Tuning generic empirical MPs with simple conditioned OMs: A case study of Japanese data-limited stock

Kohei Hamabe
Kunihiro Fujiwara
Momoko Ichinokawa

FRA
National Research and Development Agency,
Japan Fisheries Research and Education Agency

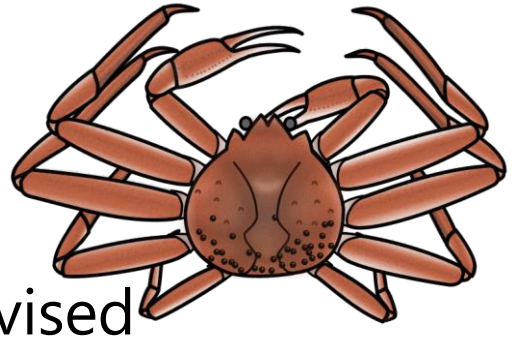
Japanese empirical MP

- For data-limited stocks in Japan
  - Cannot be assessed based on age-structured models (e.g., VPA)
  - These stocks are called “type-2” stocks
  - CPUE and catch data are available in many cases

- Generic type-2 MP (hereafter, GT2 MP)
  - GT2 MP is an empirical MP for type-2 stocks
  - The MP have been developed based on an unconditioned OM in which data-limited situation and a wide range of uncertainties in population parameters are assumed (Okamura et al., in preparation)

  - Pros) being automatically applied for any stocks
  - Cons) the MP tends to calculate quite conservative ABC

The Sea of Japan subpopulation of snow crab in region B (SCB)

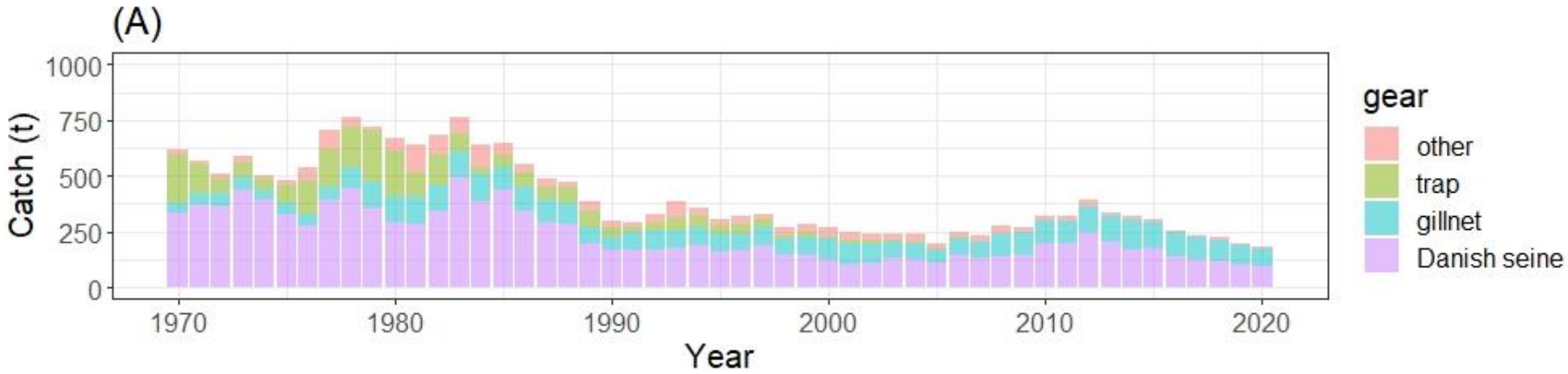


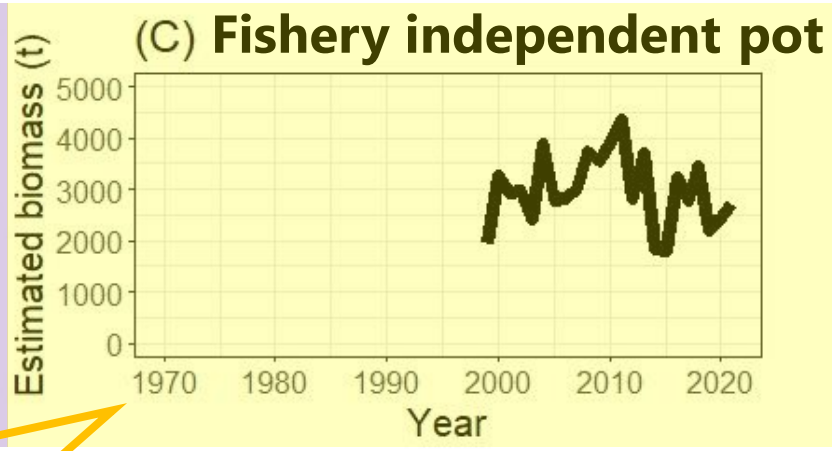
- The first stock to which the GT2 MP was proposed under the Revised Fisheries Act
- GT2 MP was not accepted by the stakeholders
  - The ABC calculated by GT2 MP was extremely small compared to the ABC calculated under the previously used reference point
  - F30%SPR with using survey abundance was used until then
- F30%SPR MP has not been fully evaluated under potential uncertainties in the estimation of reference points and survey abundance
- GT2 MP would result in highly conservative catch because uncertainties in the generic OMs may have been overestimated when considering the specific stock of SCB

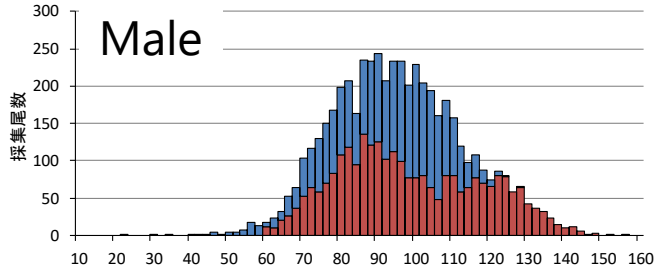
Objectives

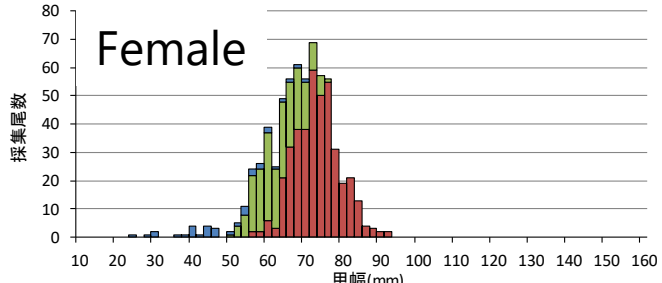
- Stock-specific MSE was constructed with simple conditioned OMs for SCB
- We compared performances between F30%SPR and GT2 MPs under the stock-specific MSE
- Stock-specific type-2 (SS2) MP have been developed by changing tuning parameters of GT2
- State-space surplus production model was employed to conditioned OMs according to data availability

Data of SCB



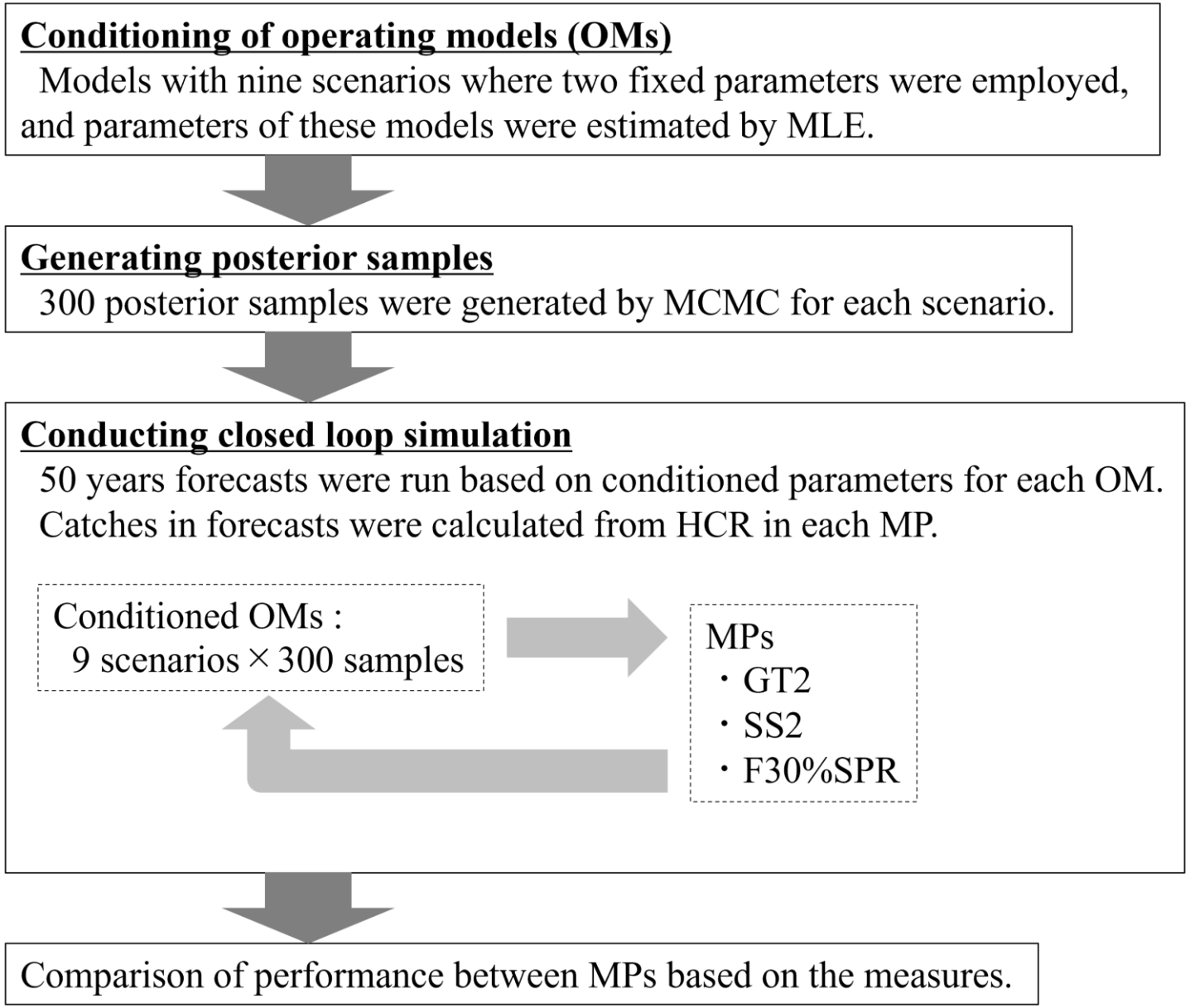






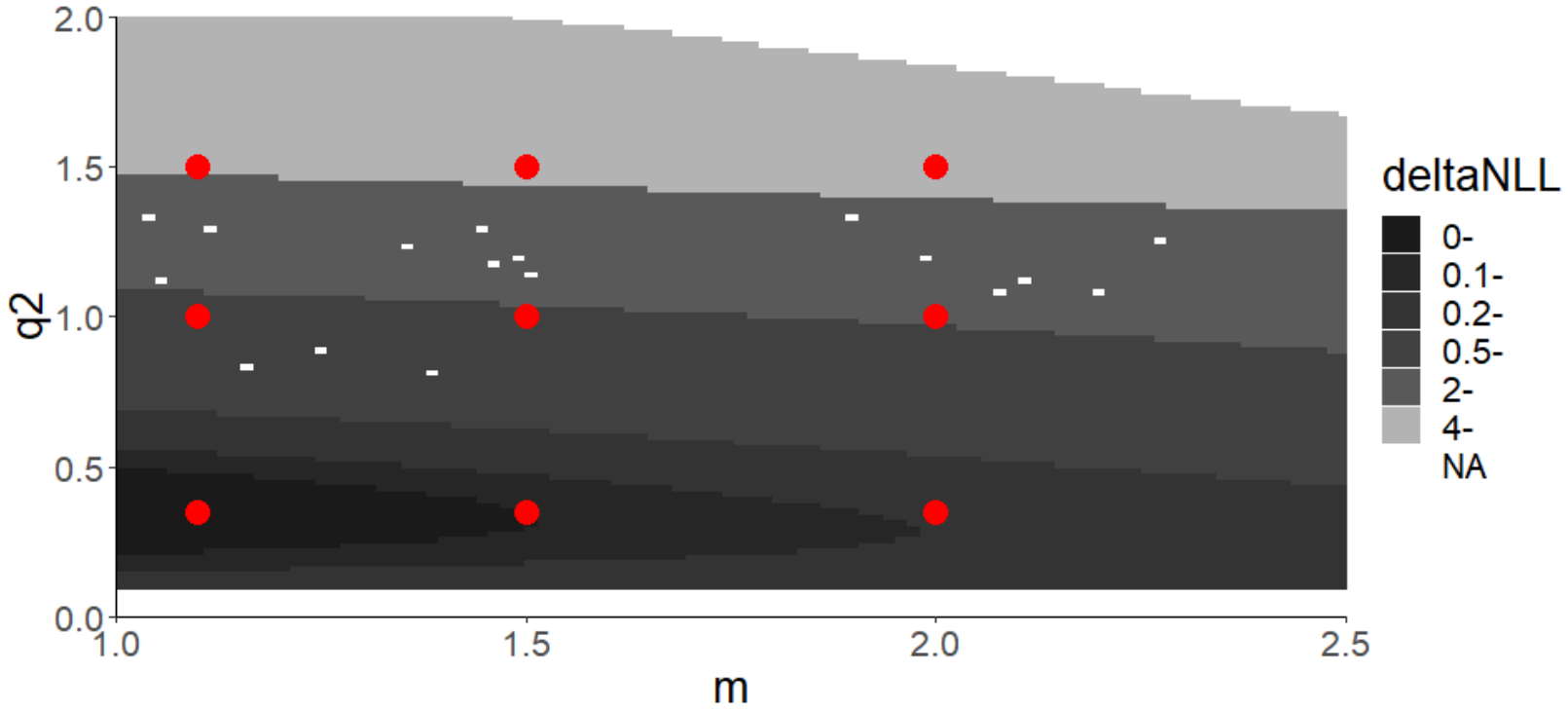
Characteristic of pot survey
- be captured large individuals
- be difficult to separate instar-composition

Simulation flowchart



Simulation flow 1
- construction of 9 OM scenarios

- According to profile likelihood, two parameters were difficult to be estimated
  - Shape parameter of surplus production model (m)
  - A bias coefficient of survey abundance (q2)
- m (1.1, 1.5, 2.0) and q2 (0.25, 1.0, 1.5) were fixed

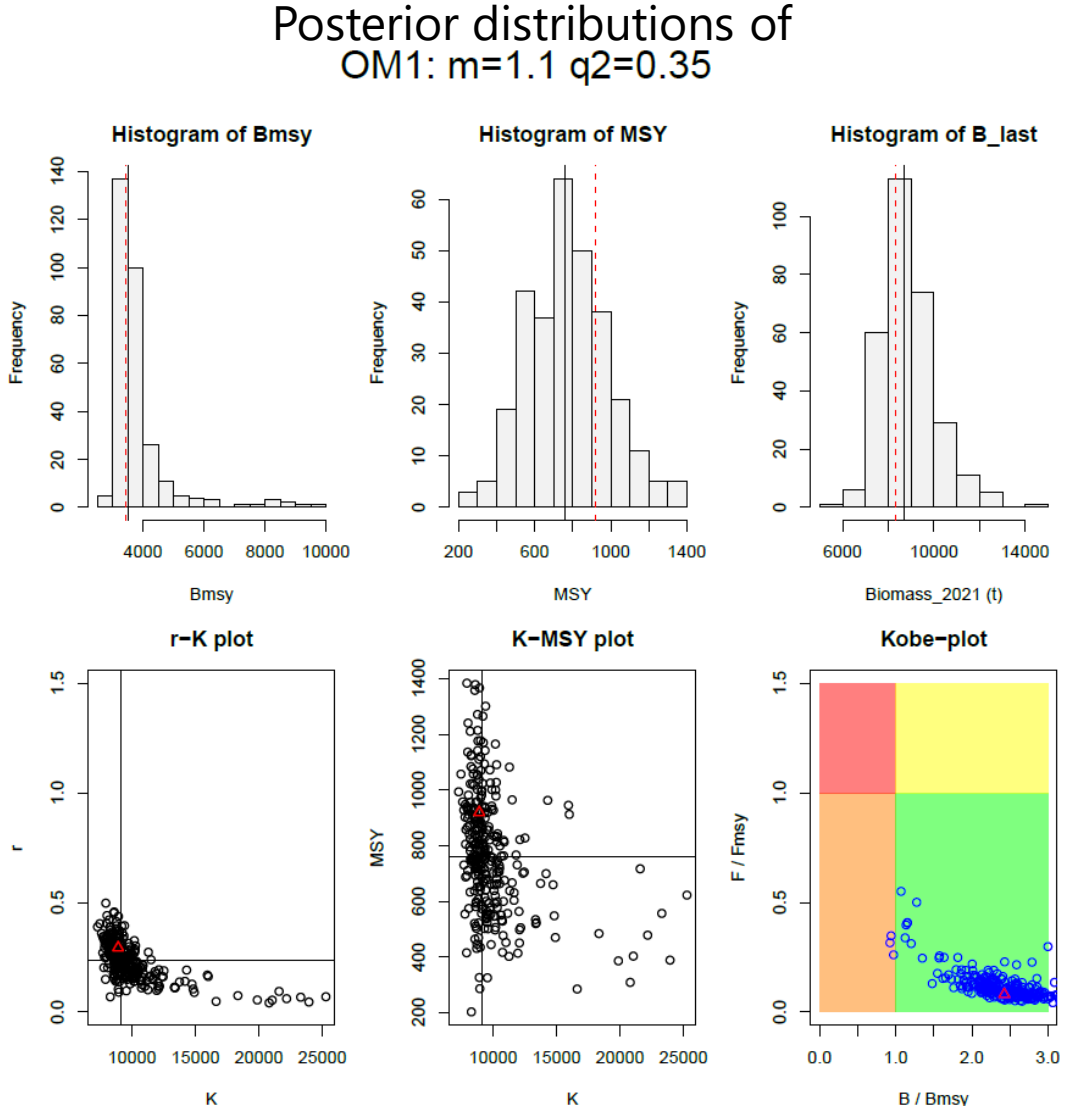


Simulation flow 2 - generating posterior samples

- Conditioned OM were estimated by MLE in self-coded TMB

- Posterior samples were generated by 'adnuts' package in R

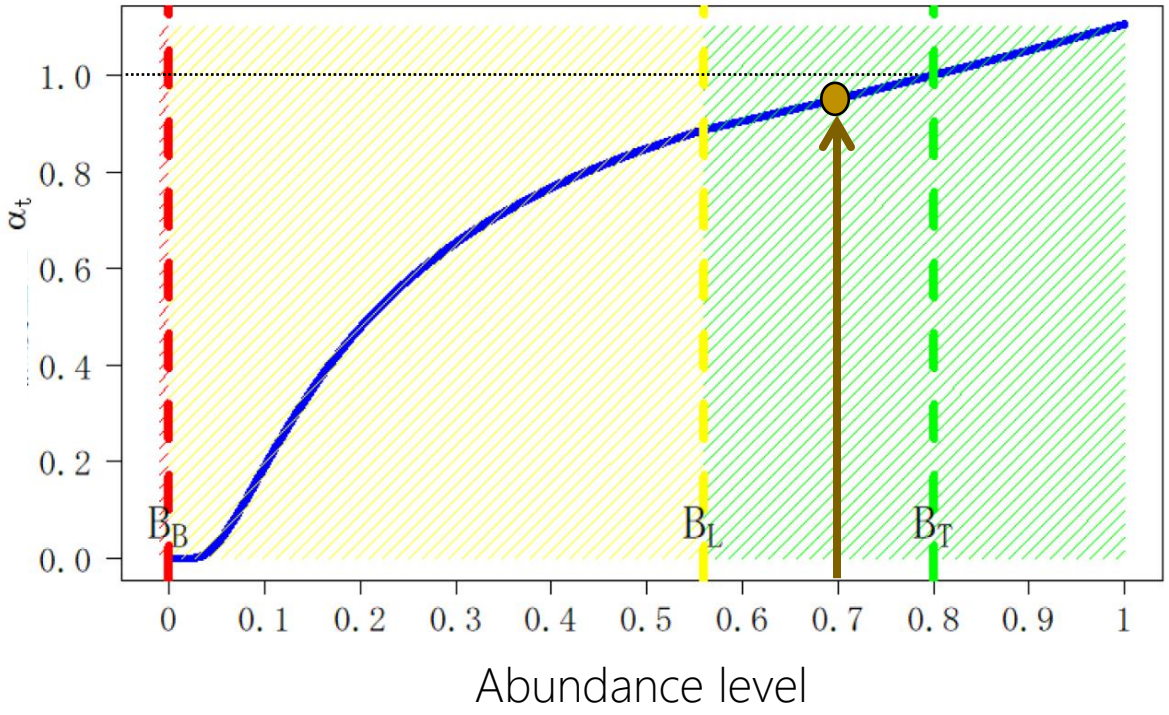
  (Probably 'tmbstan' is more suitable)



Candidate MPs - GT2 and SS2 MPs

- GT2 is the target-based empirical MP
- ABC is calculated from $\alpha_t \beta \bar{C}_t$
  - α_t : determined algorithm (right figure)
  - $\bar{C}_t$: average of last 5-years catches
  - β : an adjustment coefficient (default is to 1)

- SS2 is tuned below three options
  - B_T : 0.3, 0.5, 0.8 (GT2 is to 0.8)
  - β : 1.0, 1.1, 1.2, 1.3, 1.4, 1.5
  - Abundance level with last 5yr averaging
- 35 SS2 MPs were constructed



- **Blue line** is computed according to an algorithm
- **The current abundance level** (0.7 is above example) was calculated from the level of recent CPUE, when assuming a cumulative normal distribution of CPUEs

Candidate MP
- F30%SPR MP

- Survey abundance
  - Abundance was calculated multiplied area by density
  - Density was calculated from the number of captured crabs and a catchability
  - Catchability of male was cited from previous study
  - Catchability of female was given the value assumed that instar composition is same as different region snow crab stock
  - But uncertainty of the estimated catchabilities is not known

- F%SPR based on survey data
  - F%SPR was calculated from instar-structured equilibrium model (Ueda et al., 2009)
  - In 2020, F%SPR was estimated as 0.22
  - Fishing rate (Catch/Biomass) was corresponded to 0.19

- (ABC) = 0.19*(average of last 5 years survey abundances)

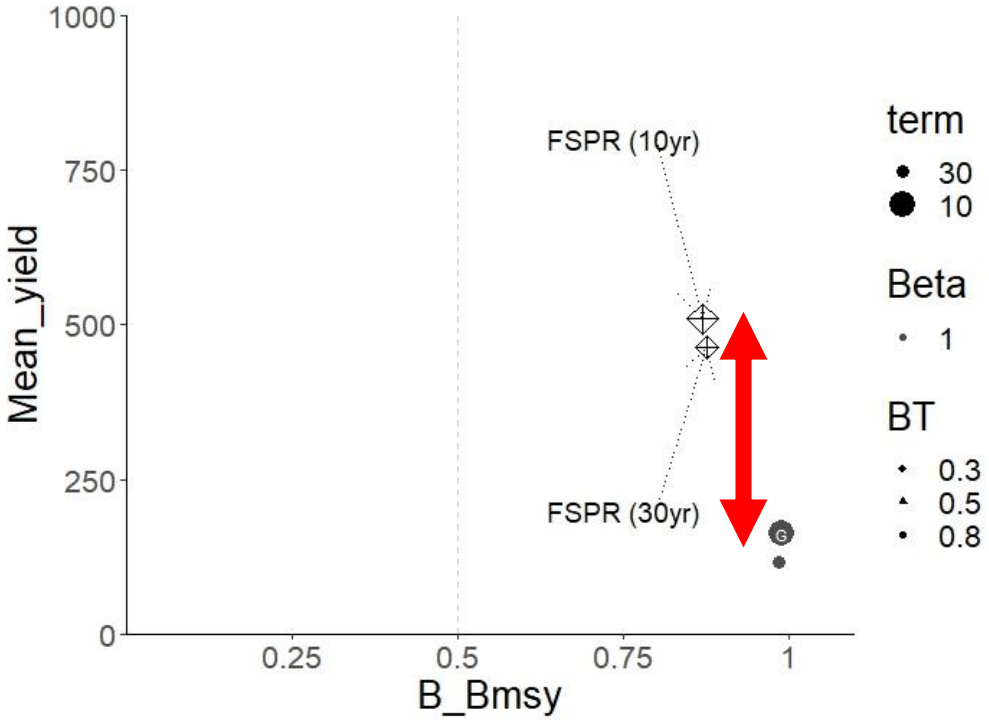
Performance measures

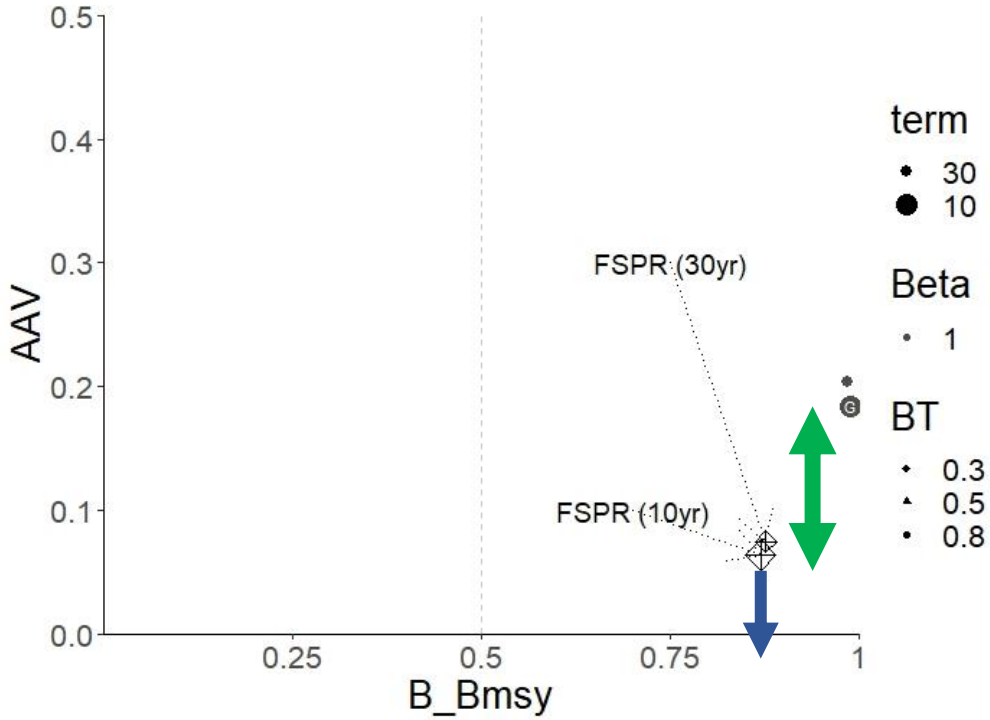
- The following three performance measures were established for the 10/30 years of management

- 1. a probability that biomass in 10/30 years after was over Bmsy (B_Bmsy)
- 2. mean catch over the management period, 10-/30-years duration (Mean_yield)
- 3. average catch variation (AAV) over the management period, 10-/30-years durations

Results
- Trade-off plots of GT2 and F30%SPR

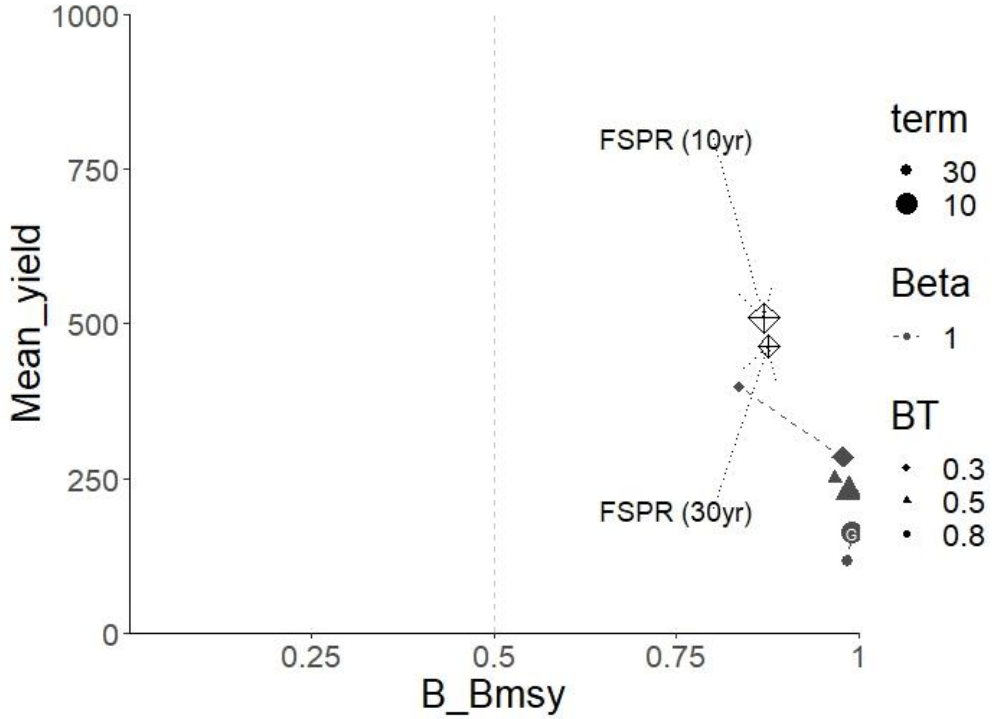
- The mean catch of GT2 was only half of that of F30%SPR (⇔)
- AAV of F30%SPR was half of that of GT2 (⇔)
- When managed at F30% SPR, there was a greater than 75% probability that the biomass exceeded Bmsy (↓)

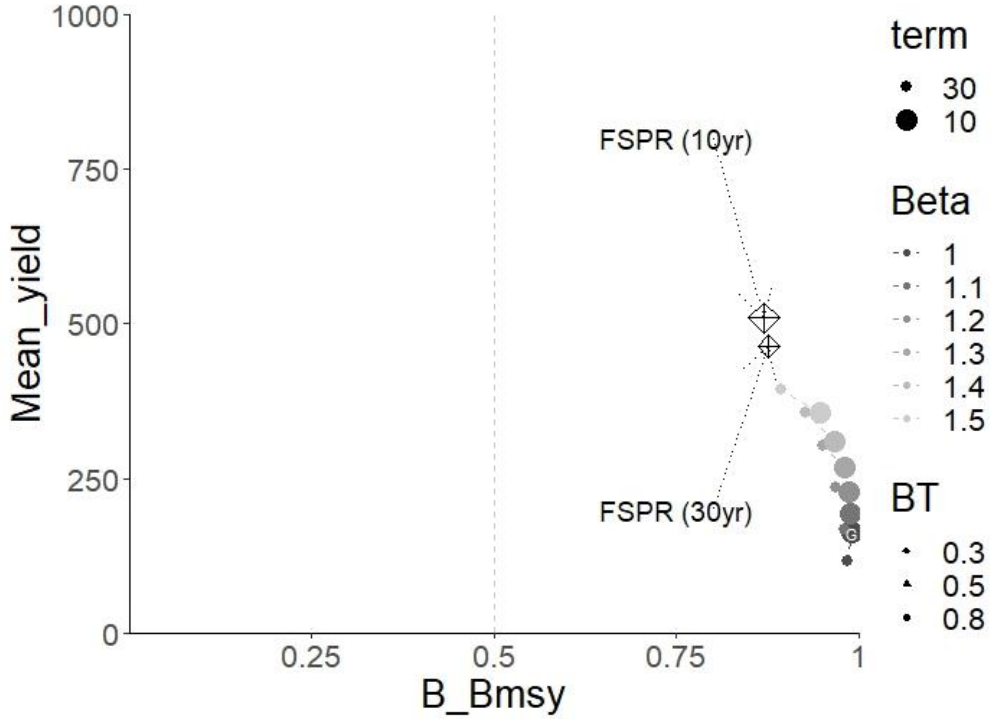




Results
- Trade-off plots of SS2 and GT2

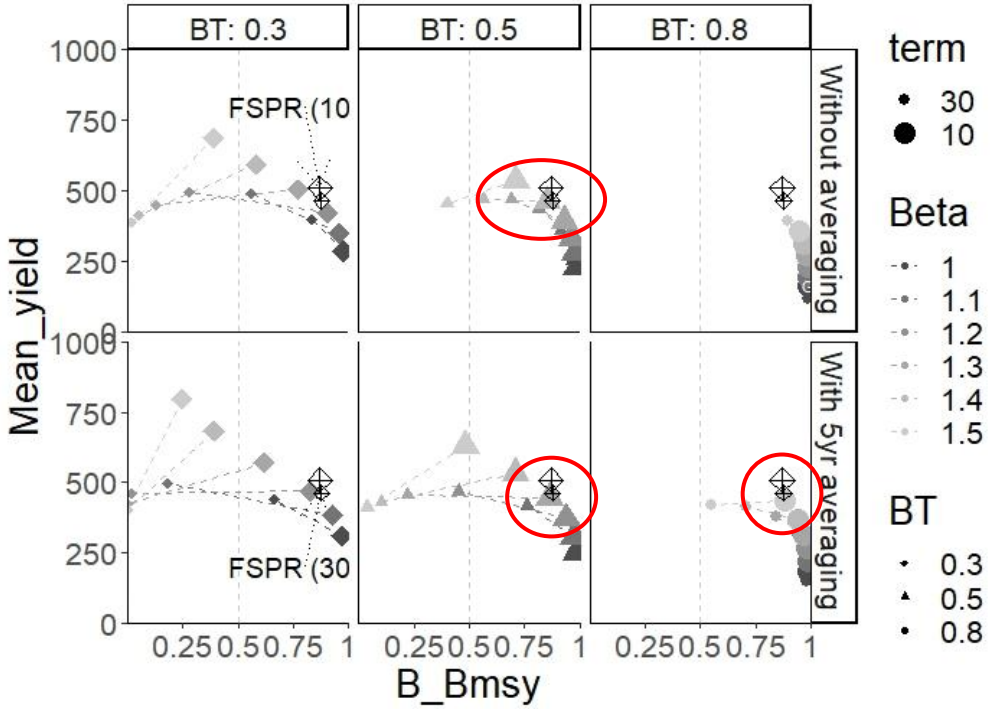
- The smaller BT, the larger the Mean_yield and the same B_Bmsy
- The larger Beta, the larger the Mean_yield and the slightly lower B_Bmsy
- The trade-off relationship was clearer changing Beta than changing BT.

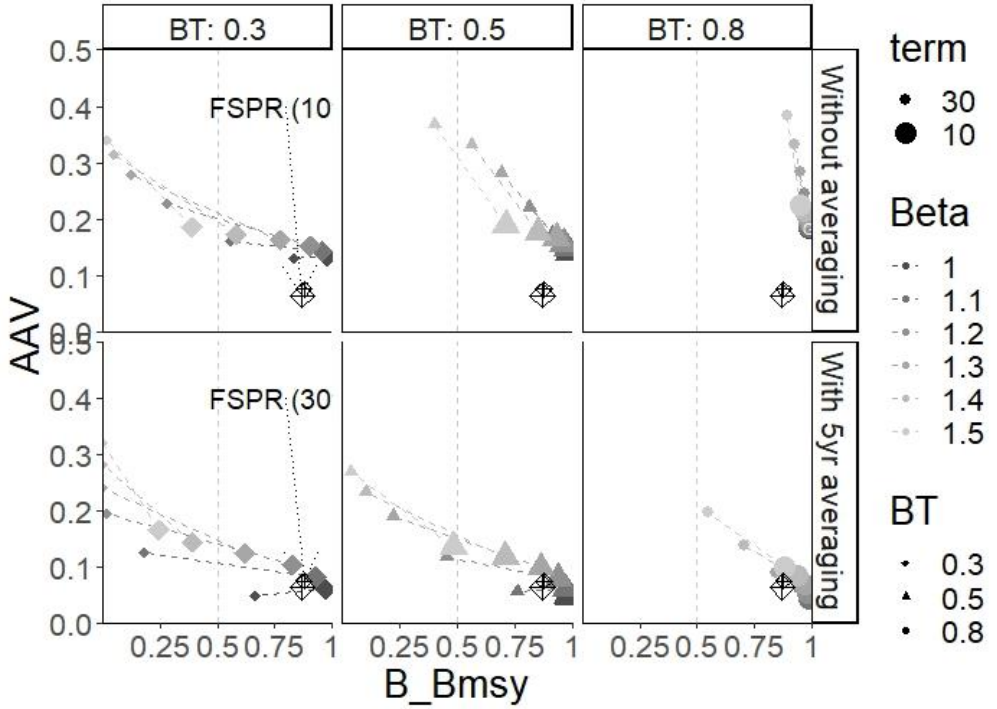




Results
- Trade-off plots of SS2 and GT2

- With 5yr averaging option tended to have a smaller AAV
- SS2 shows higher risk of depleting the stock after 30 years of management
- No SS2 above Mean_yield of FSPR was confirmed when B_Bmsy level was the same of FSPR
- Several SS2 MPs (◯) were close to F30%SPR performance





A good practice for…

- We demonstrate that SS2 MP could be developed by tuning GT2 by stock-specific MSE with simple conditioned OMs
- Compared to GT2, the tuned SS2 MPs can achieve higher catches and greater probabilities of exceeding Bmsy after 10 years

- Potential application to other Japanese ‘type-2’ stocks
  - State-space surplus production models are being attempted to be applied the ‘type-2’ stocks (Ichinokawa et al, this workshop)
  - However, estimation accuracy of absolute value was tended to be low
  - There is a possible direction of tuning GT2 through MSE with simple conditioned OM estimated by SSPM

Prospects for the future

For the flow of this MSE

- Considered production model-based MPs
- But model structures of OMs and MPs are the same, that is problem

For SCB stock management

- Employed more complicated model (e.g., age-structured models)
  - New trawl survey have begun since 2017 to capture small crabs
  - Models incorporating this data will have to be developed
  - FSPR in this MSE could not be considered F%SPR estimation error
- CPUE and pot survey standardizations