Small yellow croaker is one of the most popular commercial species in the Republic of Korea. In particular, the fish species accounts for about 9% of the total fish production amount in Korean coast, and it accounts for approximately 40% of the total output of the offshore Gill-net fishery. But, the catch amount of small yellow croaker has been declining since 2011. Therefore, it seems that management plans are needed to restore the catch amount. For small yellow croaker, size limit and season limit have existed, but there is no TAC regulation. In this study, we use the Bayesian state-space surplus production model for assessing the resource status of small yellow croaker and deriving B_{opt}. Besides, the biological and economic effects depending on the TAC scenarios are conducted for the setting of the annual TAC.

Introduction

Materials and Methods

1. Materials
   - Catch and effort data (1992-2018) of Gill-net, Stow-net, and Pair-net which account for approximately 85% of the total catch of small yellow croaker are used.

2. CPUE standardization
   - Generalized linear model (GLM, Gavaris, 1980) is conducted to standardize CPUE.

   ![Fig. 1. Fishery ground ellipses computed using the CPUE distribution of small yellow croaker by the three fisheries by each period range (left panel) and the center of fishing grounds by each fishing year (right panel).](image)

   - It was researched that main fishing area of small yellow croaker had been moved.

   \[
   \log(CPUE) = \text{Intercept} + Year + \text{Gear} + \text{Mov} + \text{Gen} + \text{Moverr} - \text{Error}_{\text{CPUE}} \sim N(0, \sigma^2)
   \]


3. Stock assessment
   - Bayesian state-space surplus production model is applied to assess the status of small yellow croaker’s biomass.

   \[
   \begin{align*}
   P_1(\sigma^2) &= \mathcal{E}(\sigma^2, \theta) \\
   P_1|p_{1,t-1}, q_{1,t-1}, r_{1,t-1} &= \mathcal{N}(p_{1,t-1}, 1 - \frac{C_t}{B_t}, \theta) \\
   P_2(\sigma^2) &= \mathcal{E}(\sigma^2, \theta) \\
   P_2|p_{2,t-1}, q_{2,t-1}, r_{2,t-1} &= \mathcal{N}(p_{2,t-1}, 1 - \frac{C_t}{B_t}, \theta) \\
   P_3(\sigma^2) &= \mathcal{E}(\sigma^2, \theta) \\
   P_3|p_{3,t-1}, q_{3,t-1}, r_{3,t-1} &= \mathcal{N}(p_{3,t-1}, 1 - \frac{C_t}{B_t}, \theta)
   \end{align*}
   \]

   - Posterior distributions of model parameters are formed by 10,000 samples,

   - 250,000 iterations after discarding the initial 50,000 samples (burn-in period) are used to reduce the influence of the initial value,

   - Every 25th sample are extracted to avoid autocorrelations of samples.

4. Economic analysis
   - The average market prices of the recent 5 years from Gill-net and Stow-net were applied.

   \[
   TB_t = C_t \cdot \text{price}_{\text{Gill}}
   \]

   - The average costs per standardized vessel for catching small yellow croaker are calculated by the business survey situation (average of the recent 5 years).

   \[
   TC_t = \text{cost} \_\_ \text{vessel} \_t
   \]

Summary and conclusion

- According to the Bayesian state-space surplus production model, the biomass of small yellow croaker is recently decreasing.

- If the amount of TAC is set as 24,000 tons per year, the biomass of small yellow croaker could be decreased. However, if the quantity of TAC is set as 23,000 tons per year, the biomass could be sustainable.

- From the economic analysis, it seems the annual TAC could be set over 16,663 tons and the biomass should be managed over 84,620 tons for ensuring the positive profits of Gill net and Stow net fisheries.