The operating model (OM) is developed by Stock Synthesis (SS) and various fisheries and population parameters are estimated using SS based on the historical data, and 1,000 bootstrap estimations are conducted to obtain the approximate posterior distribution of each parameter. Then, 100 times of random sampling were carried out based on the bootstrap approximate posterior distribution of each parameter, and substituted into the OM to generate simulated catch and CPUE time series.

A model-based harvest control rule (HCR) is adopted, and 4 HCRs are created by setting different levels of minimum catches (Cmin) and maximum catches (Cmax) corresponding to the target reference point (TRP) and limit reference point (LRP), which are based on the spawning stock biomass estimated by the estimation model (EM).

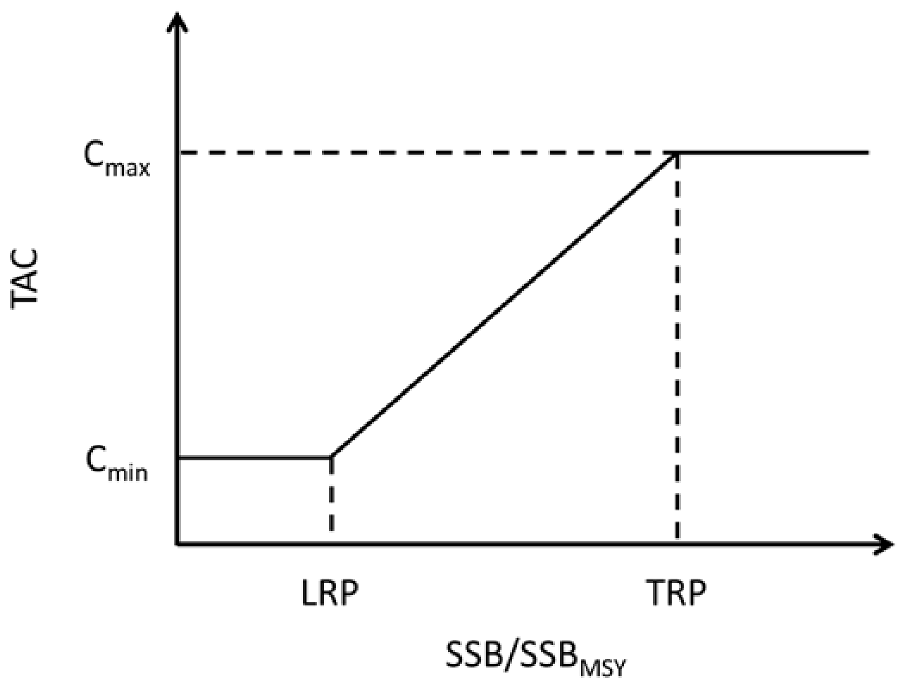

Fig. 1. Preliminary model-based harvest control rule (HCR) for mahi mahi in the northwest Pacific Ocean.

Four HCRs were created as following settings:
HCR1 : Cmax = 1.0*MSY ; Cmin= 0.5*MSY
HCR2 : Cmax = 1.0*MSY ; Cmin= 0.2*MSY
HCR3 : Cmax = 0.9*MSY ; Cmin= 0.5*MSY
HCR4 : Cmax = 0.9*MSY ; Cmin= 0.2*MSY

To maintain the stability of catch management, a maximum interannual catch variability (IAV) of 20%, that is, a 20% increase or decrease in the catches is the limit when catches calculated based on the HCR exceed or fall below 20% of catches than the previous year. In addition, the annual catch implementation error is set to be 10%. Several performance indices are used to evaluate the impact of various HCRs on future stock status and catches.

Based on the comparison of simulated catch and CPUE data through the EM, the catches and CPUE series obtained from OM and EM are quite close in terms of estimated values and trends. Therefore, the estimation results of EM can appropriately reflect the historical population and fisheries of OM.

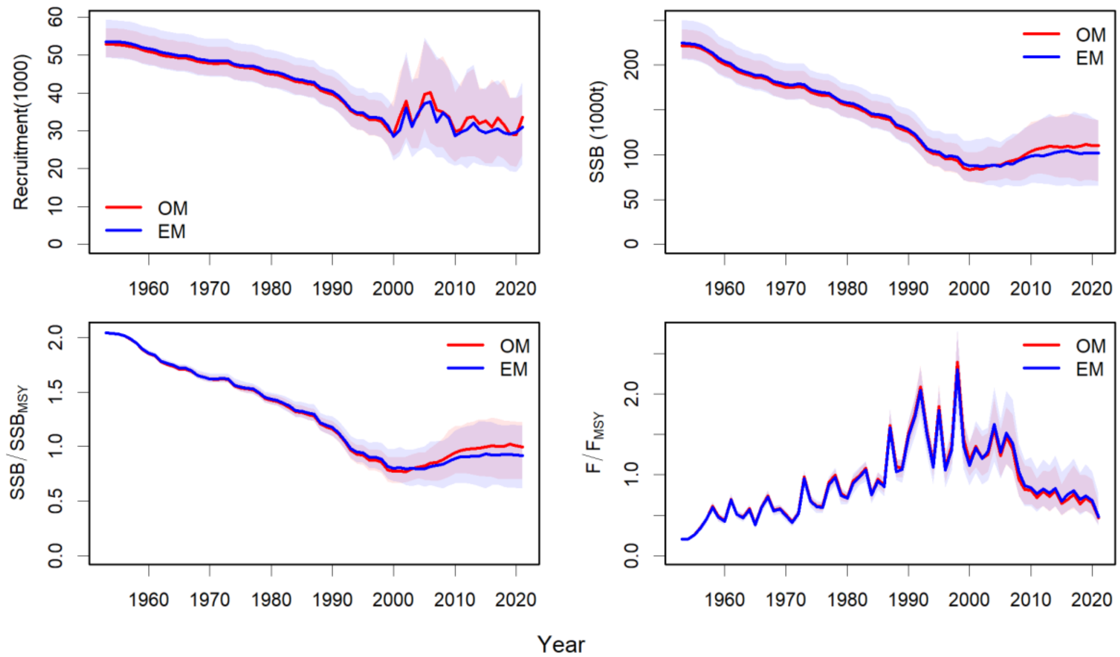

Fig. 2. The trajectories or recruitment, spawning stock biomass and relative spawning stock biomass and fishing mortality estimated by operating and estimation models.

The results indicate that increasing Cmin or reducing Cmax can lead to a higher probability of achieving the target level (the green quadrant of the Kobe plot), and can maintain higher biomass and lower fishing levels, but the long-term catches will also be reduced. There was no significant difference in the stability of catches between different HCRs.

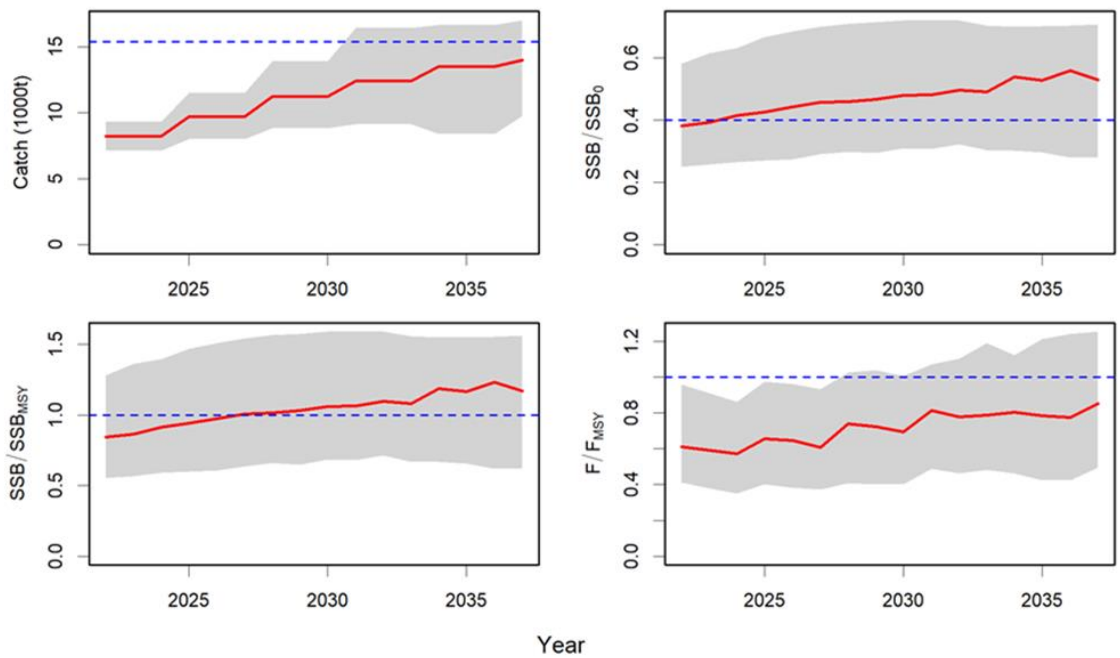

Fig. 3. The trajectories or recruitment, depletion of spawning stock biomass and relative spawning stock biomass and fishing mortality obtained from HCR1 as an example.

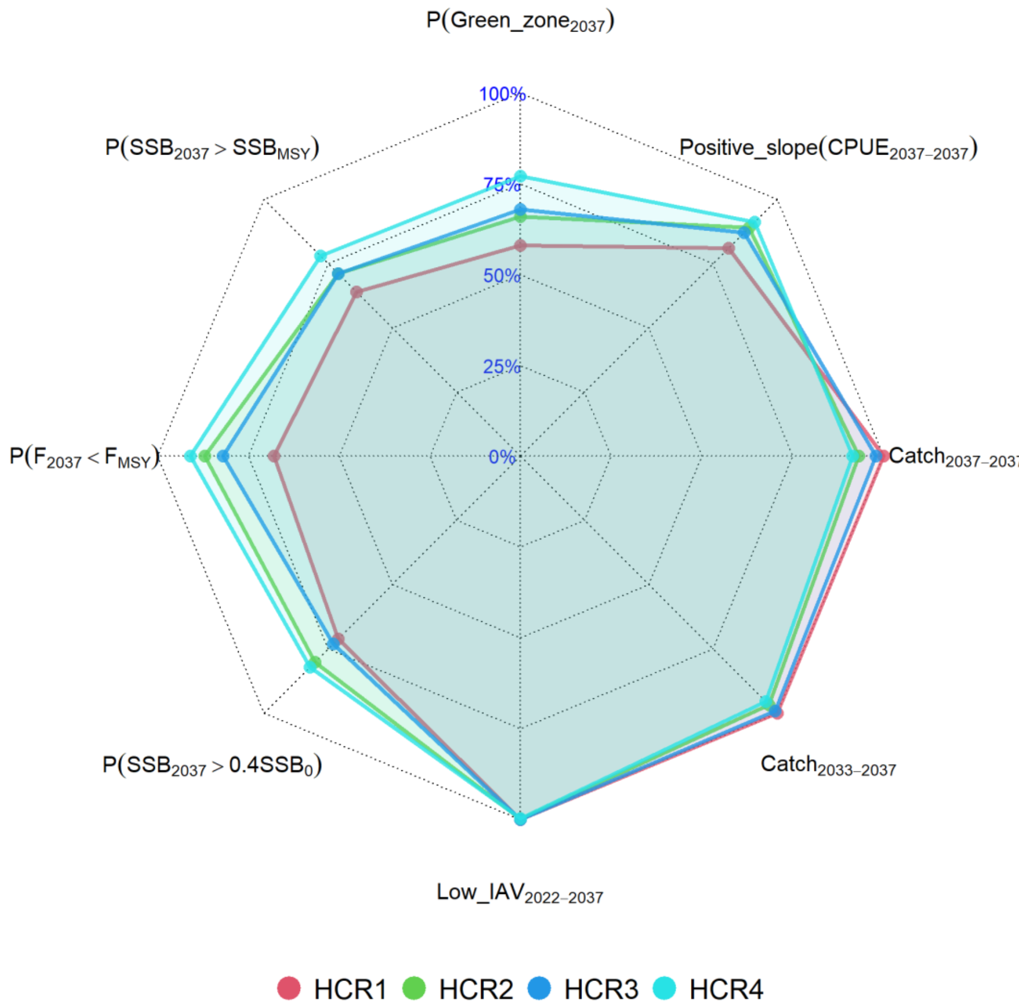

Fig. 4. Performance indicators obtained from four HCRs.

However, more considerations related to various uncertainties are needed for further analyses, and then the analyses of the management strategy evaluation under various assumptions and uncertainties also need to be tested and evaluated by performance indicators for setting a reference for future TAC settings.