Latest Topic of Stock Assessment

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FIGURE 1
WORLD CAPTURE FISHERIES AND AQUACULTURE PRODUCTION

NOTE: Excludes aquatic mammals, crocodiles, alligators and caimans, seaweeds and other aquatic plants.
FIGURE 16
THE THREE TEMPORAL PATTERNS IN FISH LANDINGS, 1950–2015

CONTINUOUSLY INCREASING TREND

- Indian Ocean, Eastern
- Pacific, Western Central
- Indian Ocean, Western

77.8%

FLUCTUATIONS AFTER REACHING A PLATEAU

DECREASING TREND FOLLOWING A PEAK

NOTE: In each graph, the grey bar shows the percentage of stocks fished at biologically sustainable levels.
FIGURE 14
GLOBAL TRENDS IN THE STATE OF THE WORLD’S MARINE FISH STOCKS, 1974–2015

YEAR

PERCENTAGE


Overfished

Maximally sustainably fished

Underfished

Biologically sustainable  Biologically unsustainable
Possibility to increase Yield

**Figure 14:** Global trends in the state of the world's marine fish stocks, 1974–2015

- **Underfished**
- **Maximally sustainably fished**
- **Overfished**

Yield vs. Percentage over Time (1975-2015)

- Biologically sustainable
- Biologically unsustainable
Mixed Species Problem

• In tropical countries, Fishery information is sometimes limited
• Catch statistics is not available by species
• Fisheries Management should be applied for multi species gear (purse seine etc)
• Single species population assessment and fisheries management model are not applicable without validation.
Species Composition by Purse Seine Vessel in East Cost of Peninsula Malaysia

Surveyed on August 2017 with SEAFDEC/MFRDMD
Harliyan et al. unpubl. data
Stock Assessment Methods

- Age based method (VPA etc)
  - Aging is difficult for tropical fished
- Production Model
  - Applicable if effort range is wider
- Feedback Control Management
  - Applicable in data poor situation
  - Maybe conservative
- All are developed for Single Species Fishery
Rule 2-1 in Japanese Stock Assessment Procedure

• Applied for **Data Poor Situation**
• Population Estimation is not available
• Data: $C$, Stock Level, CPUE
• $ABC = \delta_1 \times C_t \times \gamma_1$
• $\delta_1 = 1.0$ (High)  
  1.0 (Middle)  
  0.8 (Low)
• $\gamma_1 = 1 + \frac{k b}{I}$
  – $k$: feedback parameter (1.0)
  – $b$: tangent of the CPUE for recent 3 years
  – $I$: Average of the CPUE for recent 3 years
Feedback Effort Control

• The idea is appeared in Tanaka (1980)

• If the biomass is increasing, more fishing effort can be allowed, and vice versa.
Aim of this study

• Conduct simulation of **fishing operation and management** by feedback control rule with **mixed species** situation

• Analyze the result by comparing **MSY** to examine the applicability of the feedback control rule **for the mixed species situation**
Method

• Based on Hiramatsu (2004),
• Three (3) species
  – Population dynamics are independent
  – Caught by same gear (multi-species gear)
  – Catch and CPUE are not divided to species (mixed species data)
• Simulation for 51 years 100 iterations
  – 21 years for constant effort
  – Populations at 1st and 21st year are given ($K/2$)
  – After 22nd year, caught following Rule 2-1 calculated from mixed species data
  – Catch for each species are proportional to the biomass
  – Observe the population dynamics and catch for each species
Equations

\begin{align*}
B_{y+1} &= \left\{ B_y + r B_y \left(1 - \frac{B_y}{K}\right)\right\} \exp \left(\sigma_R \varepsilon_y - \frac{1}{2} \sigma_R^2\right) - q X_y B_y \\
I_y &= \frac{B_y + B_{y+1}}{2} \exp \left(\sigma_I \eta_y - \frac{1}{2} \sigma_I^2\right)
\end{align*}

- \( B \): Biomass
- \( r \): Intrinsic Growth Rate
- \( K \): Carrying Capacity
- \( X \): Effort
- \( I \): Population Index
- \( \varepsilon \): Process error
- \( \eta \): Observation error
- \( \sigma_R, \sigma_I \): Standard deviations

\( \varepsilon_y, \eta_y \sim N(0, 1) \)
## Parameters

**Case 1**

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<th>Sp 1</th>
<th>Sp 2</th>
<th>Sp 3</th>
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<td>$qE$</td>
<td>0.106</td>
<td>0.106</td>
<td>0.106</td>
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<tr>
<td>$r$</td>
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<td>$B_{msy}$</td>
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<td>5,000</td>
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<td>$MSY$</td>
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<tr>
<td>Trend</td>
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**Case 2**

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<td>Error</td>
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Example of a Result

Case 1

Biomass of Mixed Species

Yield of Mixed Species
Fig. 2. Biomass and catch trajectories for three species after applying the default feedback harvest control rule to both mixed-species and single-species data, for the most common scenario \((B_M - B_M)\). Only 20 trajectories are shown in each figure; both \(\sigma_R\) and \(\sigma_m\) were fixed at 0.2. Bold horizontal lines through the biomass and catch trajectories, respectively, indicate the \(B_{MSY}\) level and MSY level.
## Result

### Case 1

<table>
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<th>After Mix Mgmt</th>
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<th>Sp 2</th>
<th>Sp 3</th>
<th>Total</th>
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<tbody>
<tr>
<td>Yield/MSY</td>
<td>58%</td>
<td>46%</td>
<td>27%</td>
<td>35%</td>
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<tr>
<td>B51/Bmsy</td>
<td>99%</td>
<td>166%</td>
<td>176%</td>
<td>126%</td>
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<tr>
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<td>0%</td>
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<td>46%</td>
<td>46%</td>
<td>27%</td>
<td>30%</td>
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<tr>
<td>B51/Bmsy</td>
<td>104%</td>
<td>165%</td>
<td>185%</td>
<td>129%</td>
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<td>Failure</td>
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### Case 2

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<td>41%</td>
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<td>25%</td>
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<td>B51/Bmsy</td>
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<td>158%</td>
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<td>1%</td>
<td>15%</td>
<td>16%</td>
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<td>37%</td>
<td>20%</td>
<td>21%</td>
</tr>
<tr>
<td>B51/Bmsy</td>
<td>60%</td>
<td>152%</td>
<td>137%</td>
<td>93%</td>
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<tr>
<td>Failure</td>
<td>23%</td>
<td>0%</td>
<td>16%</td>
<td>36%</td>
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Result

Case 1

Case 2
Calculation in progress

• More species parameters \((r, K)\)
• More parameters for errors \((\sigma_R, \sigma_I)\)
• Optimum parameters for the feedback control \((k, \sigma)\)
• Examine the influence of population dynamics before the management
• Examine the influence of duration for calculating CPUE trends \((b)\)
Result of Multi-species Production Model

r is different among 3 species
r-L: r is large
r-S: r is small
(L is twice than S)

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<td>SP1</td>
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<td>S</td>
<td>S</td>
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<tr>
<td>r</td>
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Fox Model and Shaefer Model

- Fox model assume the production follows Gompertz curve instead of Logistic Curve in Schaefer’s Model.

Graphs showing the comparison between Fox and Shaefer models for CPUE, Yield, and Biomass with Effort as the x-axis.
Conclusion

• Feedback control procedure has a similar performance for mixed species data comparing single species data, as far as in the limited simulation cases.

• For applying the single species model for mixed species data, validity should be assessed through simulation studies.

• Implementation for multi-species, multi-gear situation fishery management should be also carefully considered.

• These researches can contribute sustainable fishery in ASEAN Region.