Perspective on Evaluating “Management Procedures”

- In case of International Whaling Commission -

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Development of “generic RMP” in IWC through a so-called “MSE process”

RMP in International Whaling Commission (IWC)

- IWC: the first annual meeting was held in 1949
- Many whale stocks have been *"depleted"* because of the heavy utilization period
- In 1982, IWC decided to impose a moratorium on commercial whaling; in 1986, the moratorium was taken effect
- IWC Scientific Committee started the process of developing a procedure *for setting safe and practical catch limits* for commercial whaling
- "Revised Management Procedure" (RMP) was adopted in 1994
- RMP is a pioneer of MSE approaches

Why RMP (and why MSE)?

- *Need to set safe and practical catch limits*

BUT, in the past

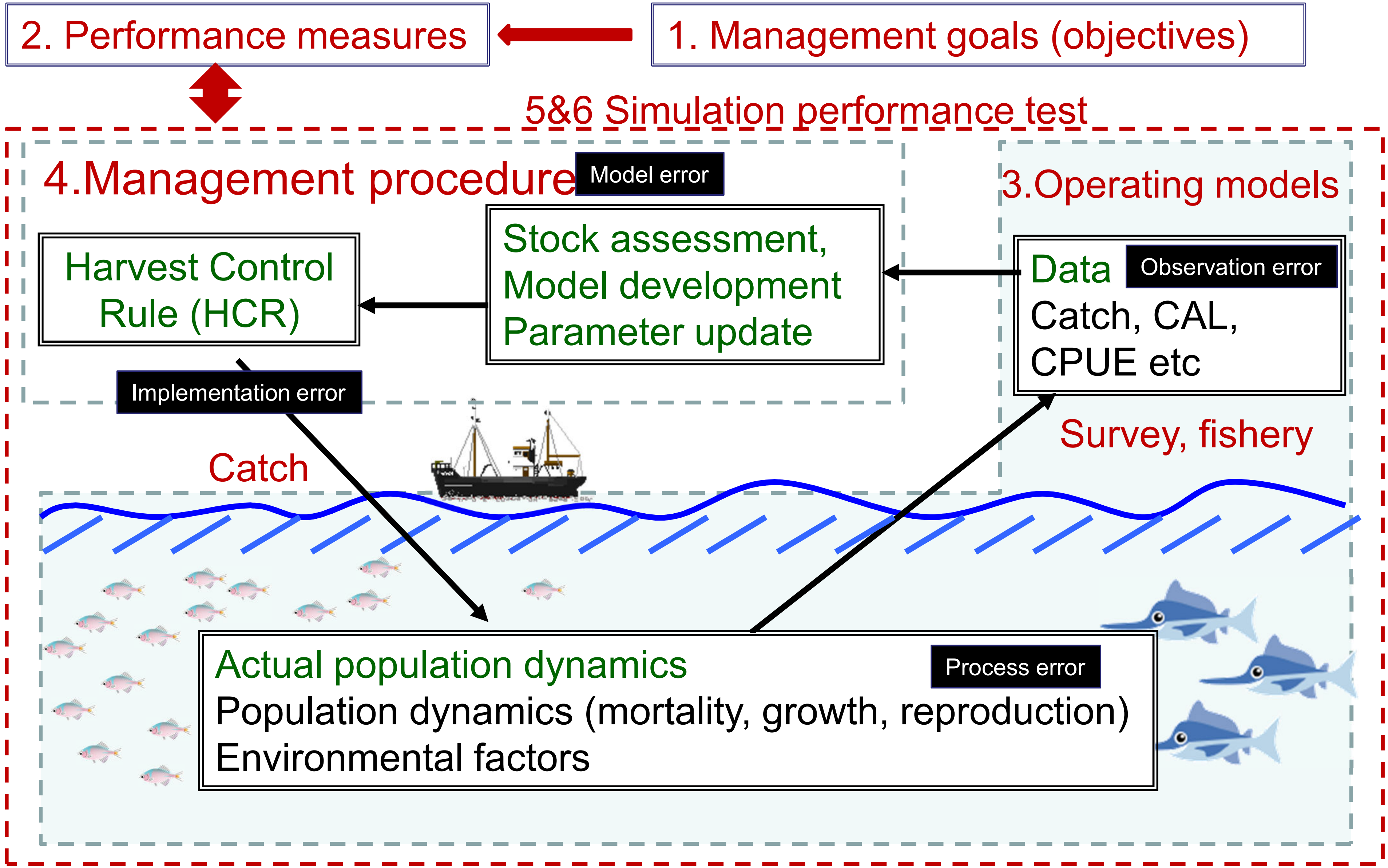
- True stock status tended to be poorly known
- Unknown key parameters
- Uncertainty in “abundance estimates” by surveys

Even so, in the future

- Repeated surveys give more information on abundance
- This longer time series in abundance also helps to estimate some key parameters

Therefore, even if information is poor at the beginning of management, we can assume the improvement of knowledge in the future and reflect it to the management procedure

MSE in nutshell



Temporal interpretation of MSE

Past

Current

Future (in the simulation)

Research-Stock Assessment

Collection of data and initial assessment

More collection and manipulation of data
and better stock assessment

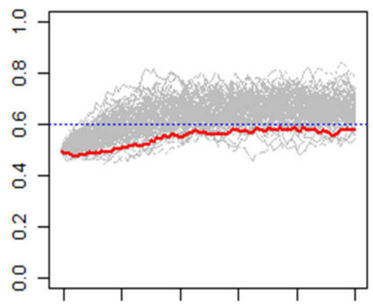
Consideration of Objectives
and better management procedures

Virtual reality for XX years
data generation by using several OMs
stock assessment in future
application of several MPs

Application of MSE

conditioning
Simulation models
(so-called operating models

Management objectives
and risks



Objectives: Achievable??
CHECK by MSE!!

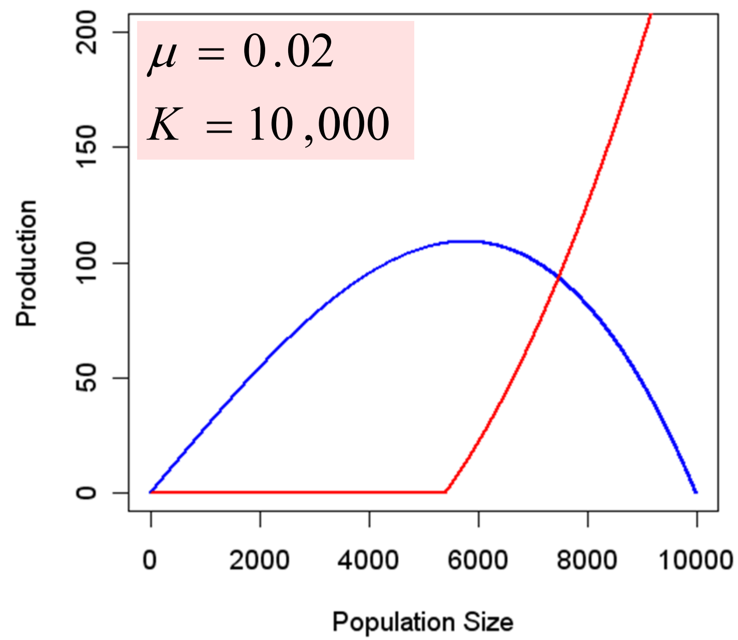
Development of "generic RMP"

		IWC/SC's RMP
1	Specification objectives	● Catch not be allowed on stock below 54% of K ● Stable and high catch
2	Performance measures	● Minimum and final depletion after 100 years ● Prob(catch occurs when stock below 54% of K) ● Average and variance of catch etc.
3	Operating models (simulation model)	Generating future abundance data from "conditioned" single stock age-structured model
4	Management Procedure (incl.HCR)	● Five candidates of catch limit algorithms ● Every 5 years, catch limit is re-evaluated using new information ● Tuned to target a specific median depletion (e.g. 72% of K)
5	Simulation trials and comparison	Several scenarios including episodic events
6	Advice of MPs/HCRs	Final agreement of MPs/HCRs and advice

Catch Limit Algorithm (CLA): basic formulas

Pella-Tomlinson model

$$P_{y+1} = P_y - C_y + 1.4184\mu P_y \left[1 - \left(\frac{P_y}{K} \right)^z \right]$$



Catch limit

$$C_y = \begin{cases} 0 & if \ \frac{P_y}{K} < 0.54 \\ 3\mu \left(\frac{P_y}{K} - 0.54 \right) P_y & if \ \frac{P_y}{K} \geq 0.54 \end{cases}$$

Internal threshold so that catch not be allowed on stock below 54% of K

Agreed "tuned-Catch Limit Algorithm"

Pella-Tomlinson model

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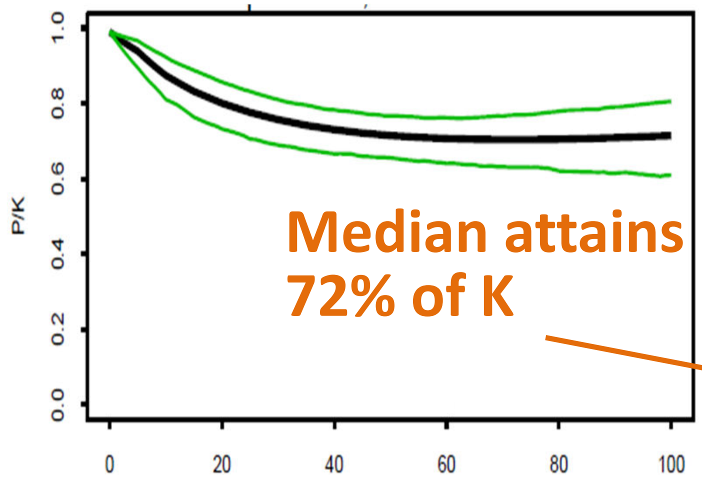
Catch limit

$$C_y = \begin{cases} 0 & \text{if } \frac{P_y}{K} < 0.54 \\ 3\mu \left(\frac{P_y}{K} - 0.54 \right) P_y & \text{if } \frac{P_y}{K} \geq 0.54 \end{cases}$$



Parameter estimation (Bayesian)

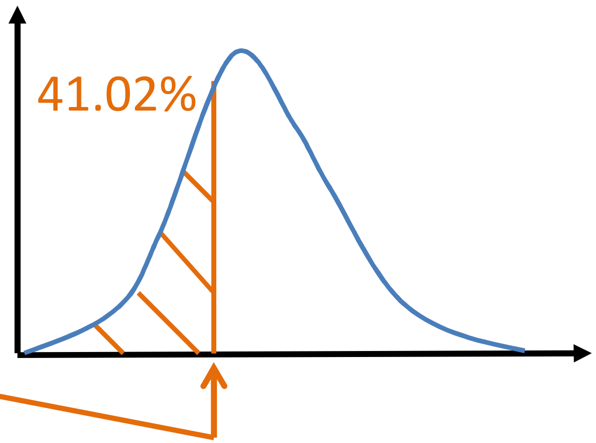
Likelihood from abundance[1/16]
(account for estimation bias)

+

Prior distribution of parameters
(Conservative)

→ Posterior of parameters

→ Posterior of Catch Limit

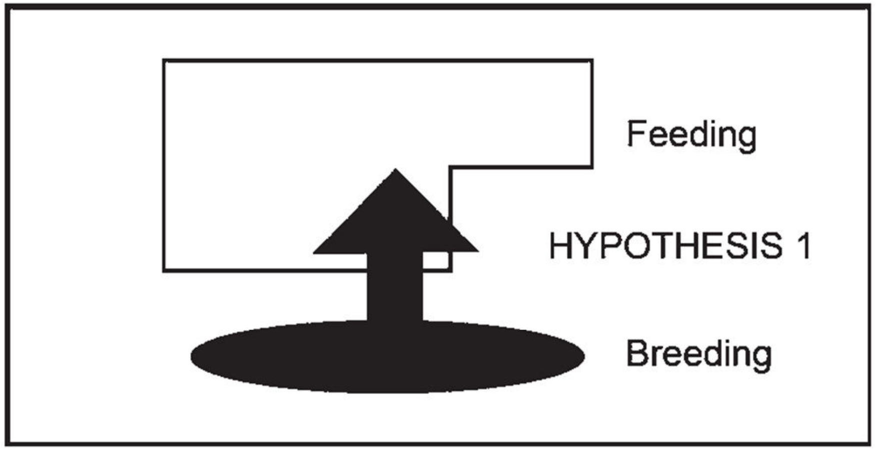


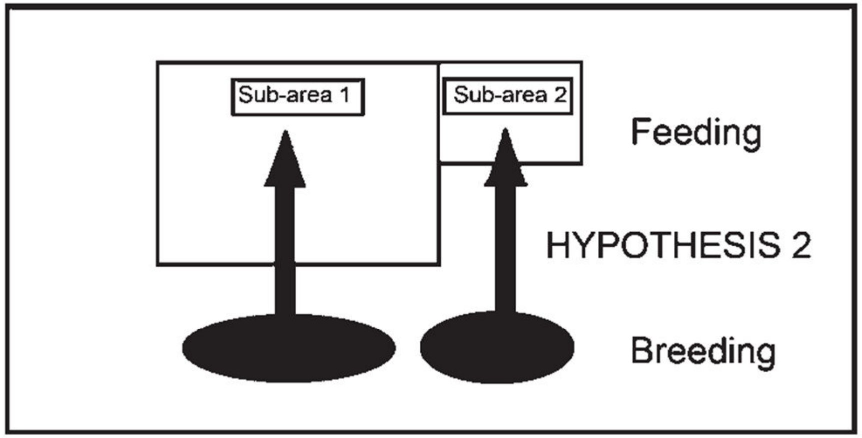
Final form of "generic" RMP

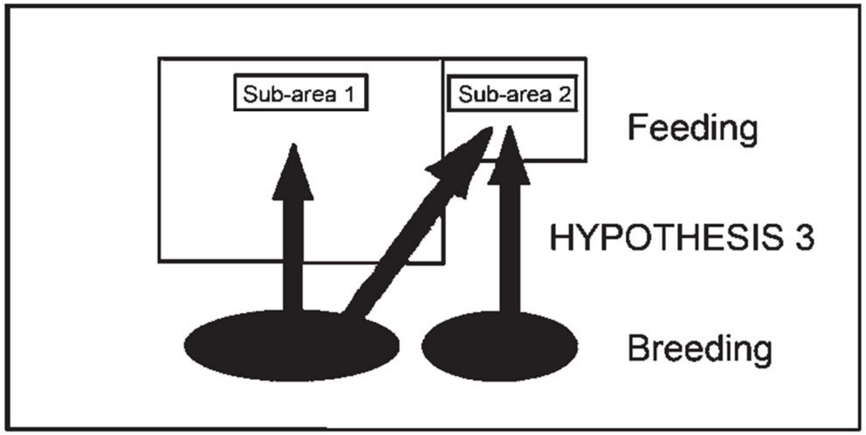
- Catch Limit Algorithm (CLA) Based on a simple model !
  - Developed for a single stock
  - Time series of catch and abundance estimate
- Simulation performance test (OMs) Comprehensive !
  Performance check under various scenarios
  - Uncertainty in biological parameters, stock structure etc.
- A strict *guideline* for abundance survey and estimation
- In principle, "abundance" and "catch limit" will be updated every 5 years (also assumed in the simulation process)
- If new abundance estimate is not available for 8 years, catch will reduced automatically (phase-out rule)

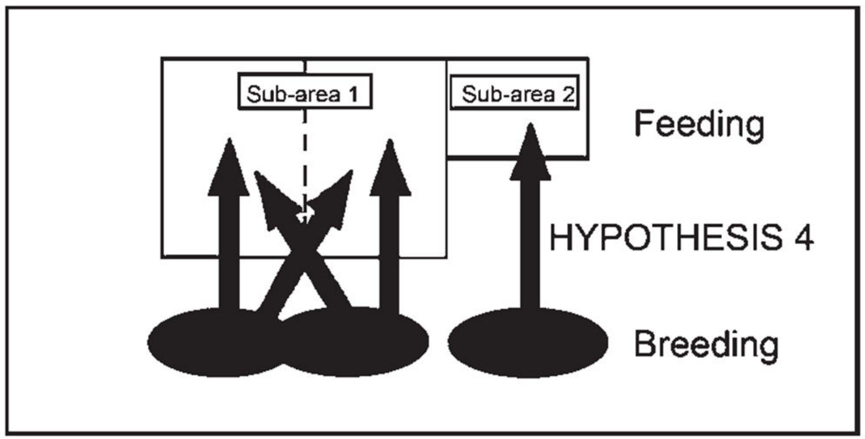
Extension of RMP for cases of multiple stocks and actual process in *Implementation* of RMP (with an example)

Stock structure hypotheses



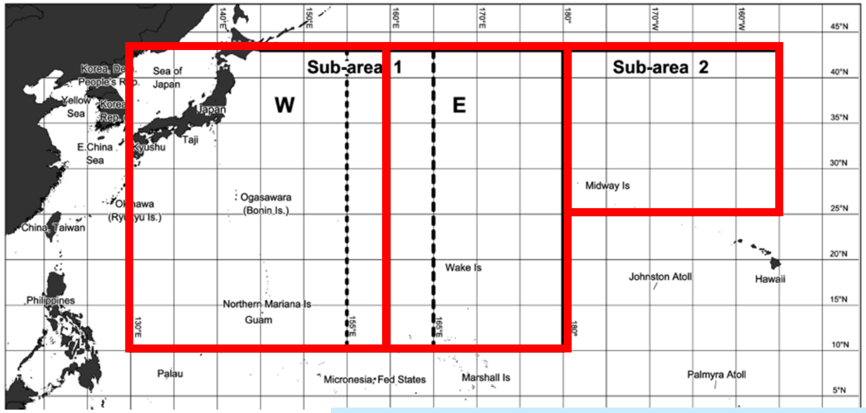




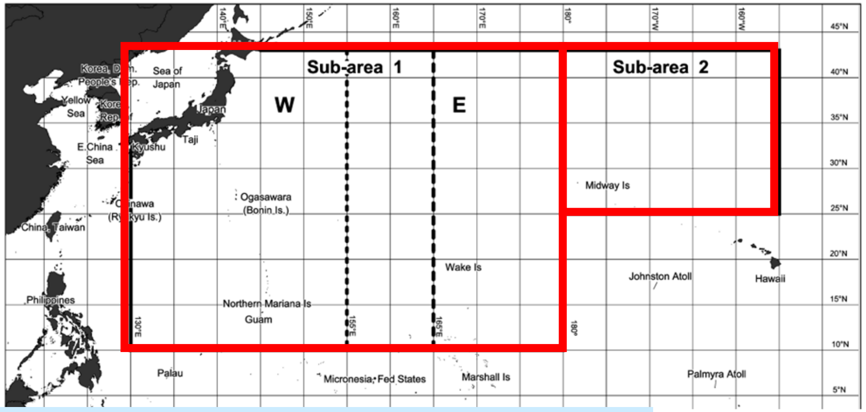


Spatial allocation of CLA and Catch limits

Variant 1

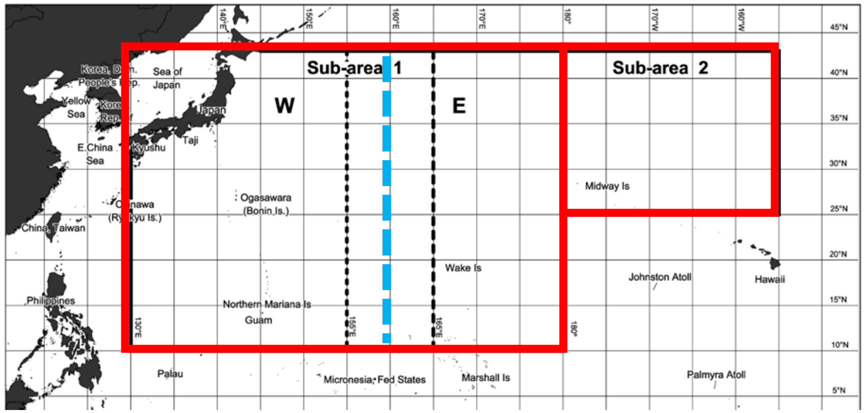


Variant 2

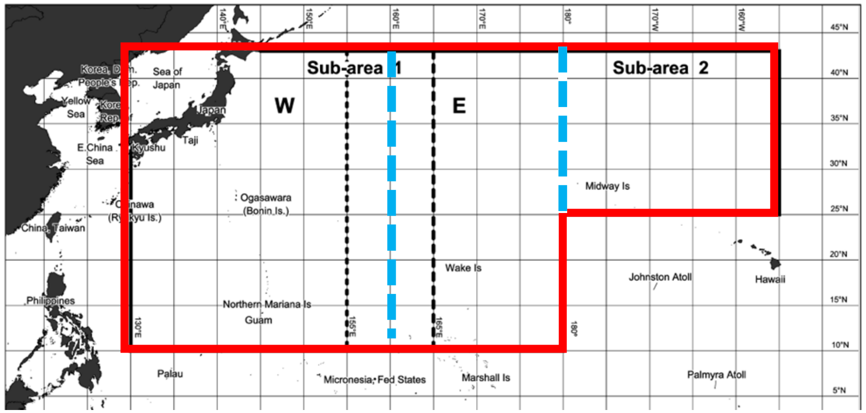


Establish *Small Areas* for CLA application

Variant 3



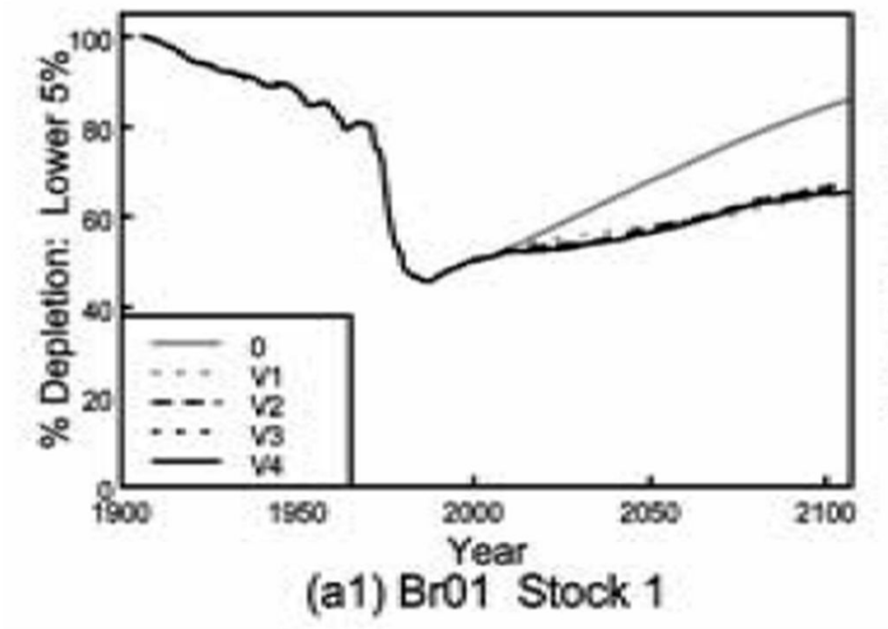
Variant 4



A total of 28 trials

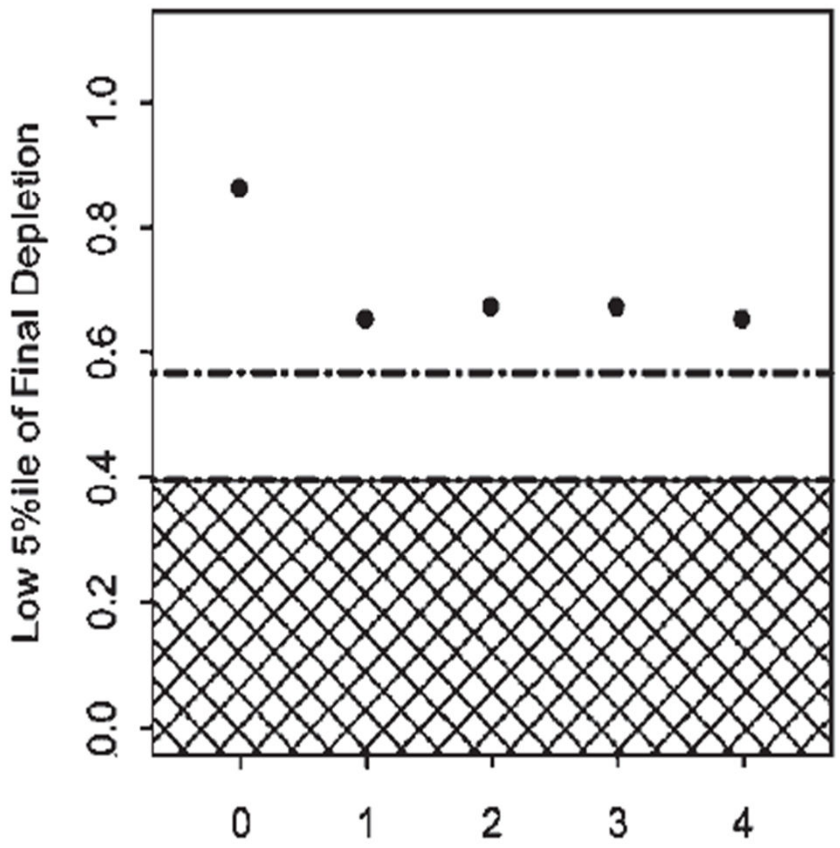
Trial No.	Stocks	Sub-stocks	$MSYR_{mat}$	Mixing matrix	Process error	Stochastic mixing in 1W/1E	Catch series	Age-dependent Mixing?	1W/1E boundary	Comment	Trial weight
Br1	1	No	1	A	Baseline	No	Best	No	165°E	Stock structure hypothesis 1	M
Br2	1	No	4	A	Baseline	No	Best	No	165°E	Stock structure hypothesis 1	**H**
Br3	2	No	1	B	Baseline	No	Best	No	165°E	Stock structure hypothesis 2	M
Br4	2	No	4	B	Baseline	No	Best	No	165°E	Stock structure hypothesis 2	**H**
Br5	2	No	1	C	Baseline	No	Best	No	165°E	Stock structure hypothesis 3 *	M
Br6	2	No	4	C	Baseline	No	Best	No	165°E	Stock structure hypothesis 3 *	**H**
Br7	2	Yes	1	D	Baseline	No	Best	No	155°E	Stock structure hypothesis 4	M
Br8	2	Yes	4	D	Baseline	No	Best	No	155°E	Stock structure hypothesis 4	M
Br9	2	No	1	B	Baseline	No	Best	**Yes**	165°E	B + Age-dependent mixing	M
Br10	2	No	4	B	Baseline	No	Best	**Yes**	165°E	B + Age-dependent mixing	**H**
Br11	2	Yes	1	D	$\sigma_p = 0.9$	No	Best	No	155°E	D + Additional process error	M
Br12	2	Yes	4	D	$\sigma_p = 0.9$	No	Best	No	155°E	D + Additional process error	M
Br13	2	Yes	1	D	Baseline	**Yes**	Best	No	155°E	D + Stochastic mixing *	M
Br14	2	Yes	4	D	Baseline	**Yes**	Best	No	155°E	D + Stochastic mixing *	M
Br15	2	Yes	1	D	Baseline	No	Best	No	**160°E**	D + Alternative Boundary 1	M
Br16	2	Yes	4	D	Baseline	No	Best	No	**160°E**	D + Alternative Boundary 1	M
Br17	2	Yes	1	D	Baseline	No	Best	No	**165°E**	D + Alternative Boundary 2	M
Br18	2	Yes	4	D	Baseline	No	Best	No	**165°E**	D + Alternative Boundary 2	M
Br19	2	Yes	1	D	Baseline	No	**Low**	No	155°E	D + Low catch series	M
Br20	2	Yes	4	D	Baseline	No	**Low**	No	155°E	D + Low catch series	M
Br21	2	Yes	1	D	Baseline	No	**High**	No	155°E	D + High catch series	M
Br22	2	Yes	4	D	Baseline	No	**High**	No	155°E	D + High catch series	M
Br23	2	No	1	B	Baseline	No	**High**	No	165°E	B + High catch series	M
Br24	2	No	4	B	Baseline	No	**High**	No	165°E	B + High catch series	**H**
Br25	2	No	1	B	$\sigma_p = 0.9$	No	Best	No	165°E	B + Additional process error	M
Br26	2	No	4	B	$\sigma_p = 0.9$	No	Best	No	165°E	B + Additional process error	**H**
Br27	2	No	1	B	Baseline	No	**High**	**Yes**	165°E	B + Age-dep.mixing+high catch	M
Br28	2	No	4	B	Baseline	No	**High**	**Yes**	165°E	B + Age-dep.mixing+high catch	**H**

RMP process for Bryde's whales



(a1) Br01 Stock 1

Trial BR-01



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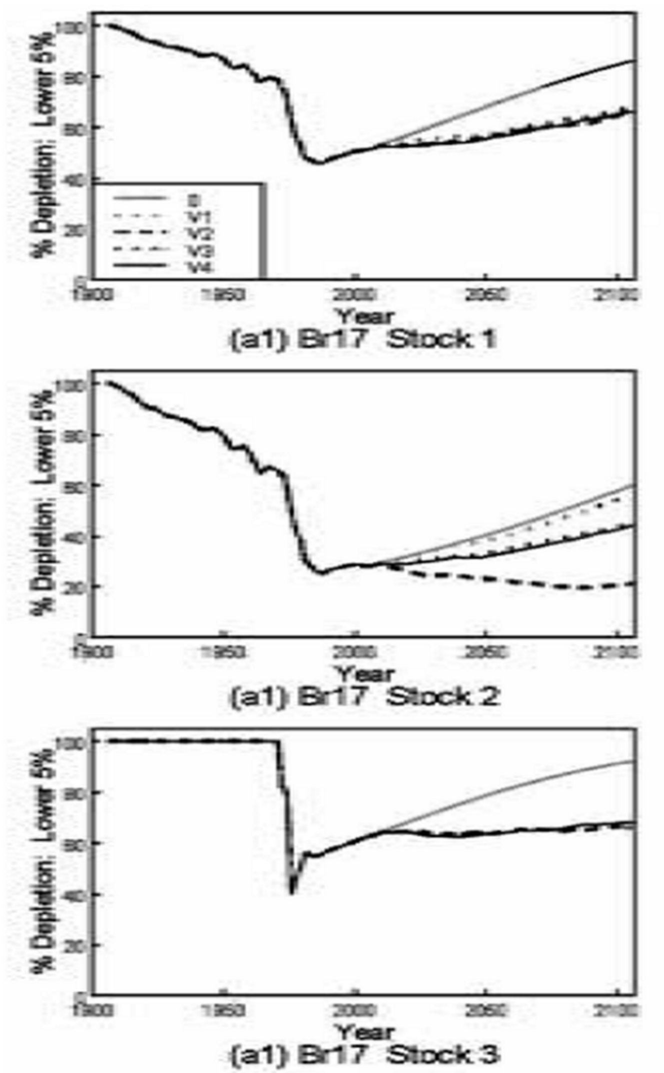

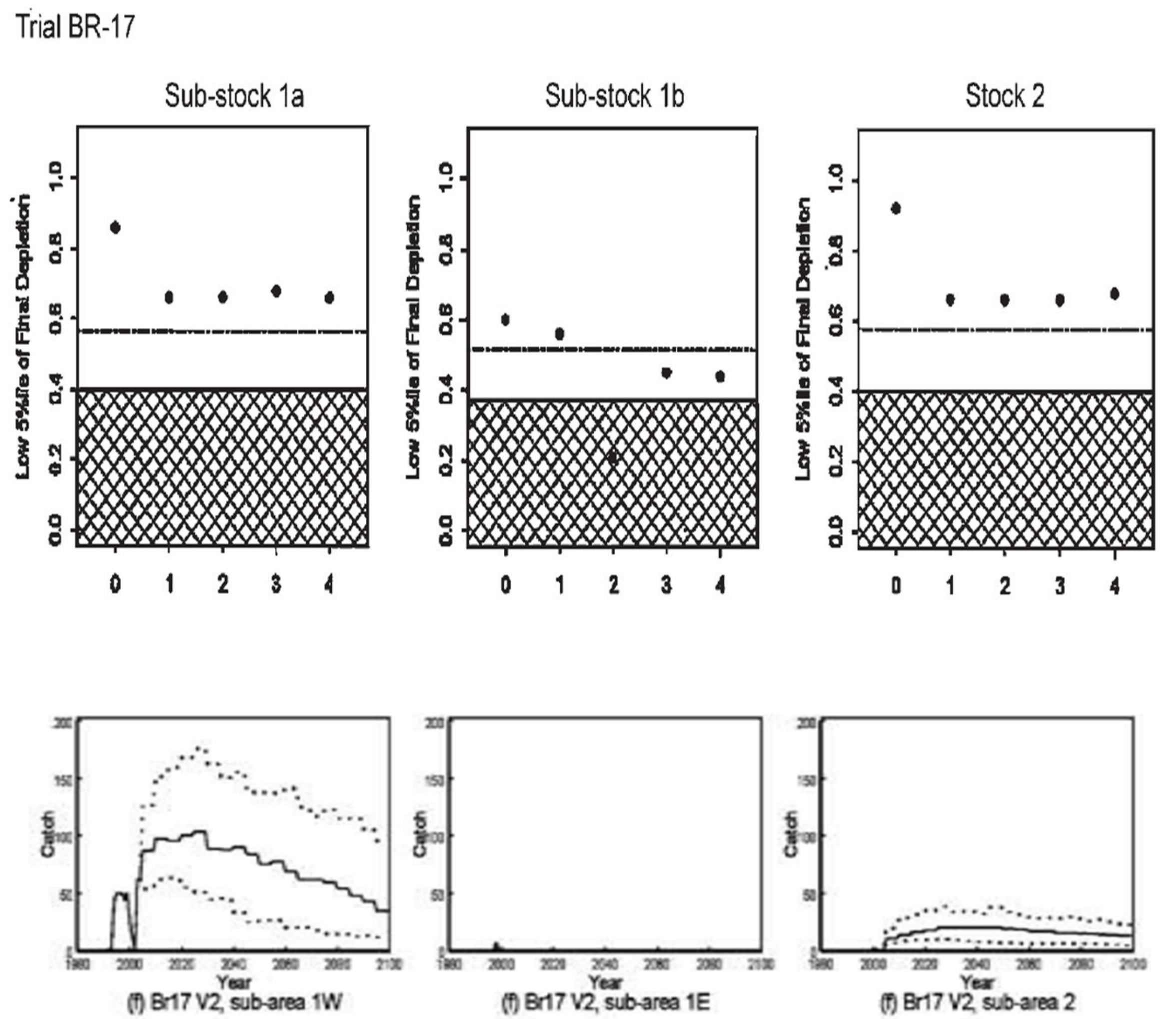

RMP process for Bryde's whales

Highest catch limits among "survived" variants

Area	Abundance	CV	Abundance date stamp	Tuning level	Catch limit split to area	Catch limits (after applying phaseout)				
						2010	2011	2012	2013	2014
1W	4,957	0.398	2000	72%	3.7	2	1	1	0	0
1E	11,213	0.498	1999	72%	8.5	3	2	0	0	0
2	4,331	0.553	2002	72%	(3.3)					
1W	4,957	0.398	2000	60%	22.2	13	9	4	0	0
1E	11,213	0.498	1999	60%	50.3	20	10	0	0	0
2	4,331	0.553	2002	60%	(19.4)					

A look at RMP in this case

- CLA is only a catch limit algorithm (not HCR itself)
- HCR in this RMP is a combination of tuned CLA and formulation of variant which is a spatial allocation of catch given CLA
- Selection of *better and safe variant* using comprehensive simulation with OMs
- Through this process, various sources of uncertainty are taken into account

Lessons learnt and advantage/disadvantage of MSE

Advantage/disadvantage of MSE in the case of RMP

Advantage

- Comprehensive examination of performance and risk for potential MPs (HCRs)
- Incentive to invention of good Harvest Control Rules
- Incentive to summarization of available information through MSE process
- Incentive to continued survey
- *Transparency* of process and decision making

Disadvantage

- Heavy load for construction and conditioning of OMs
- Have to consider various uncertainty
- Need human Resources

Management Procedures in IWC

- Revised Management Procedure (RMP)

  - Generic management procedure developed for baleen whales
  - Use "Catch Limit Algorithm (CLA)" as a HCR

- Aboriginal Whaling Management Procedure (AWMP)

  - A framework for case-specific management procedures for aboriginal whaling
  - Use "Strike Limit Algorithm (SLA)" (incl. Struck-and-lost)
  - Allow the algorithm depending on data richness

Lessons learnt

- Clearly written specification (incl. time line) helps discussion in the process of actual RMP Implementation
- Difficulty in weighing plausibility for OMs (within base trials, robustness trials)
- Difficulty in conditioning on parameters (e.g. mixing proportions) in cases of complex multiple stock structure (sometime due to the nature of migration corridor)
- Need to consider ecosystem perspective
  - Time variation of *production rate* and *carrying capacity* due to food availability and competition among species