A comparative study on the structure and function of Korean marine ranching ecosystems

Hee Won Park, Chang Ik Zhang and Jae Bong Lee

Pukyong National University, Korea
National Fisheries Research and Development Institute, Korea
Bird-eye View of the Marine Ranching Area

Marine ranching projects

- 1998 Tongyeong
  (1998-2006 : 9 yrs)

- 2002 Jeonnnam
  (2002-2009 : 8 yrs)
Schematic Diagram of Ecosystem Models

Goal

-To compare of 2 MaRE using the geographical data and ecopath model
Status of the Marine Ranching Area

Construction of seaweed

♦ Tongyeong

- Species
  : two brown algae *Ecklonia stolonifera*, *Ecklonia cava*
- Below 6 m
- Area : 1,117,118 m²

♦ Jeonnam

- Species
  : two brown algae *Ecklonia stolonifera*, *Ecklonia cava*
- Below 20 m
- Area : 304,163 m²
What is Ecopath?

- Ecopath model is a useful tool for ecosystem modeling.
- To run an Ecopath model, you need basic input parameters:
  - Biomass (B, t/km²), Catch (C, t/km²), P/B ratio, Q/B ratio, and Diet composition.
- Ecopath has enabled a number of generalizations about the structure and function of ecosystems.
- In Korea,
  - To apply for East/Japan sea, East China sea, and Yellow sea.
  - To apply for the marine ranching area (Tongyeong, Jeonnam).
Ecopath diet matrices provide food web information for the calculation of macrodescriptor metrics. They tell us who eats whom, what percentage of a predator species' diet is made up of a prey species, the number of species, and trophodynamic interactions. Ecopath also provides descriptions of system level characteristics.

**Basic information**

- Trophic level decomposition
- Flows and biomasses
- Primary production required
- Trophic impact
- Ascendancy
- Consumer <-TL1
- Consumer <-prey<-TL1
- Top predator <-prey
- Cycles (living)
- Cycles (all)
- Cycling and path length
- Ecotrophic efficiency
- Production / consumption
**Data and Methods**

  Study on the foundation-laying of Jeonnam archipelago marine ranching program in Korea
  - 19 group, 97 species
  - 4 trophic levels

  - 26 group, 87 species
  - 5 trophic levels
<table>
<thead>
<tr>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sum of all consumption (mt·km⁻²·yr⁻¹)</td>
</tr>
<tr>
<td>2. Sum of all flows into detritus (mt·km⁻²·yr⁻¹)</td>
</tr>
<tr>
<td>3. Sum of all production (mt·km⁻²·yr⁻¹)</td>
</tr>
<tr>
<td>4. Total system throughput (mt·km⁻²·yr⁻¹)</td>
</tr>
<tr>
<td>5. Total primary production (mt·km⁻²·yr⁻¹)</td>
</tr>
<tr>
<td>6. Mean trophic level of the catch (10⁻⁴)</td>
</tr>
<tr>
<td>7. Total primary production/total respiration</td>
</tr>
<tr>
<td>8. Total primary production/total biomass</td>
</tr>
<tr>
<td>9. Total biomass (excluding detritus) (mt·km⁻²)</td>
</tr>
<tr>
<td>10. Connectance index</td>
</tr>
<tr>
<td>11. System omnivory index</td>
</tr>
<tr>
<td>12. Finn’s cycling index (% of total throughput)</td>
</tr>
<tr>
<td>13. Finn’s mean path length</td>
</tr>
<tr>
<td>14. Cumulative # paths connecting primary producers to upper trophic levels</td>
</tr>
<tr>
<td>15. Throughput cycled (including detritus) (mt·km⁻²·yr⁻¹)</td>
</tr>
<tr>
<td>16. Total flows from primary producers to upper trophic levels (mt·km⁻²·yr⁻¹)</td>
</tr>
</tbody>
</table>
Maps Showing the Marine Ranching Area of Jeonnam & Tongyeong, Korea

Area
- Total : 20300 ha
- Main : 15100 ha

Area
- Total : 9000 ha
- Main : 2000 ha
Location of Releasing and Released Target Species in the Marine Ranching Area

**Tongyeong**
- Jacopever rockfish
- Black rockfish
- Black seabream
- Red seabream

**Jeonnam**
- Black seabream
- Black rockfish
- Rock bream
- Abalone
### Geographical comparison

#### 2 marine ranching ecosystem (MaRE)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Jeonnam MaRE</th>
<th>Tongyeong MaRE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Western part of East China sea</td>
<td>Eastern part of East China sea</td>
</tr>
<tr>
<td>Total area</td>
<td>20,300ha</td>
<td>9,000ha</td>
</tr>
<tr>
<td>Target area</td>
<td>15,100ha</td>
<td>2,000ha</td>
</tr>
<tr>
<td>Study period</td>
<td>2002~</td>
<td>1998~2006</td>
</tr>
<tr>
<td>Target species</td>
<td>Black seabream</td>
<td>Jacoveper rockfish</td>
</tr>
</tbody>
</table>
Flow chart for marine ranching

Jeonnam

Tongyeong

Trophic Level

1

2

3

4

Detritus

Benthic Algae

Phytoplankton

Zooplankton

Gastropoda

Epifauna

Infauna

Predation

Benthic Feeders

Infauna

Gastropoda

Zooplankton

Detritus

Benthic Algae

Phytoplankton

Tongyeong

Skates

Otter

Pisc. Birds

Arguilliformes

Hairtail

Large Pelagics

Small Pelagics

Finless Porpoise

Flatfishes

Juv. Jacopever

Other Benthos

Other Demersal

Sparidae

Moronidae

Grey Mullet

Tongyeong

Jeonnam

Trophic Level

1

2

3

4

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Foodweb Pathway

\[
\#\text{Paths}(\text{Tongyeong}) = 0.004 \times 10^{3.887 \times \text{TL}} \\
(R^2 = 0.7744)
\]

\[
\#\text{Paths}(\text{Jeonnam}) = 0.0005 \times 10^{4.822 \times \text{TL}} \\
(R^2 = 0.8216)
\]
<table>
<thead>
<tr>
<th>Variable</th>
<th>Metric</th>
<th>Jeonnam</th>
<th>Tongyeong</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sum of all consumption</td>
<td>52.5</td>
<td>3952</td>
</tr>
<tr>
<td>2</td>
<td>Sum of all exports</td>
<td>33043</td>
<td>11754</td>
</tr>
<tr>
<td>3</td>
<td>Sum of all respiratory flows</td>
<td>7986</td>
<td>1867</td>
</tr>
<tr>
<td>4</td>
<td>Sum of all flows into detritus</td>
<td>33041</td>
<td>13929</td>
</tr>
<tr>
<td>5</td>
<td>Total system throughput</td>
<td>58150</td>
<td>31502</td>
</tr>
<tr>
<td>6</td>
<td>Sum of all production</td>
<td>33084</td>
<td>14915</td>
</tr>
<tr>
<td>7</td>
<td>Calculated total net PP</td>
<td>25057</td>
<td>13621</td>
</tr>
<tr>
<td>8</td>
<td>Net system production</td>
<td>33043</td>
<td>11754</td>
</tr>
<tr>
<td>9</td>
<td>Total PP/total biomass</td>
<td>263</td>
<td>19.87</td>
</tr>
<tr>
<td>10</td>
<td>Total biomass/total throughput</td>
<td>0.002</td>
<td>0.022</td>
</tr>
<tr>
<td>11</td>
<td>Total biomass (excluding detritus)</td>
<td>95.29</td>
<td>685.6</td>
</tr>
<tr>
<td>12</td>
<td>Connectance Index</td>
<td>0.316</td>
<td>0.277</td>
</tr>
<tr>
<td>13</td>
<td>System Omnivory Index</td>
<td>1.019</td>
<td>0.222</td>
</tr>
</tbody>
</table>
Conclusion

- The Jeonnam has a steep slope (0.419) of longevity compared with the Tongyeong (0.393)

- Tongyeong increases faster than the Jeonnam as a function of at trophic levels.

- Jeonnam ecosystem appears to be much more mature than the Tongyeong based on Total PP/total biomass.
Further study

Macrodescriptor

**Connectedness/Linkages**

*Connectedness*: the degree to which components of a system are affected by each other.

**Connectivity**
- (the number of interactions per component of a system)
  - **Interactive Connectance**
    (the proportion of all possible undirected, interspecific, trophic interactions that are realized)
  - **Upper Connectance**
    (competitive interactions between predators that share at least one prey)
  - **Directed Connectance**
    (the proportion of links out of the maximum number of possible directed links in a food web, including cannibalism and predation)

**Connectance**
- (the proportion of all possible connections within a system that are realized)
  - **Linkage Density**
    (total number of links divided by the number of species in the food web. The links to species ratio indicates the average number of predators per species)
  - **Linkage Complexity**
    (upper connectance multiplied by the number of species)
Further study

Using the SOM method

• Identification of the visualizing the similarities and differences between Tongyeong and Jeonnam
• Ordination of ecological metrics