

MSE application in CCSBT

Case study of

Southern bluefin tuna

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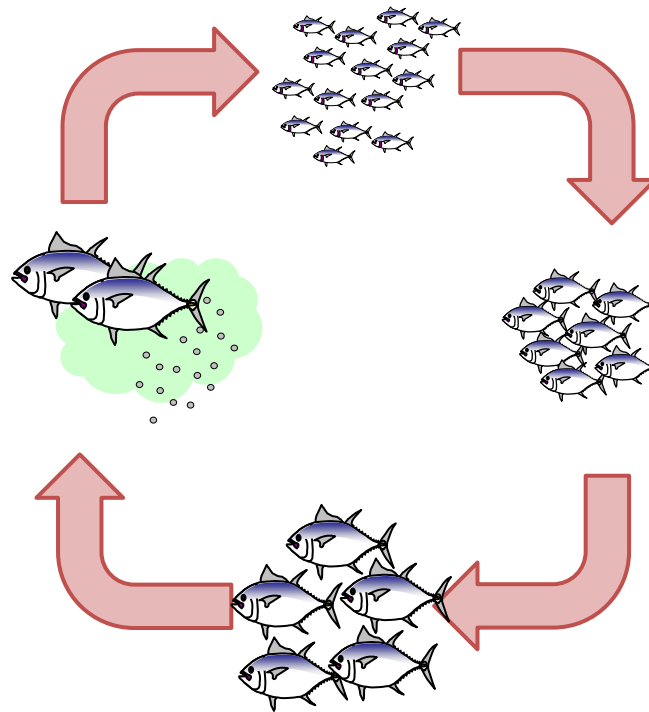
What is Southern Bluefin Tuna (SBT)?

Life history

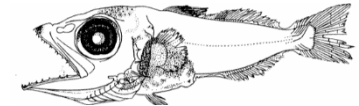
Big bodies
Long life
Mature slowly

Mature

SBT do not mature younger than 8 years (155 cm FL).



Recruitment



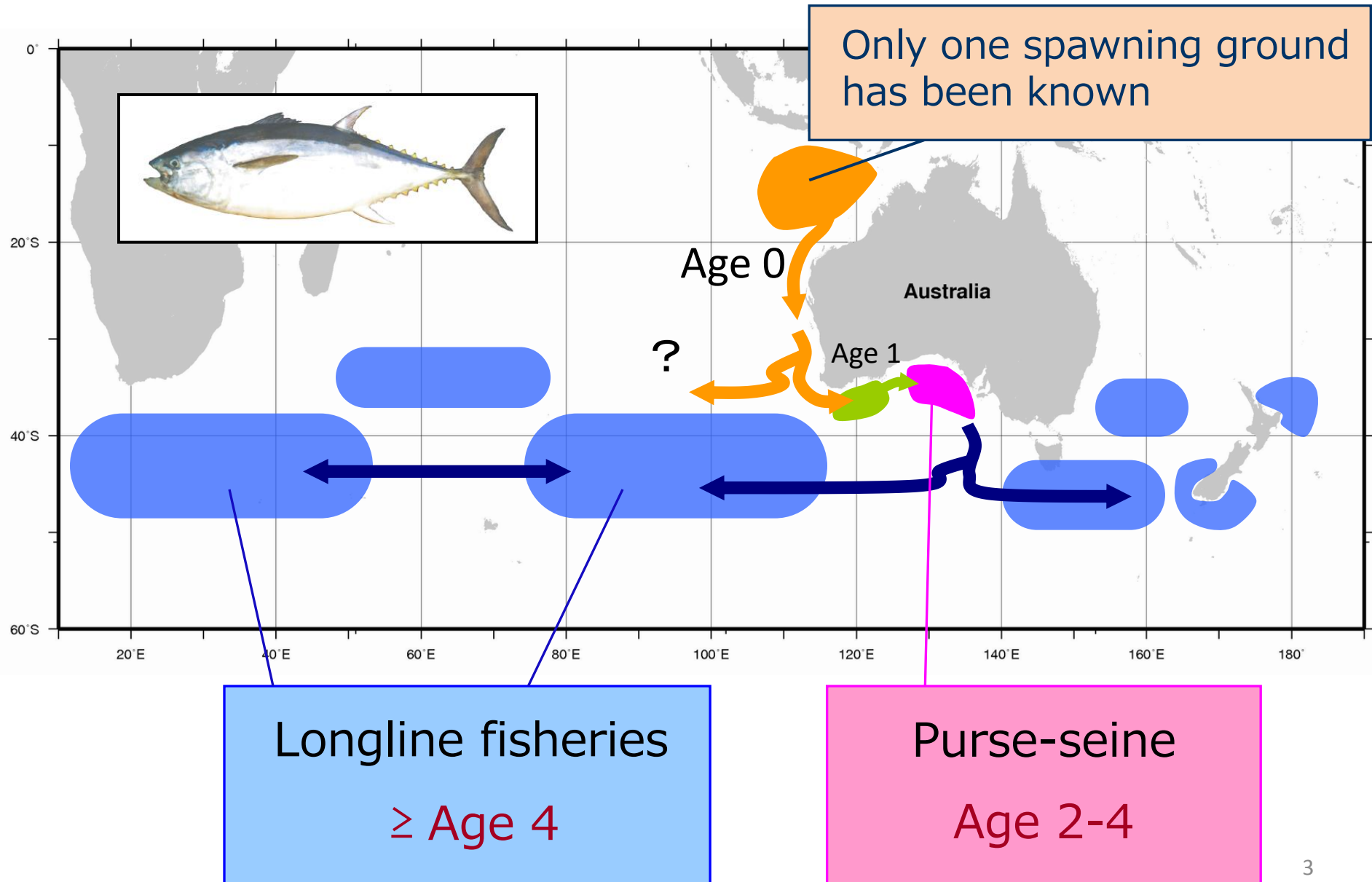
Juvenile~ Immature

Age 1 = About 50 cm FL

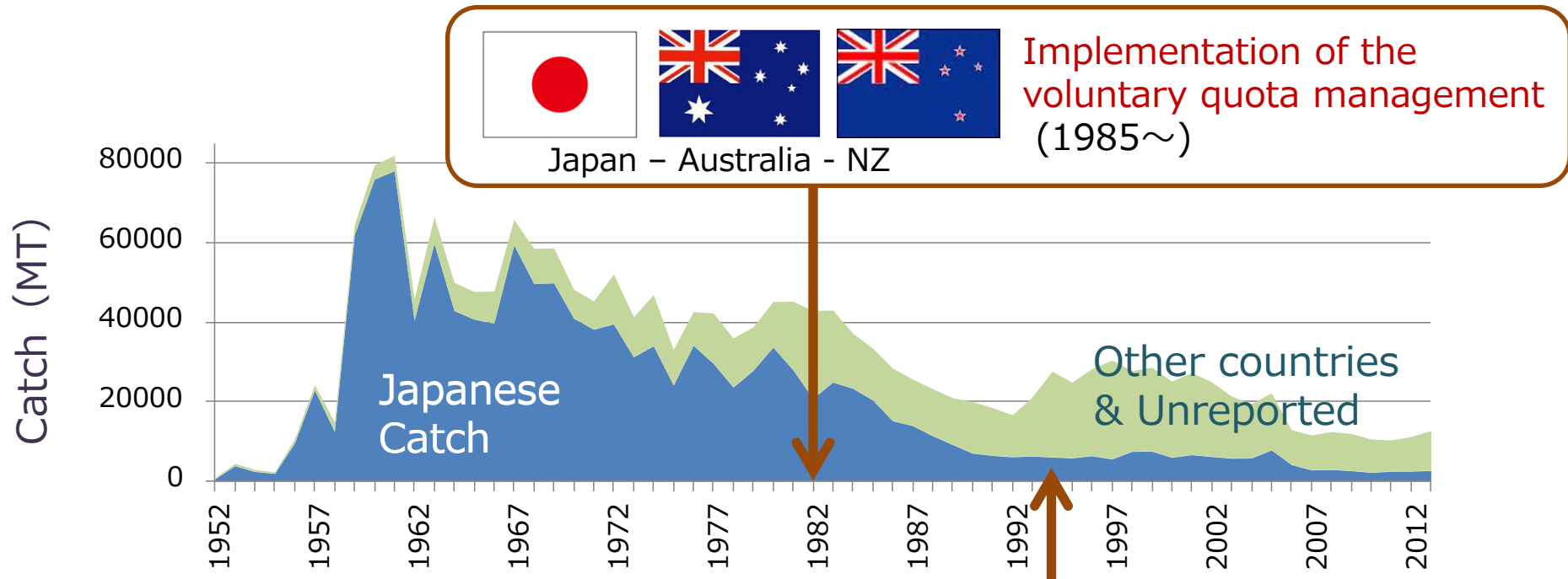


Maximum age obtained from otolith has been 42 years.
(Maximum size is about 260kg)

Distribution and current fisheries



International cooperative management



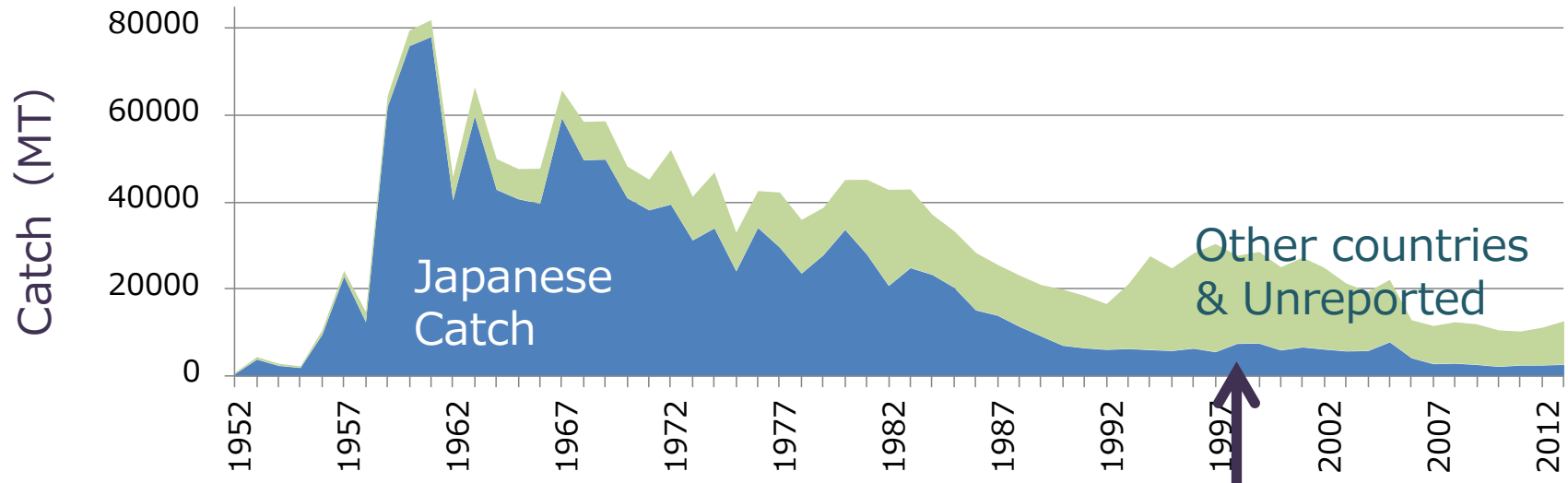
“The Convention for the Conservation of Southern Bluefin Tuna” came into force in 1994.

CCSBT formalized the management of SBT.

Original members;
Japan, Australia, NZ

Current members;
Japan, Australia, NZ, Korea, Taiwan, Indonesia
(Cooperating Non-Member: Philippines, South Africa, EC)

Did the management go well?



Since 1998, the Commission had been **unable to agree upon a new global TAC**, thus the members continued the 1994 quotas (until 2003).



Because of the **disagreement for the stock analysis**.

- Experimental fishing program -> Dispute

What was problem ?

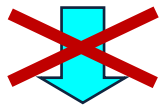
TAC decision process

Data collection



- Catch and effort
- Abundance index (CPUE)

Stock assessment



- Model base
- Estimate of stock status
- Projection

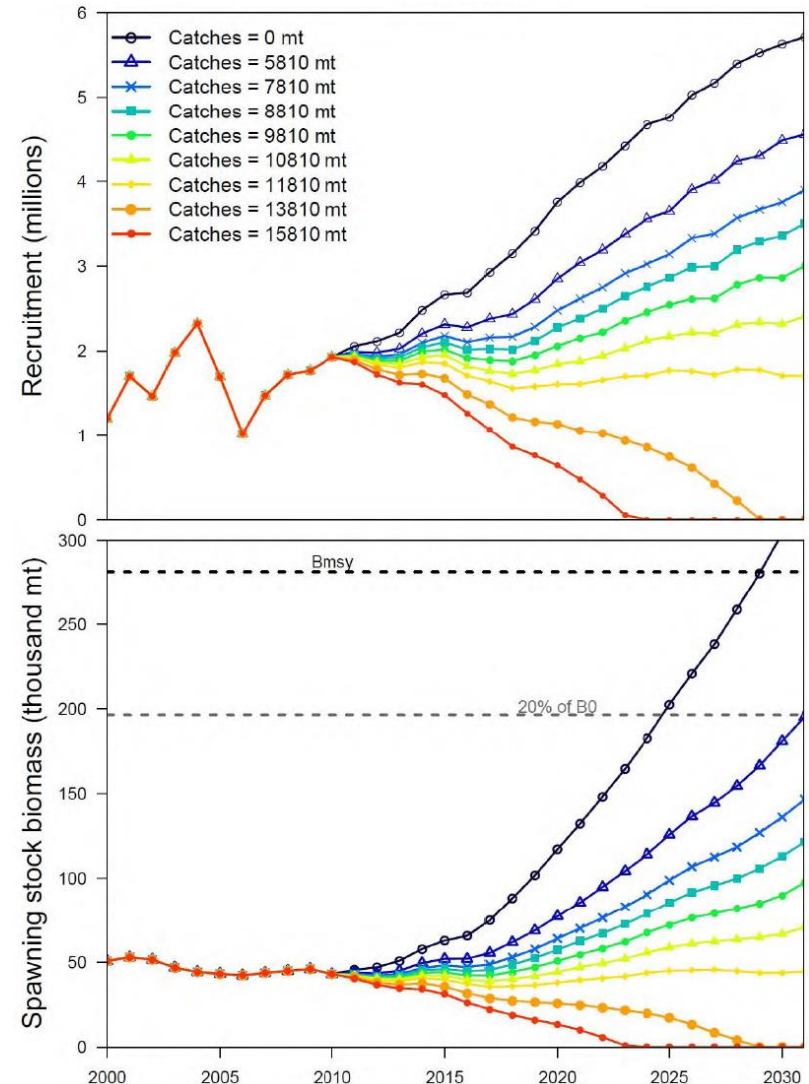
TAC agreement



- Based on the advice from scientific meeting

Management

Constant catch projection



What was problem ?

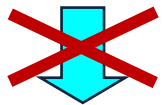
TAC decision process

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- Model base
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~~TAC agreement~~

Couldn't reach
agreement for years...

~~Management~~

For stakeholder...

If there is no agreement in the assessment result?

-> It is difficult to set the TAC.
(CCSBT has consensus rule.)

Uncertainty in stock assessment

Stock status can easily change with new data interpretation or models.

No transparency in process

There were no rules about how quotas will be set, and what model assumptions will be used.

What was problem ?

TAC decision process

Data collection



- Catch and effort
- Abundance index (CPUE)

Stock assessment



- Model base
- Estimate of stock status
- Projection

~~TAC agreement~~

Couldn't reach
agreement for years...

~~Management~~

Using Management Procedure

Data collection



- Catch and effort
- Abundance index

Management Procedure



Pre-agreed decision rule
for the TAC of SBT.

TAC calculation

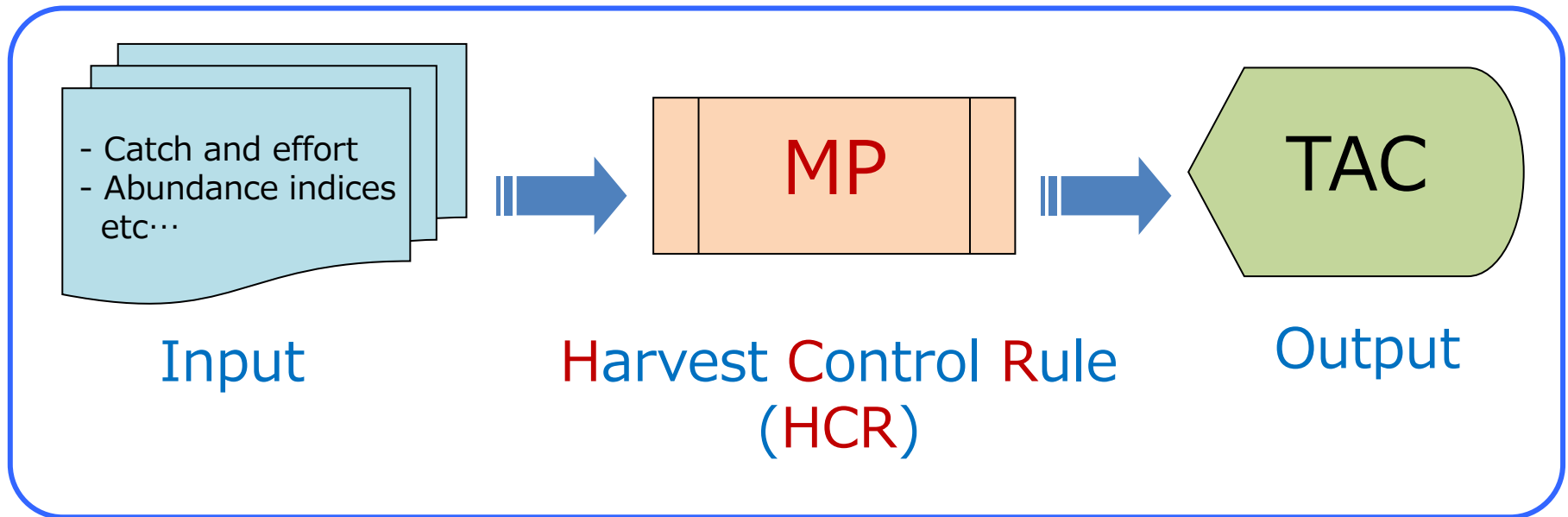


Avert the disagreement
of TAC among members.

Management

What is “Management Procedure” ?

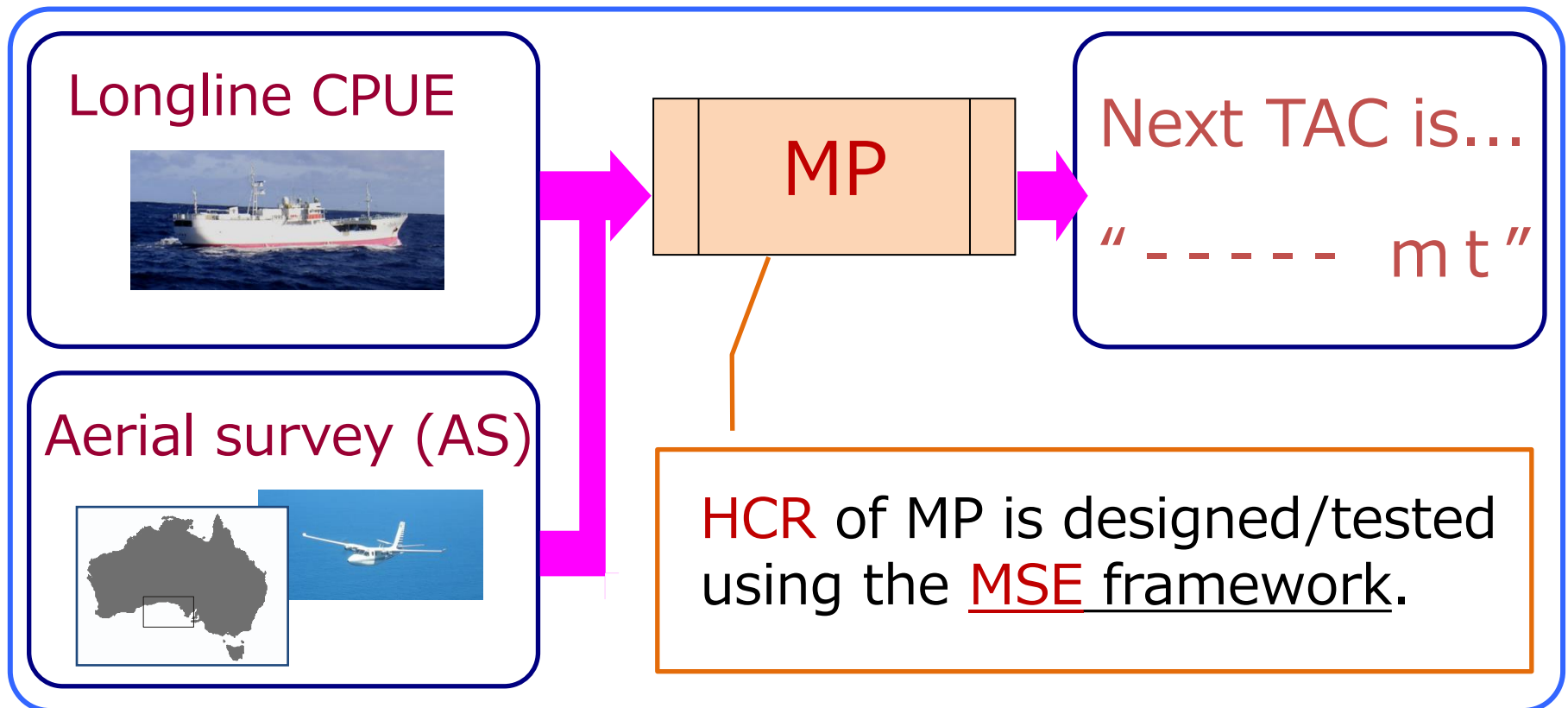
A Management Procedure (MP) is a **pre-agreed** set of rules that can **specify the TAC** based on updated monitoring data.



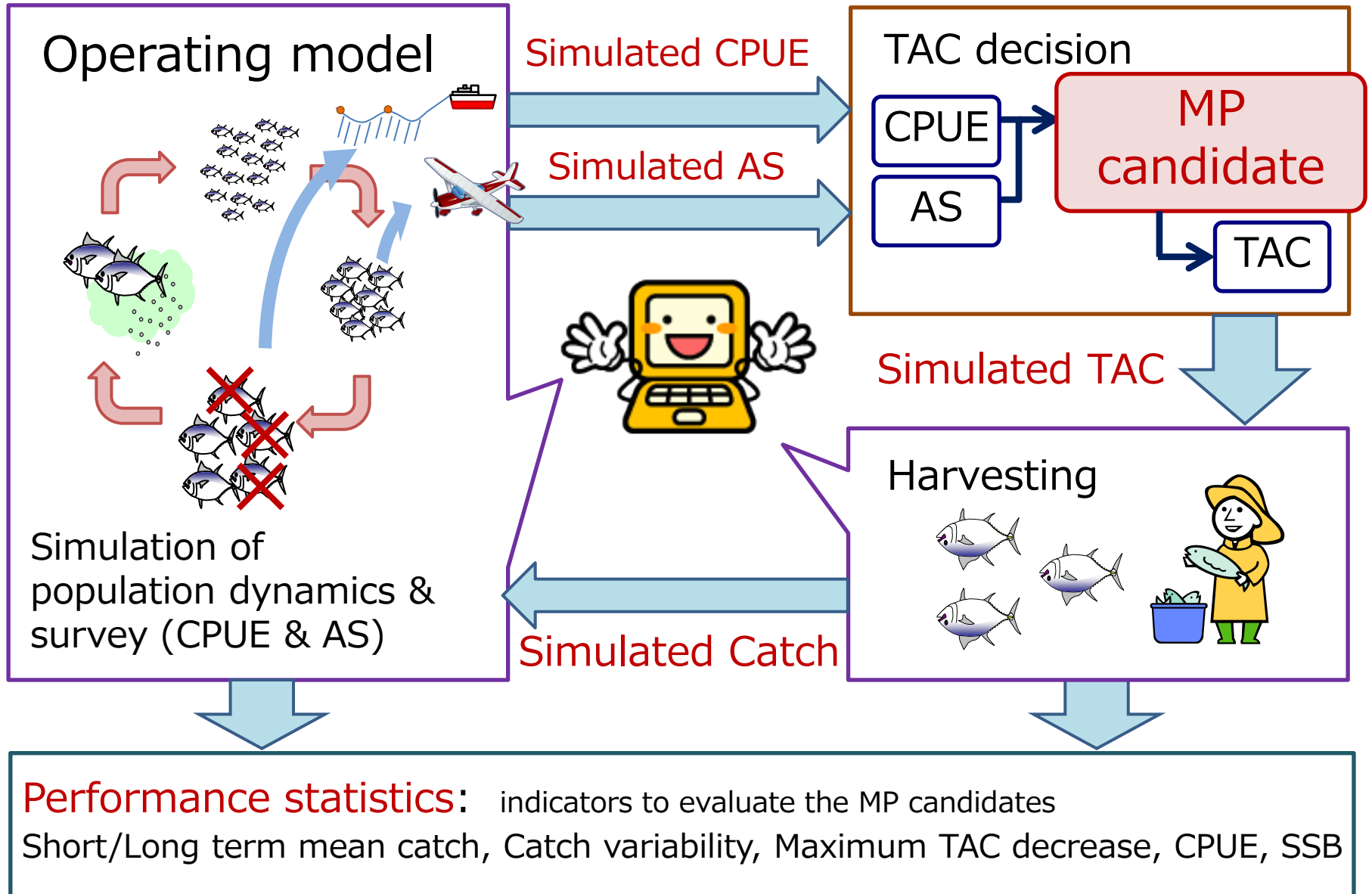
What is “Management Procedure” ?

A Management Procedure (MP) is a **pre-agreed** set of rules that can **specify the TAC** based on updated monitoring data.

CCSBT MP



Simulation in MSE framework



Simulation in MSE framework

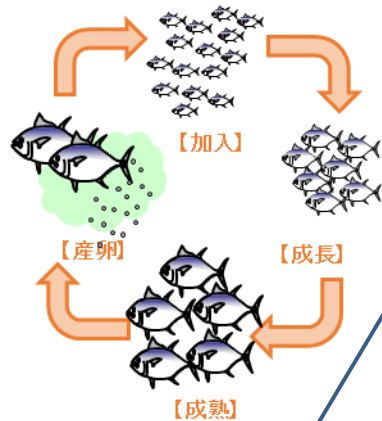
Data

Biological
Parameter

Model
assumption

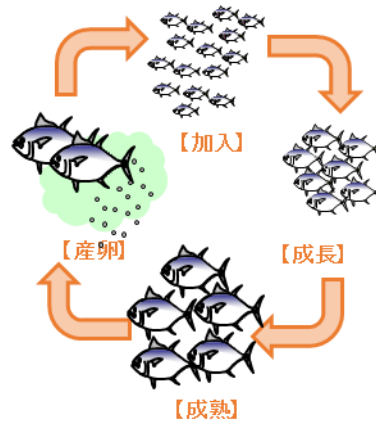
Fisheries
data

Historical
population
dynamics



MSE

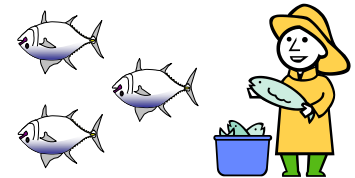
Future
population
dynamics



TAC decision

**MP
candidate**

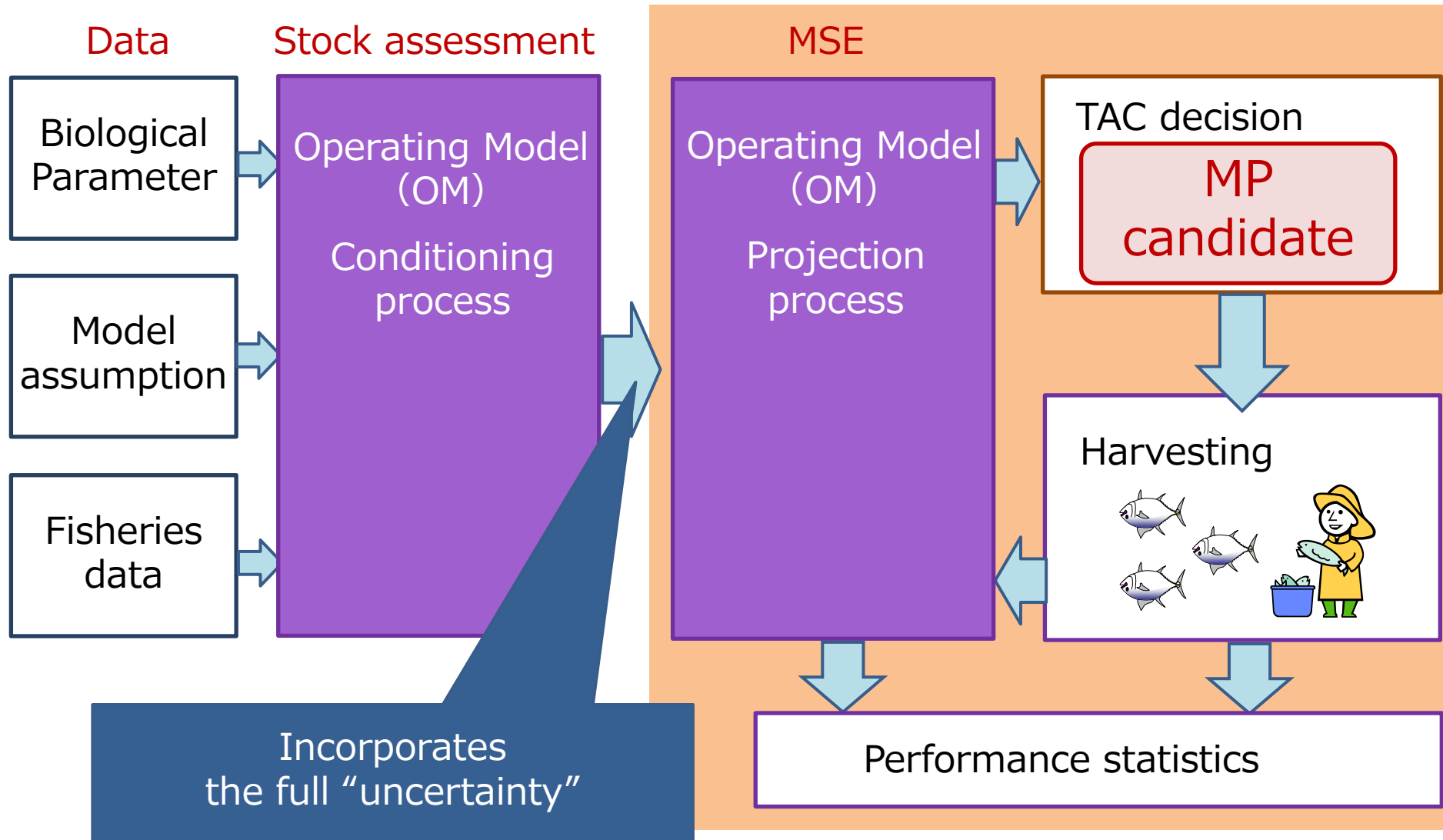
Harvesting



Reference case &
Scenarios for robustness test

Performance statistics

Simulation in MSE framework



Incorporates the full “uncertainty”

“Reference set of OM” incorporated the major range of uncertainty for the life-history/fishery parameters.

- One set is “ensemble” of 320 scenarios
(Plausible range of Natural mortality, Steepness, CPUE, etc.)

In addition, MP candidates were tested many plausible sensitivity scenarios of the OM setting;

- Some hypotheses & bias about the data
(e.g. Alternative CPUE model or catchability)
- Model structure
(e.g. Non-linear relationship between CPUE and abundance)
- Pessimistic scenario
(e.g. Short-term recruitment failure like early 2000s year-class)

MP should be robust to these uncertainties.

It is necessary that the MP can use the management of SBT stock under the somewhat extreme situation!

Development of MP

Management trial in the “virtual world”



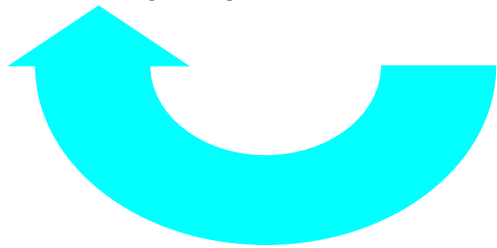
Simulated data
(Catch, abundance indices, etc.)



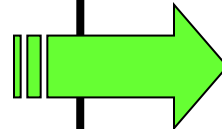
Population dynamics
with fisheries

“Operating model (OM)”

MP
candidates



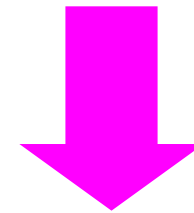
Simulated catch
(Specified by MP Candidate)



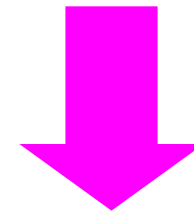
Applying adopted MP to the “real world”



Real data



Adopted MP



TAC decision

MP candidates for SBT

Name	MP	Type	Approach
HK3	Using 10 yr trend in CPUE	Empirical	Slope
HK5	Using 10 yr trend in age 4+ CPUE & age 4 CPUE (as rec)	Empirical	Slope
HK6, 7	Using 10 yr trend in age 4+ CPUE & AS index (as rec)	Empirical	Slope
ASMP	Using 4 yr moving average of AS index	Empirical	Slope
SAK1	Fox model fitted to CPUE and AS index	Model	Target
BREM1	Biomass Random Effect Model fitted to AS index	Model	Target
BREM2, BREM_s2	BREM fitted to CPUE (as the exploitable biomass) and AS index (as the recruitment)	Model	Target
FZ1	Fuzzy controlled MP using 3 yr average CPUE & AS index	Fuzzy	Target



Name	MP	Type	Approach
Bali Procedure	Combined MP which has features of both HK and BREM.	Using trend and level of the biomass from BREM	Slope & Target

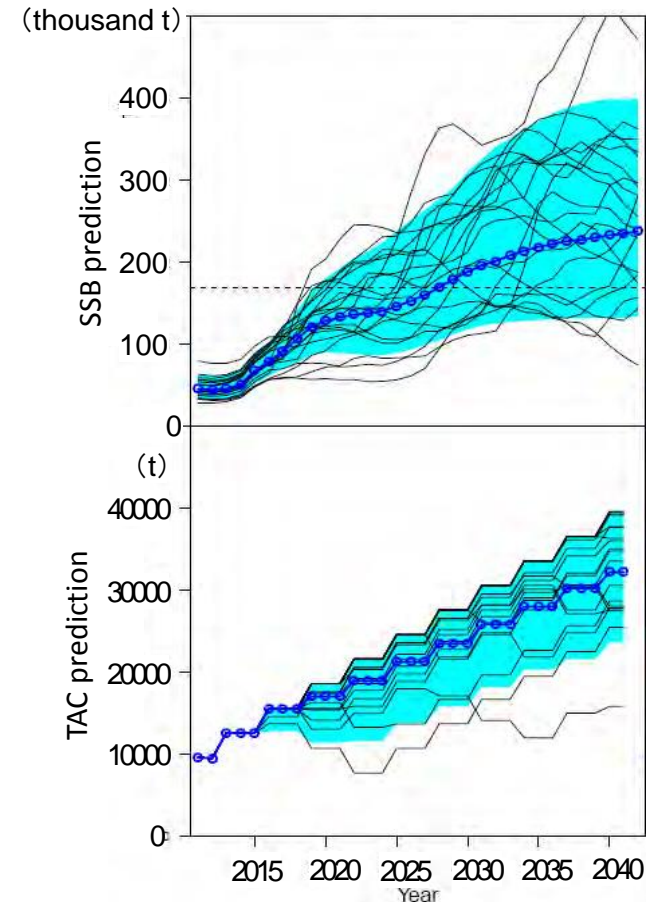
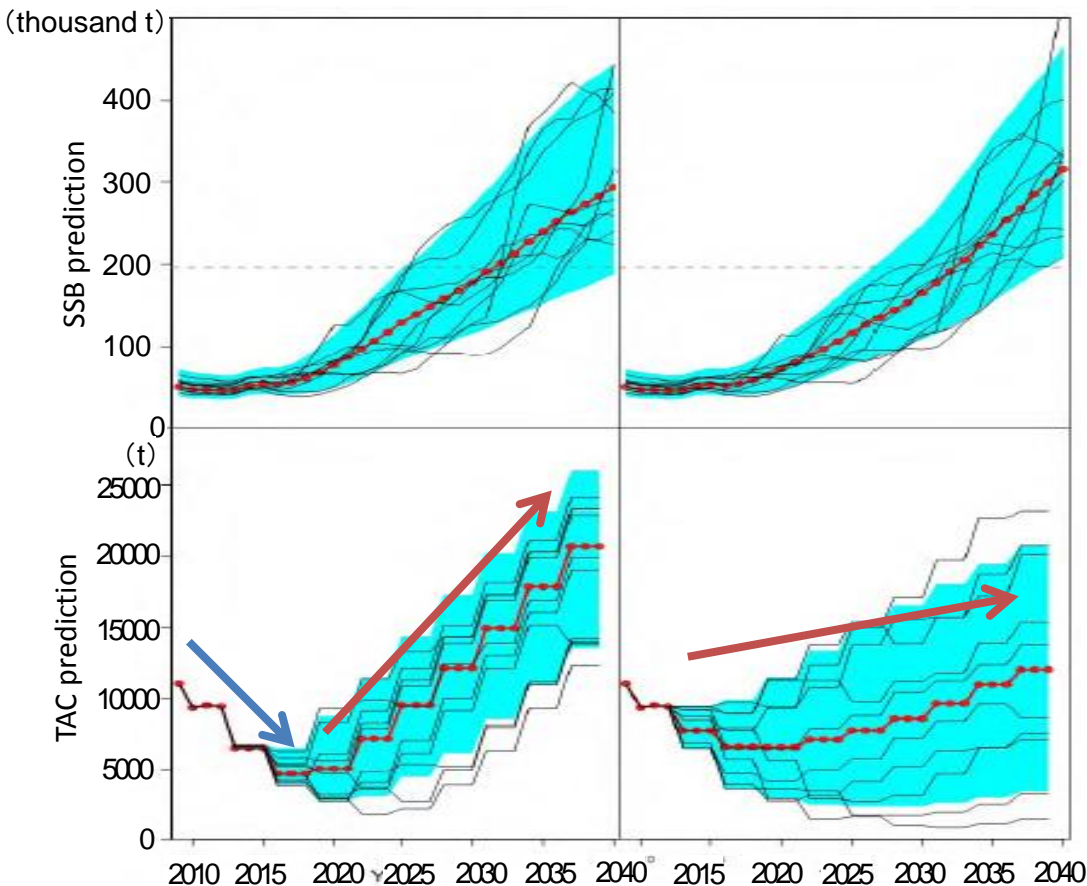
From Report of the 3rd OM and MP technical meeting (2010),
Report of the 14th meeting of the Scientific Committee (2010),
& Report of the 15th meeting of the Scientific Committee (2011)

Performance evaluation of MPs

BREM(s2)

HK7(29b)

Bali Procedure

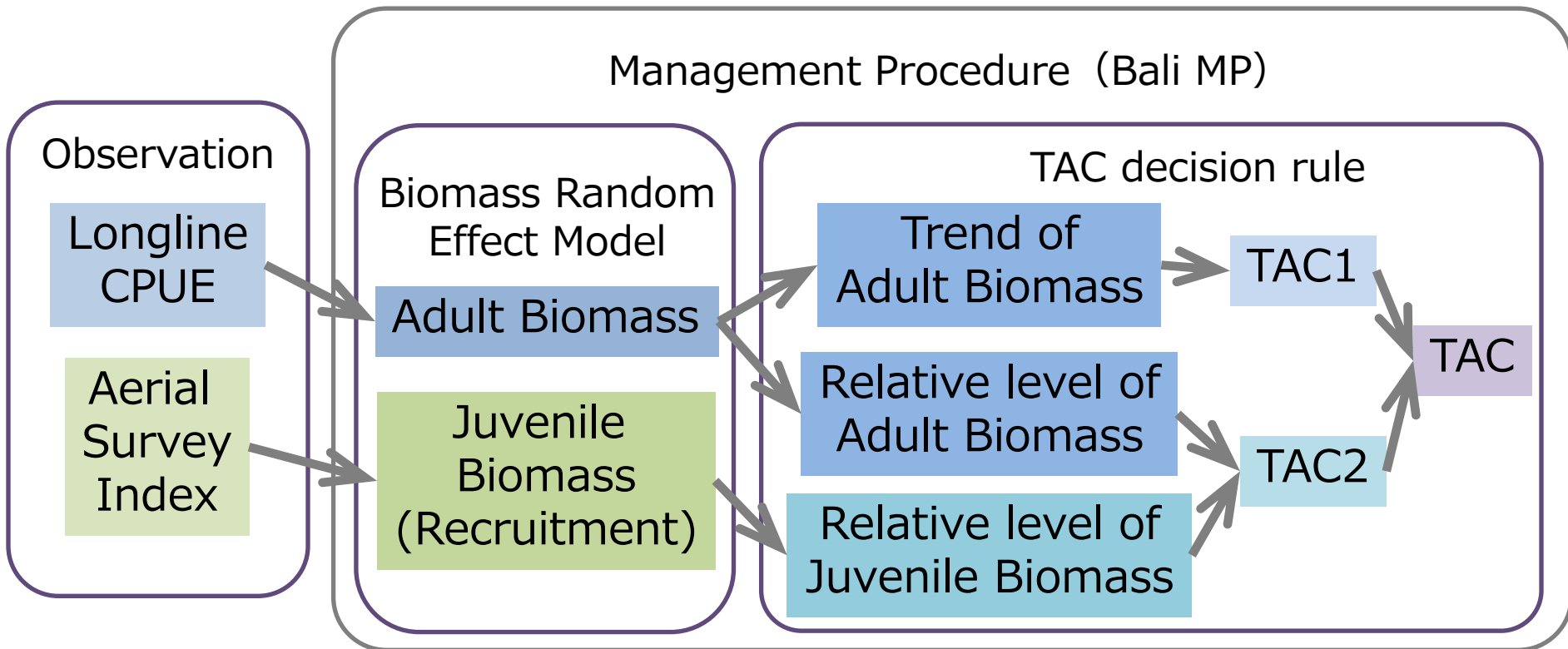


Trade-off between short term average catch and TAC increases in later years.

Adopted in 2011
by the Commission.

Adopted MP “Bali Procedure”

- ✓ Simple model-based HCR.
- ✓ The raw CPUE and AS indices are not used directly.
- ✓ Indices are translated as the BIOMASS (Adult and Juvenile) by the Biomass Random Effect Model (BREM).
- ✓ The trends and levels of adult and juvenile biomass are used to calculate the next TAC.



10 yrs history of development...

- 2000: The Management Strategy Workshop. The development of “Management Procedure (MP)” is first suggested.
- 2001: SC proposed the development of MP to the Commission, and it was approved.
- 2002: Based on the OM prototype, the model setting and structure was discussed.
The MP using CPUE was scheduled for completion in 2004.
- 2003: The MP candidates were tested using updated OM.
The SC requested the commission to show the management guidance.
- 2004: **The updated OM had problems. The completion of MP was rescheduled to 2005.**
- 2005: **Finalized MP was adopted by the Commission.** The implementation of MP was scheduled in 2009 after the retuning.
- 2006: **Long-term under-reported catches were recognized.**
The development of MP went back to the start...
- 2007: Improving the compliance. The review of reliability for the longline CPUE as the input data of MP.
- 2008: Aerial survey index was included in the OM as the fishery-independent index.
- 2009: **The commission scheduled to finalize the MP in 2010 and implement it in 2011.**
The SC considered the work plan to develop MP that utilize CPUE & AS index.
- 2010: The MP candidates were tested and two MP (and average MP) are finalized.
The commission requested further examination of MP in 2011.
- 2011: The SC combined the two MPs and developed “Bali Procedure”.
The commission adopted “Bali Procedure”, and 2012-15 TAC was decided based on the output of this MP.

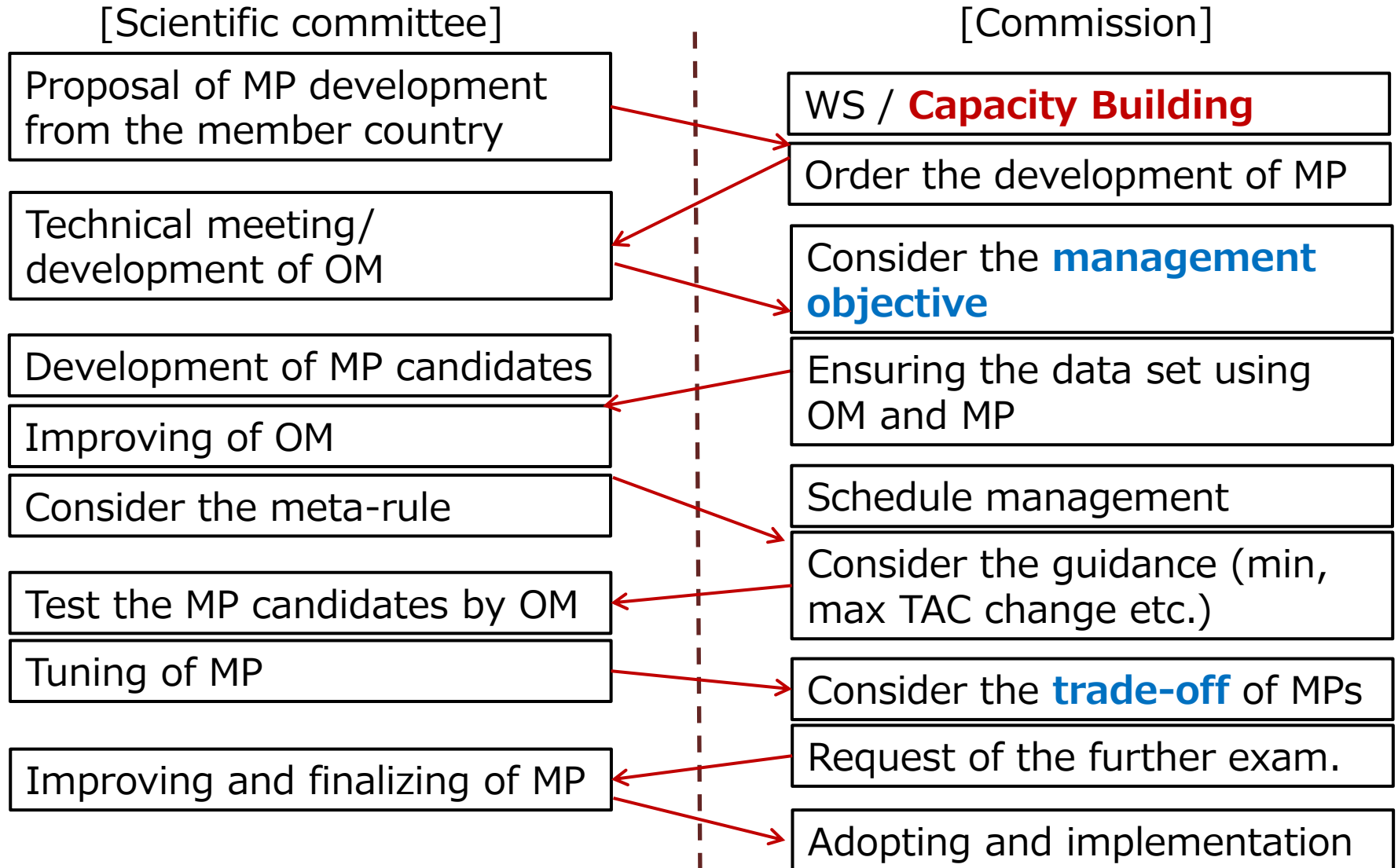


First 5 years



Next 5 years

Step of development

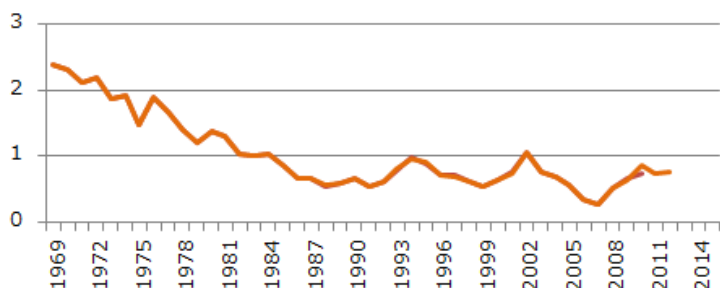


Conversation process between the scientists and stakeholders

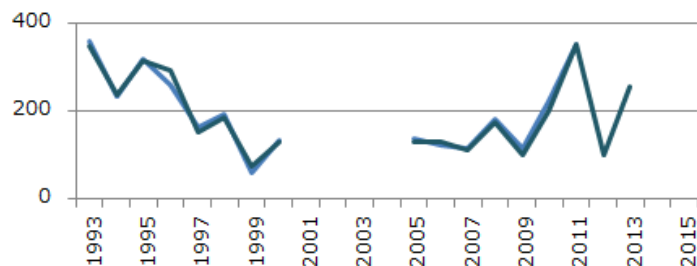
TAC decision using MP

2013: TAC decision

LL CPUE



Aerial Survey



Year	TAC
2011	9449 t
2012	10449 t
2013	10949 t
2014	12449 t
2015	14647 t
2016	14647 t
2017	14647 t

TAC has increased since 2011 (fortunately).

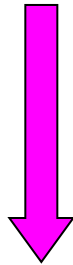
If lower value is calculated, TAC have to be decreased.

Maintain the MP: “Meta-rule process”

Review the abundance indices (annual)
In depth stock assessment (every 3 years)

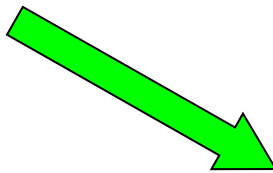
Is there evidence for “**exceptional circumstances**” ?

YES



“**Emergency of the MP**”

Review the exceptional circumstances,
and “take action” if necessary.



NO

MP-derived TAC should be
retained/applied.

“Meta-rule” can be thought of as “rules” & “guideline of process”
in the unlikely situation.

Who should monitor the situation?

Who will determine whether there is evidence for exceptional circumstances?

Who and when is the action considered?

Example:

Annual check of abundance index

exceptional circumstances:

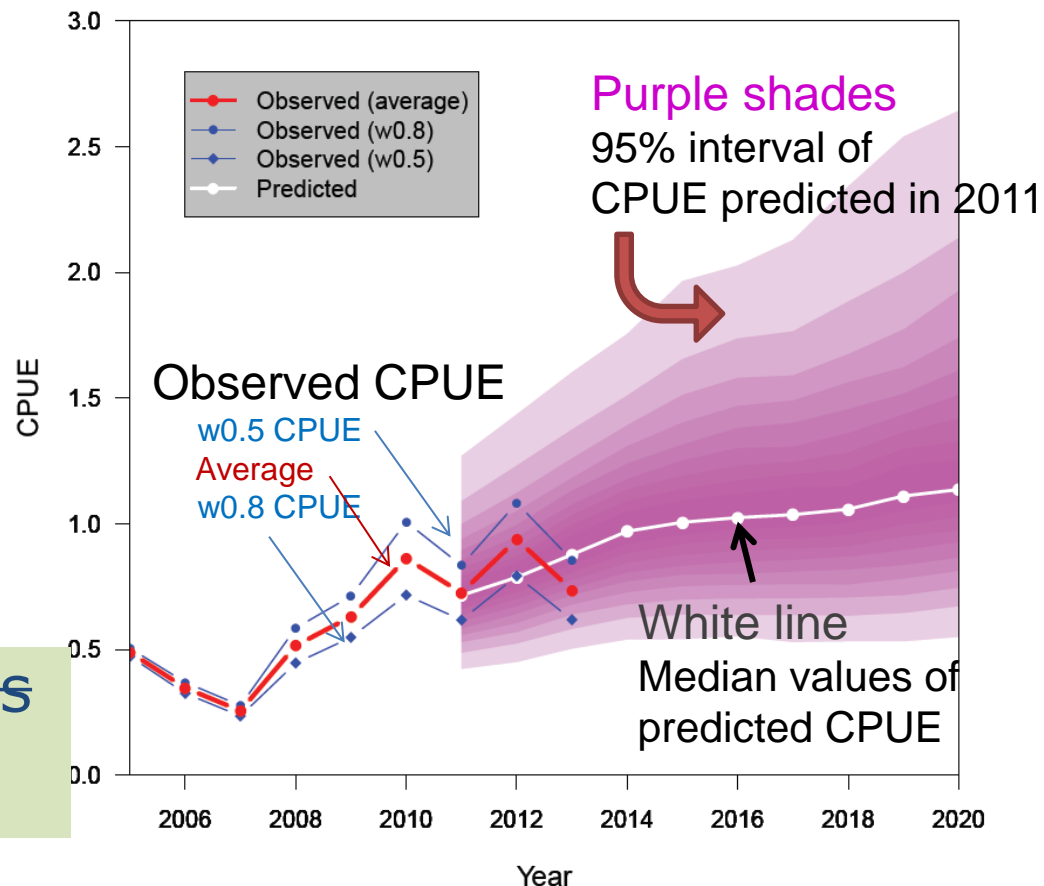
the observed abundance indices was outside the range for which the MP was tested.

Observed CPUEs have been within the 95% probability envelope predicted using base case OM in 2011.

~~Exceptional circumstances~~

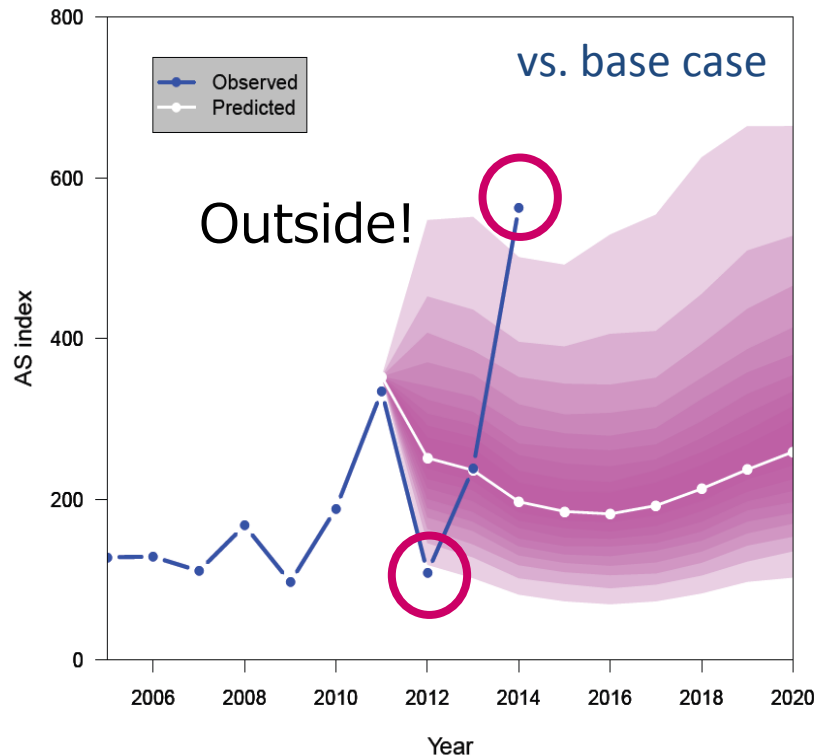
Expected circumstances

Longline CPUE

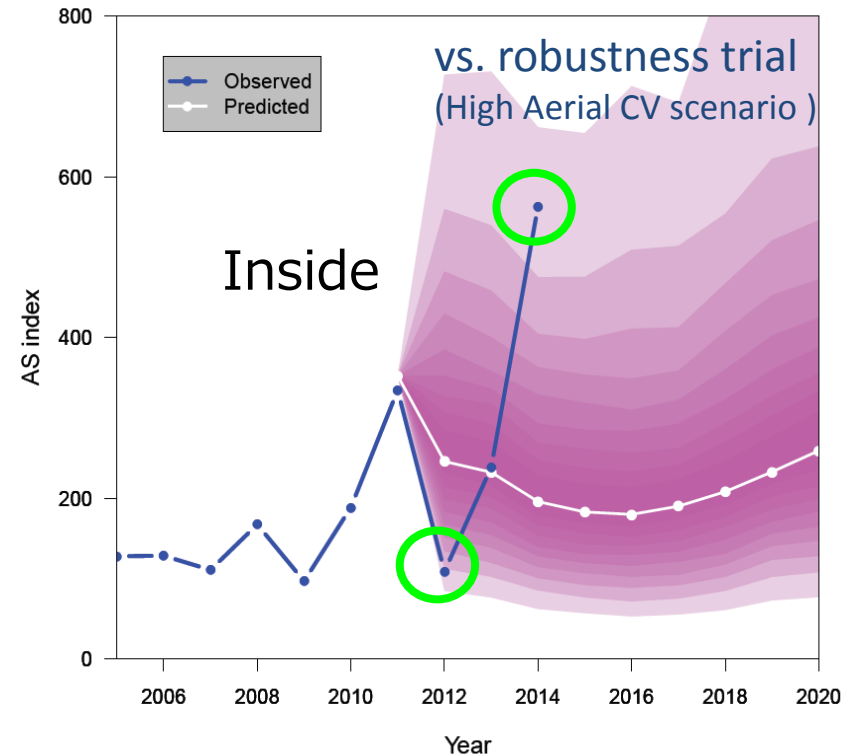


Example: Annual check of abundance index

Aerial Survey



Aerial Survey



Outside of the 95% probability envelope of “base case” **BUT**,
Inside of that of a robustness scenario (“High Aerial CV scenario”).

Expected circumstances. Not indicate the exceptional circumstances.

Example:

Every 3 yrs in depth stock assessment

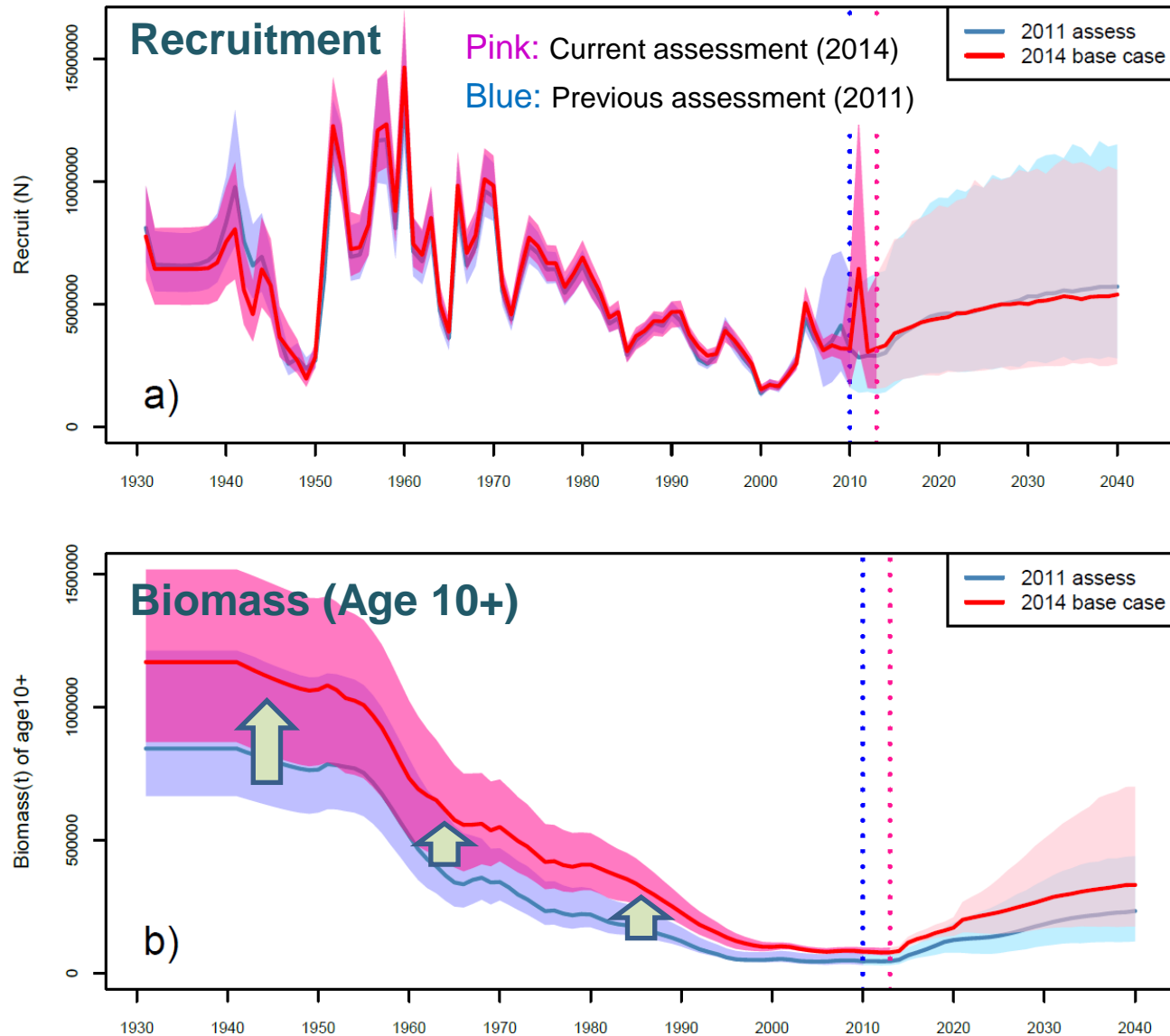
exceptional circumstances:
the stock assessment was substantially outside the range of simulated trajectories considered in MP evaluations

New information was included in current assessment.

Close-Kin:
genetic tech. to estimate absolute size of SSB.

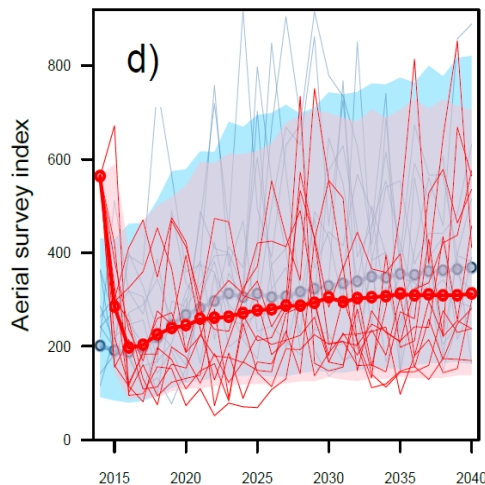
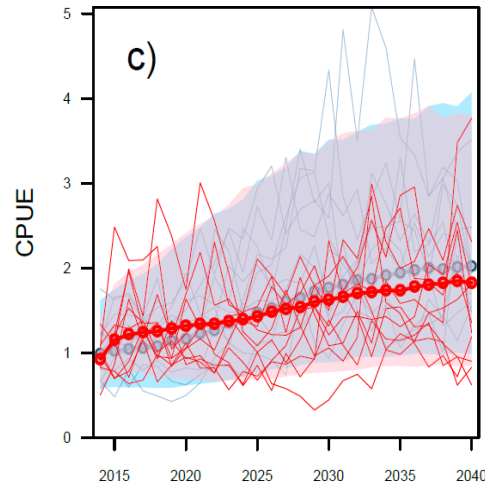
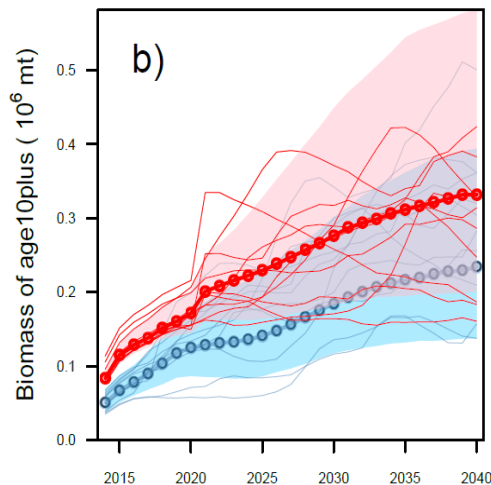
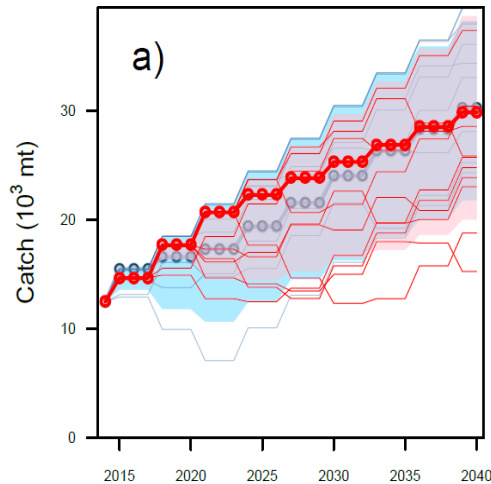


Biomass is greater in absolute terms!



Example: Every 3 yrs in depth stock assessment

Projection



Compared to the previous assessment...

- Biomass is greater in absolute terms.
- The expected catch (TAC), CPUE, and AS index are overlapped.

The MP will be able to manage SBT stock adequately, so that there is no need for re-tuning (Not indicate the exceptional circumstances).

Blue : previous assessment (2011), Red : current assessment (2014)

But, in 2015...

Aerial Survey was canceled by budgetary problem(?)...



exceptional circumstances:

missing input data for the MP,
resulting in an inability to calculate a
TAC from the MP.

Exceptional circumstances ?

If there is the evidence of the exceptional circumstances?

“Meta-rule process” says...

The scientific committee will...

- agree that exceptional circumstances exist.
- determine the severity of the exceptional circumstances.
- formulate advice on the action required;
 - Immediate TAC change or not?*
 - Review to determine whether the MP is on track or not? etc...*
- report to the commission that exceptional circumstances exist.
- provide advice to the commission.

The commission will...

- consider the advice from the SC.
- decide on the action to take.

The role of the scientists are still important after the implement of the MP.

What did we learn?

- (i) the need for the transition from “best assessment and short-term constant catch projections”, to design and evaluation of robust candidate MPs that could meet Commissions’ objectives;
- (ii) the value of transparent and collaborative model development and candidate MP testing;
- (iii) the central importance of verified catch and effort data and effective monitoring and compliance;
- (iv) the value of fisheries independent monitoring;
- (v) commitments by Commissions to make difficult decisions on global catch limits based on the best scientific advice, and implement binding and effective management measures both immediately and in the future.

Benefit and Limitation

MP is “expressly-defined management rule”

The assessment and management process became transparent, which can avoid the problem of “shifting goalposts” of achieving objectives.

MP is “Robust only to what has been evaluated”

It is important to generate the hypotheses for what we don't know about the stock and fisheries, and incorporate them in the robustness test in the MSE process.

The exceptional circumstances would happen easily if the MP was not robust to uncertainty.

“Low probability events do happen” by Ray Hilborn

Thank you for your attention!

Bali Procedure

$$B_{y+1} = R_y + g_y B_y,$$

Calculate the Biomass (y+1) from Biomass (y) and recruitment

$$R_y = \exp(\mu_R + \epsilon_y^R), \quad I_y^{AS} \sim LN(q^R R_{y+1}, \sigma_{AS}^2)$$

Recruitment was adjusted to AS

$$g_y = \exp(\mu_g + \epsilon_y^g), \quad I_y^B \sim LN(q^B B_y, \sigma_B^2)$$

Biomass was adjusted to CPUE

TAC1

$$TAC_{y+1}^1 = TAC_y \times \begin{cases} 1 - k_1 |\lambda|^\gamma & \lambda < 0 \\ 1 + k_2 \lambda & \lambda \geq 0 \end{cases}$$

Calculate the "TAC1" using "slope" of the biomass.
λ is the slope of 7 yrs lnB_y

TAC2

$$TAC_{y+1}^2 = 0.5 \times (TAC_y + C_y^{targ} \Delta_y^R)$$

Calculate the "TAC2" using "level" of the biomass and recruitment

$$C_y^{targ} = \begin{cases} \delta [B_y / B^*]^{1-\epsilon_b} & B_y \geq B^* \\ \delta [B_y / B^*]^{1+\epsilon_b} & B_y < B^* \end{cases}$$

B* is target level
δ is tuning parameter

$$\Delta_y^R = \begin{cases} [\bar{R} / \Phi]^{1-\epsilon_r} & \bar{R} \geq \Phi \\ [\bar{R} / \Phi]^{1+\epsilon_r} & \bar{R} < \Phi \end{cases}$$

Φ is the average recruitment
R̄ is the average level of recent 5 yrs recruitment

$$\bar{R} = \frac{1}{\tau_R} \sum_{i=y-\tau_R+1}^y R_i$$

$$TAC_{y+1} = 0.5 \times (TAC_{y+1}^1 + TAC_{y+1}^2).$$

TAC is the average of TAC1 and TAC2

Bali procedure has the concept of the filtering of biomass & recruitment values based on the "Biomass Random Effect Model", and slope/target approach to determine the TAC.