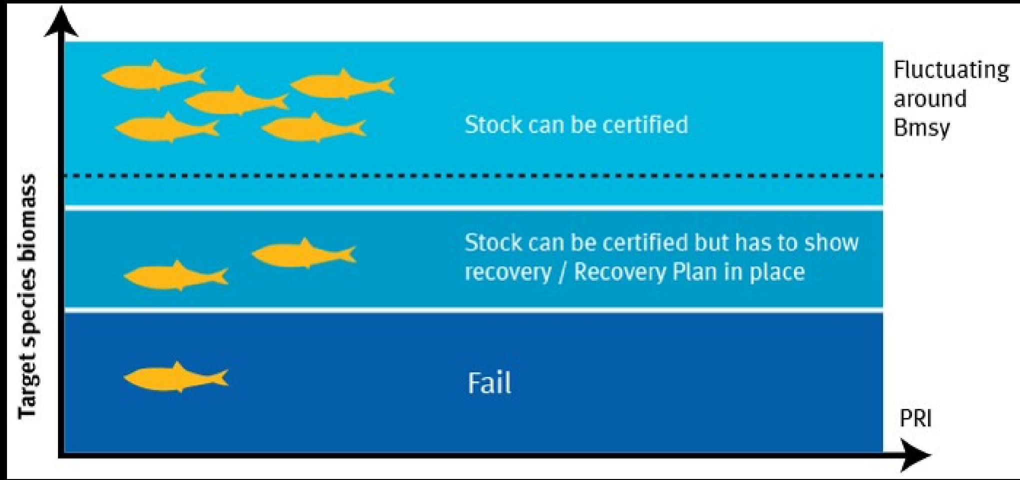


Source: MSC

P 1 Sustainable Fish Stocks – t-RFMOs



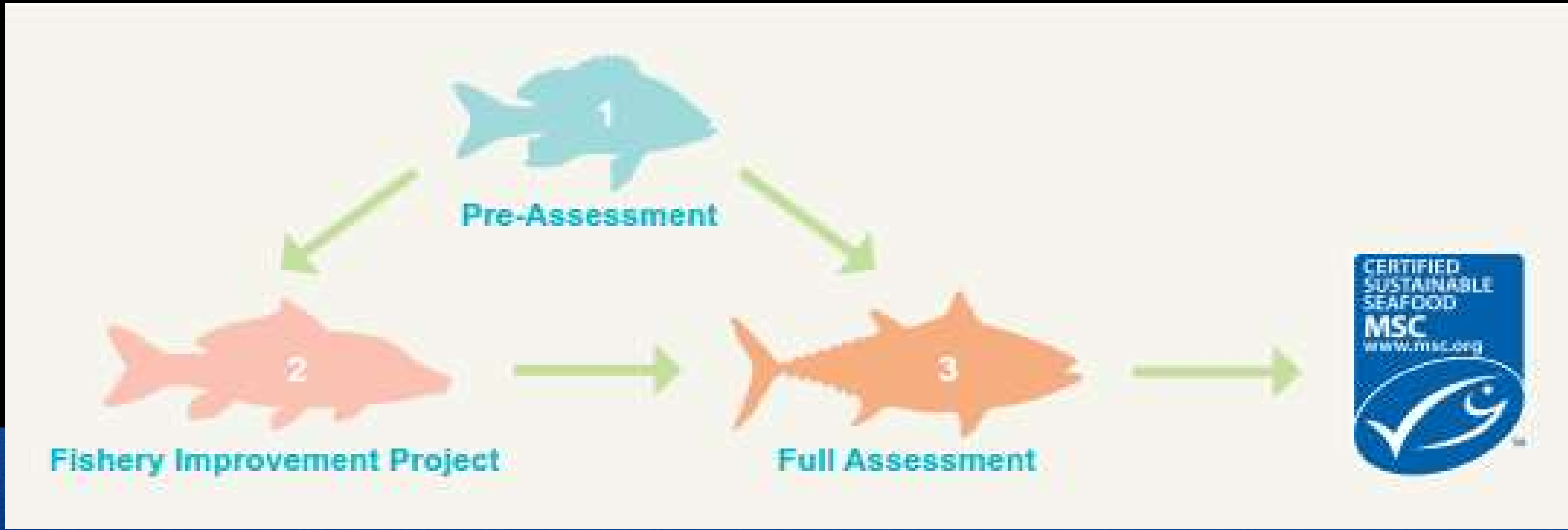
RFMO Stock Status
Stock Assessment Outcome
MSY(Bmsy, Fmsy), Reference Points, TAC,
Rebuilding Modelling



Harvest Strategy, Harvest Control Rule,
Information/Assessment
(WCPFC CMM 2014-06)

Source: flatfish

Fishery Improvement Projects

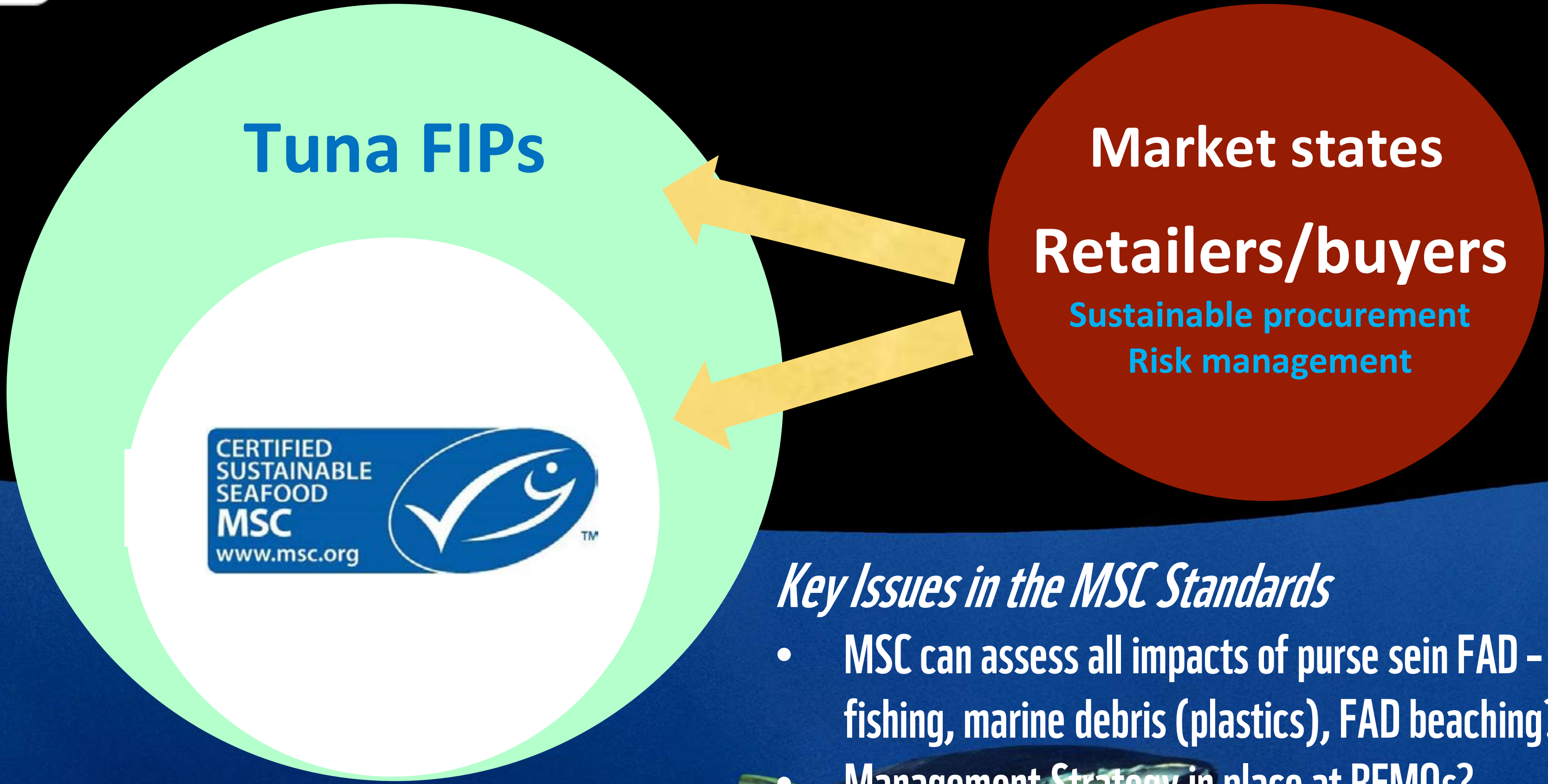


WWF uses a three-step process to help a fishery identify its sustainability issues, implement improvements (if needed), and achieve certification

FIPs Help Accelerate Tuna Sustainability

- Providing a smart and strong voice in the supply chain
- (Bottom-up joining in the top-down supply chain efforts)
- Being consistent in advocacy to governments and RFMOs
- Developing/implementing best practices before RFMOs
- Gaining recognition, ultimately through MSC certification

Tuna FIPs – More than just MSC-certified



Key Issues in the MSC Standards

- MSC can assess all impacts of purse sein FAD – bycatch, ghost fishing, marine debris (plastics), FAD beaching?
- Management Strategy in place at RFMOs?

What retailers/buyers want to see - beyond MSC

- Longline fisheries – RFMO's minimum observer requirements
- Traceability – REM, Blockchain, etc

WWF-Korea Maritime Institute Joint Symposium

- 18th July 2018, Seoul
- Gov't, DWF Industry and NGOs
- 1st Multi-stakeholder dialogue seeking collaboration to support the shift of Korean DWF industry towards sustainability, after IUU Yellowcard 2013-2015
- Import control measures of market states (EU, USA)
- Stock status of major t-RFMOs
- Market incentives - MSC/FIPs, ISSF's Conservation and Management Measures and Tools
- Sustainable seafood consumption movements
- Innovations - Blockchain in seafood traceability, "Bait to Plate"
- Japanese tuna round-table

Commitments - Continue regular multistakeholder dialogues

Korean Roundtable for Sustainable Tuna (KORST)

Key Features

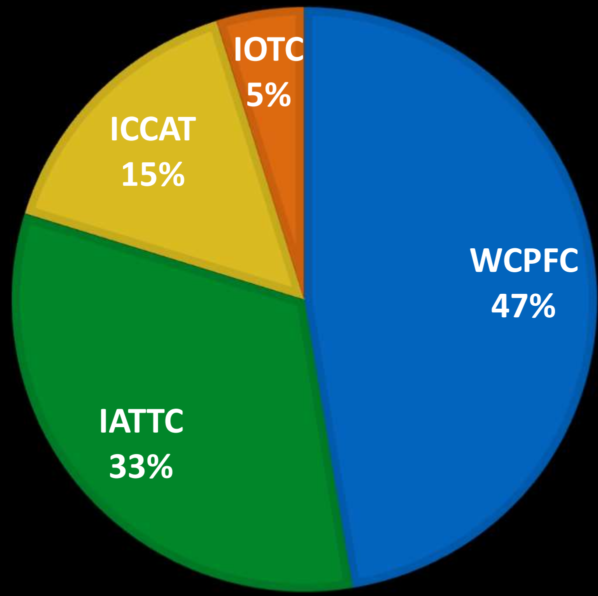
- A pre-competitive business partnership supported by NGOs
- Jun, Nov 2019, Seoul
- Corporate owners of tuna purse seiners and longliners
- Gov't, NGOs, CABs
- WCPO (WCPFC) and more
- SKJ, YFT
- FAD-related measures
- Market Incentives: MSC, FIPs, Traceability/Transparency
- Policy advocacy at t-RFMOs (16th WCPFC, Dec 2019, PNG)
- Market Engagement: TESCO, New England Seafood International
- Jun, Nov 2020 (Skipper workshop, WCPFC MSE workshop, etc)







Korean Roundtable for Sustainable Tuna (KORST)



Key Features

- 4 corporate vessel owners
- 169 tuna vessels flagged KR (146) and coastal states under J/V arrangements (23)
- 50 PSs and 119 LLs in key t-RFMOs
- 1st MSC Certified tuna fisheries in Korea

✓ *Tropical Pacific yellowfin and skipjack free-school purse seine fishery* (18th Oct 2019 - 17th Oct 2024)
✓ 11 KR-flagged purse seiners / 161,747.16 metric tonnes
✓ SKJ: 108,598.7 mt / 53.20% of all SKJ in Korea
✓ YFT: 53,148.46 mt / 80.3% of all YFT in Korea

3331.13 MT of YFT, BET, ALBC will be added in April 2020
Pan Pacific yellowfin, bigeye and albacore longline fishery, MSC Full Assessment

Some Key Sustainability Issues

1. Precautionary Harvest Strategies (Advocacy)

   - Target & Limit Reference Points
   - Harvest Control Rules

2. Bycatch mitigation (Action by Vessel Owners)

   - FAD management (purse seine)
   - Observer coverage (longline)
   - Sharks, rays, sea turtles (purse seine & longline)

3. Effective & Fair Enforcement (Advocacy)

   - Transparency
   - Observer Security & Safety

WCPFC HCRs – Urgent action needed

Western and Central Pacific Fisheries Commission

COMMISSION
FIFTEENTH REGULAR SESSION
Honolulu, Hawaii, USA
10 – 14 December, 2018

Work Plan for the Adoption of Harvest Strategies under CMM 2014-06[1]

"… MSC noting the MCS decision to align the Harvest Control Rules … across all MSC certified tuna fisheries in the WCPFC… an urgent need to ensure that the WCPFC stayed on track with the time lines in place of Harvest Control Rules under WCPFC CMM 2014 – 06 … a firm deadline for the adoption of Harvest Control Rules for the four key tuna species at the WCPFC by end of 2021… if this condition was not met, it will result in the suspension on of the regions MSC certified fisheries in 2022."

Source: Pacific Islands Tuna Industry Association

Urgent, but not impossible

	South Pacific Albacore	Skipjack	Bigeye	Yellowfin
2021	Develop harvest control rules (e) and Management strategy **evaluation** (f) • SC provide advice on performance of candidate harvest control rules. • TCC consider the implications of candidate harvest control rules. • Commission consider advice on progress towards **harvest** control **rules**. Adopt a Harvest Control Rule.	Harvest Strategy for Skipjack in place	Develop harvest control rules (e) and Management strategy **evaluation** (f) • SC provide advice on performance of candidate harvest control rules. • TCC consider the implications of candidate harvest control rules. • Commission consider advice on progress towards harvest control rules. Adopt a Harvest Control Rule	Develop harvest control rules (e) and Management strategy **evaluation** (f) • SC provide advice on performance of candidate harvest control rules. • TCC consider the implications of candidate harvest control rules. • Commission consider advice on progress towards harvest control rules. Adopt a Harvest Control Rule

Directed meetings

Forum participation & Capacity building

Position papers

Scientific output

WWF Global FIP Alliance for Sustainable Tuna (G-FAST)

G-FAST

- Focus on vessel owners & comprehensive FIPs only
- Make rapid progress towards MSC standard
- Participate with WWF in consistent gov't. & RFMO advocacy
- Priority in WWF Tuna Procurement Guidelines

8 large purse seine comprehensive FIPs

- 180 major purse seiners, 20% of global tuna catch
- Span all 4 tropical tuna RFMOs
- 850,000 metric tons annually / 17% of all global catch

WWF is actively recruiting more FIPs for G-FAST in NE Asia

G-FAST: Participating FIPs

	Oceans	Fleets	Species	Mgnt	Landings (MT)
TUNACONS	EPO	45 PSs	YFT, ALBC, SKJ	IATTC	113, 568
OPAGAC	All	47 PSs	YFT, BET, SKJ	IATTC, ICCAT, IOTC, WCPFC	385, 000
Indian Ocean Tuna (SIOTI)	IO	40 PSs	YFT, BET, SKJ	IOTC	243,000
Eastern Atlantic Tuna (EASTI)	AO	40 PSs	YFT, BET, SKJ	ICCAT	160,000
Pacific Ocean Tropical Tuna (US Pacific Ocean Group)	WCPO, EPO	11 PSs	YFT, BET, SKJ	WCPFC, IATTC	80,000


Thank you!
“WOULD YOU CARE MORE
IF I WAS A PANDA?”
The Bluefin Tuna is being fished to extinction
So like a few other species, it would appreciate your help
WWF
wwf.com