

Ecosystem-based fisheries resources assessment and management system in Jeonnam marine ranching in Korea

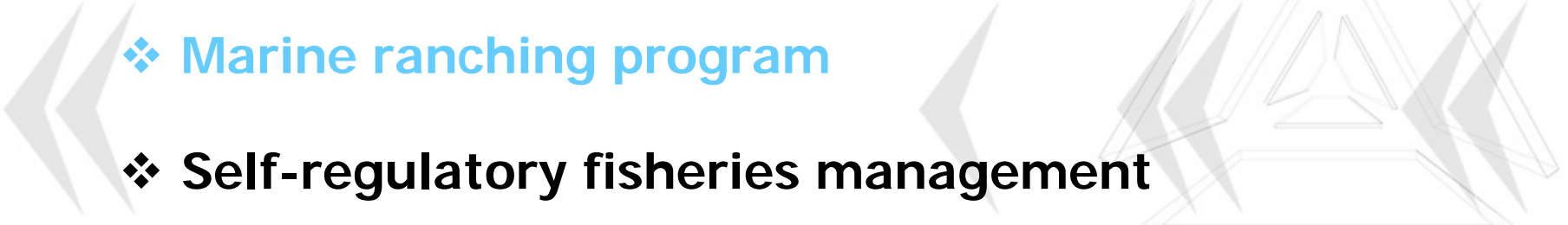
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Current fisheries management in Korea waters



- ❖ **TAC**-based management for 10 species
- ❖ Resource **rebuilding** activities by artificial reefs
- ❖ **Releasing** fries and juveniles, seaweed beds
- ❖ Buy-back program to reduce fishing vessels
- ❖ MPAs
- ❖ **Marine ranching program**
- ❖ Self-regulatory fisheries management



Ecosystem based fisheries approach in Korea

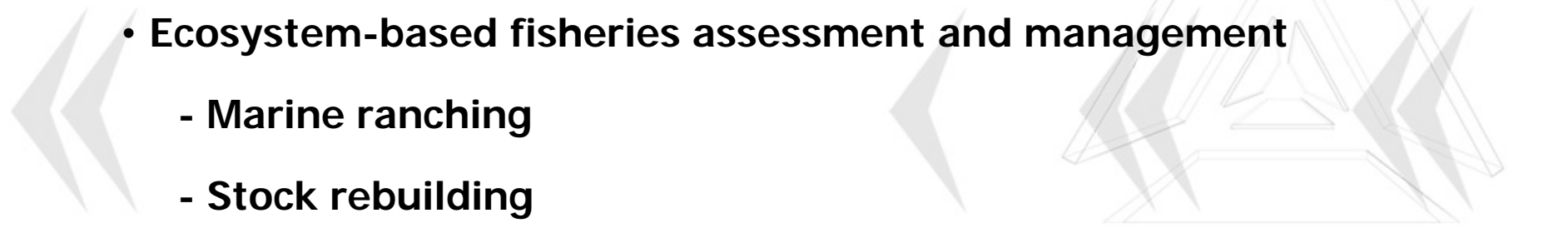


❖ Ecosystem modeling

- Apply to marine ranching ecosystems (Lee, 2007)
- Apply to Korean waters (East/Japan sea, Yellow sea)

❖ Ecosystem-based integrated fisheries assessment approach

- Ecological Risk Assessment
 - Analysis for Large purse seine fishery (Park, 2007; Kwon, 2007)
- Ecosystem-based fisheries assessment and management
 - Marine ranching
 - Stock rebuilding
 - TAC fisheries



In this study



- **Introduction** for ecosystem-based fisheries assessment using Jeonnam marine ranching data
- **Effectiveness** of marine ranching program between pre-, post construction by ecosystem-based fishers assessment approach



Jeonnam Marine ranching program

- **Location**

- Western part of East-China Sea

- **Study periods**

- 2002 ~ 2008 (7 years)

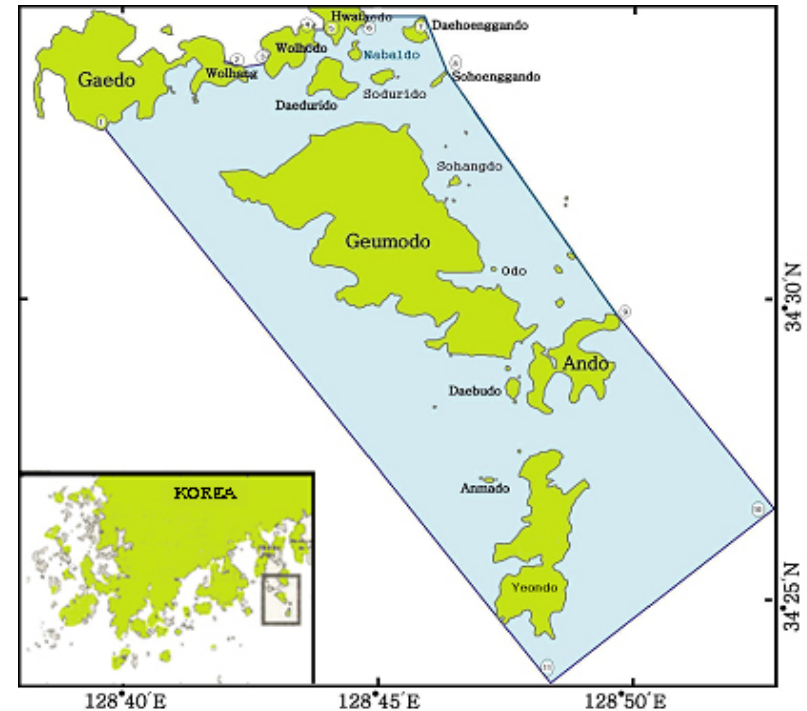
- **Areas**

- Total area : 203Km²

- Marine ranching area : 151km²

- **Target species**

- Black seabream, Rock bream, Black rockfish



Data and Methods



- Using data
 - MOMAF, Study on the foundation-laying of Jeonnam archipelago marine ranching program in Korea (2003-2007)
- Comparing Periods
 - 2003 : Pre-construction of Jeonnam marine ranching
 - 2007 : Post-construction of Jeonnam marine ranching



Ecosystem based fisheries assessment ?

2 tier system (Tier 1 and Tier 2)

Quantitative
analysis

Tier 1

- Level of information High
- For target species
- 19 indicators used

Semi
-quantitative
& quality
analysis

Tier 2

- Level of information low
- For bycatch species
- 24 indicators used

Risk Indices

ORI (Objectives risk index)

$$\text{ORI} = \frac{\sum_{i=0}^n I_i W_i}{\sum_{i=1}^n W_i}$$

I_i : Score of indicator i
 W_i : Weighting factor of indicator i
 n : Number of indicators

SRI (Species risk index)

$$\text{SRI} = \lambda_s \text{ORI}_s + \lambda_B \text{ORI}_B + \lambda_H \text{ORI}_H$$

FRI (Fisheries risk index)

$$\text{FRI} = \frac{\sum B_i \text{SRI}_i}{\sum B_i}$$

B_i : Biomass or biomass index of species i



Risk Indices

MI (Management status improvement Index)

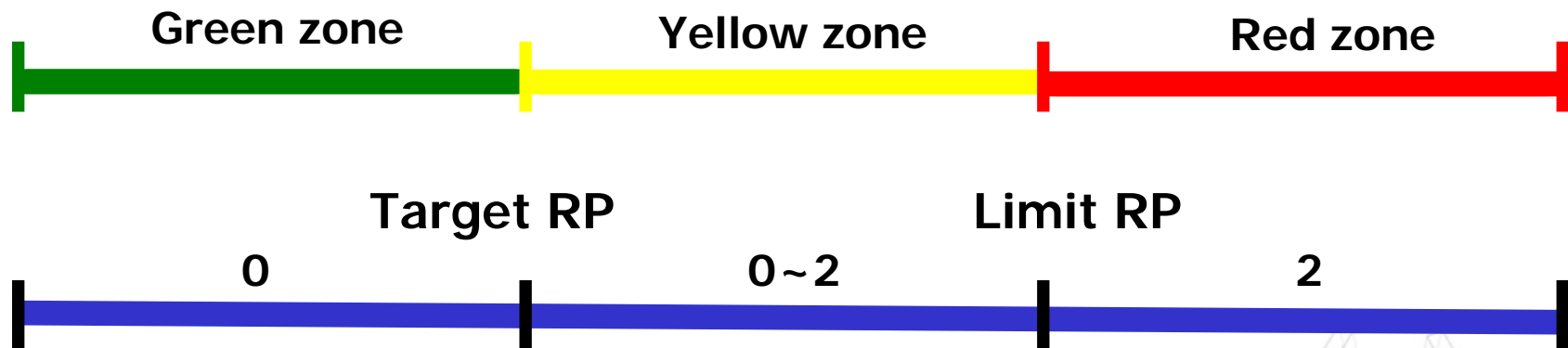
$$MI_o = \frac{ORI_t - ORI_{t+i}}{ORI_t} \times 100$$

$$MI_s = \frac{SRI_t - SRI_{t+i}}{SRI_t} \times 100$$

$$MI_F = \frac{FRI_t - FRI_{t+i}}{FRI_t} \times 100$$

Calculation for risk scores

Reference points (RP), Risk, Management



1. $X_{\text{target}} > X_{\text{limit}}$ case (e.g., biomass)

- If $X_{\text{limit}} \leq X < X_{\text{target}}$,

$$RS_x = RS_{\text{max}} \left(\frac{X_{\text{target}} - X}{X_{\text{target}} - X_{\text{limit}}} \right), \text{ where } RS_{\text{max}} = 2$$

Indicator and reference points

Tier 1_ Sustainability

Indicator	Reference points		
	Target (0)	Limit (0~2)	Beyond limit (2)
Biomass (B)	$B \geq B_{40\%}$	$B_{40\%} > B \geq B_{35\%}$	$B < B_{35\%}$
or CPUE (U)	$U \geq U_{ABC}$	$U_{ABC} > U \geq U_{limit}^1$	$U < U_{limit}$
Fishing mortality (F)	$F \leq F_{40\%} \text{ (or } F_{0.1})$	$F_{40\%} \text{ (or } F_{0.1}) < F \leq F_{MSY}$	$F > F_{MSY}$
or Catch (C)	$C \leq ABC$	$ABC < C \leq MSY$	$C > MSY$
Age at first capture (t)	$t \geq t_{target}$	$t_{target} > t \geq t_{limit}^2$	$t < t_{limit}$
Habitat size (H)	$H \geq H_{target}$	$H_{target} > H \geq H_{limit}^3$	$H < H_{limit}$
FIB index	$FIB \geq FIB_{target}$	$FIB_{target} > FIB \geq FIB_{limit}^4$	$FIB < FIB_{limit}$
FRP index	$FRP \geq FRP_{target}$	$FRP_{target} > FRP \geq FRP_{limit}^5$	$FRP < FRP_{limit}$
Total production of ecosystem (P)	$P \geq P_{target}$	$P_{target} > P \geq P_{limit}^6$	$P < P_{limit}$

FIB (Fish is balance) $FIB = \log(Y_i \cdot (1/TE)^{TL_i}) - \log(Y_0 \cdot (1/TE)^{TL_0})$ (Pauly et al., 2000)

FRP (Fish Reproduction Potential) $FRP = \log\left(\frac{Y_i \cdot MR_i}{q \cdot f_i}\right) - \log\left(\frac{Y_0 \cdot MR_0}{q \cdot f_0}\right)$ (Lee et al., 2007)

Indicator and reference points

Tier 1_ Biodiversity

Indicator	Reference points		
	Target (0)	Limit (0~2)	Beyond limit (2)
Bycatch rate (BC/C)	$(BC/C) \leq (BC/C)_{\text{target}}$	$(BC/C)_{\text{target}} < (BC/C) \leq (BC/C)_{\text{limit}}^1$	$(BC/C) > (BC/C)_{\text{limit}}$
Discard rate (DC/C)	$(DC/C) \leq (DC/C)_{\text{target}}$	$(DC/C)_{\text{target}} < (DC/C) \leq (DC/C)_{\text{limit}}^2$	$(DC/C) > (DC/C)_{\text{limit}}$
Mean trophic level (TL)	$TL \geq TL_{\text{target}}$	$TL_{\text{target}} > TL \geq TL_{\text{limit}}^3$	$TL < TL_{\text{limit}}$
Diversity index (DI)	$DI \geq DI_{\text{target}}$	$DI_{\text{target}} > DI \geq DI_{\text{limit}}^4$	$DI < DI_{\text{limit}}$
Invasive/Traditional species in catch (I/T)	$(I/T) \leq (I/T)_{\text{target}}$	$(I/T)_{\text{target}} < (I/T) \leq (I/T)_{\text{limit}}^5$	$(I/T) > (I/T)_{\text{limit}}$

Diversity index: $DI = - \sum_{j=1}^N P_j \cdot \ln P_j$ (Modified from Shannon and Wiener (1963))
 where N : is the total number of individuals, P_j : proportion of each species

Indicator and reference points

Tier 1_ Habitats

Indicator	Reference points		
	Target (0)	Limit (0~2)	Beyond limit (2)
Critical habitat damage rate (DH/H)	$(DH/H) \leq (DH/H)_{\text{target}}$	$(DH/H)_{\text{target}} < (DH/H) \leq (DH/H)_{\text{limit}}$ ¹	$(DH/H) > (DH/H)_{\text{limit}}$
Pollution rate of spawning and nursery ground (PG/G)	$(PG/G) \leq (PG/G)_{\text{target}}$	$(PG/G)_{\text{target}} < (PG/G) \leq (PG/G)_{\text{limit}}$ ²	$(PG/G) > (PG/G)_{\text{limit}}$
Lost fishing gear (Frequency, FR)	$FR \leq FR_{\text{target}}$	$FR_{\text{target}} < FR \leq FR_{\text{limit}}$ ³	$FR > FR_{\text{limit}}$
Discarded wastes (DW)	$DW \leq DW_{\text{target}}$	$DW_{\text{target}} < DW \leq DW_{\text{limit}}$ ⁴	$DW > DW_{\text{limit}}$
Prohibited area from fishing (PA)	$PA \geq PA_{\text{target}}$	$PA_{\text{target}} > PA \geq PA_{\text{limit}}$ ⁵	$PA < PA_{\text{limit}}$
No. of artificial reefs (N)	$ N - N_{\text{target}} \leq 0.2N_{\text{target}}$	$0.2N_{\text{target}} < N - N_{\text{target}} \leq 0.4N_{\text{target}}$	$ N - N_{\text{target}} > 0.4N_{\text{target}}$
Area of artificial seaweed bed (A)	$ A - A_{\text{target}} \leq 0.2A_{\text{target}}$	$0.2A_{\text{target}} < A - A_{\text{target}} \leq 0.4A_{\text{target}}$	$ A - A_{\text{target}} > 0.4A_{\text{target}}$

Indicator and reference points

Tier 2_ Sustainability

Indicator	Reference points		
	Target (0)	Limit (1)	Beyond limit (2)
CPUE	CPUE data are available and not declining	CPUE data are available, but declining	CPUE data are not available
Precautionary approach and sensitivity of stock assessment	Adequate stock assessment is provided and precautionary approach is adopted	Inadequate stock assessment is provided, but precautionary approach is adopted	Inadequate stock assessment, and precautionary approach is not adopted
Restricted access	Fixed access, little latent effort exists ($\leq 30\%$ of licenses inactive)	New entrants can be licensed $> 30\%$ latent effort in fishery	Open access
Fishery monitoring and sampling	Observer program in place, sampling for all fishery data	Monitoring and sampling for a limited number of fisheries	Negligible monitoring or sampling
Fishing method	All fishing methods and patterns are evaluated and changes monitored	Fishing methods and patterns are evaluated for main methods and some geographical areas	Main fishing methods and patterns are not evaluated
Size at entry	\geq Size at maturity	$<$ Size at maturity, but less than 20% of catch immature	Greater than 20% of the catch immature or size at maturity unknown

Application for Jeonnam marine ranching

- Target Area

- Jeonnam marine ranching (151Km²)

- Target fishery

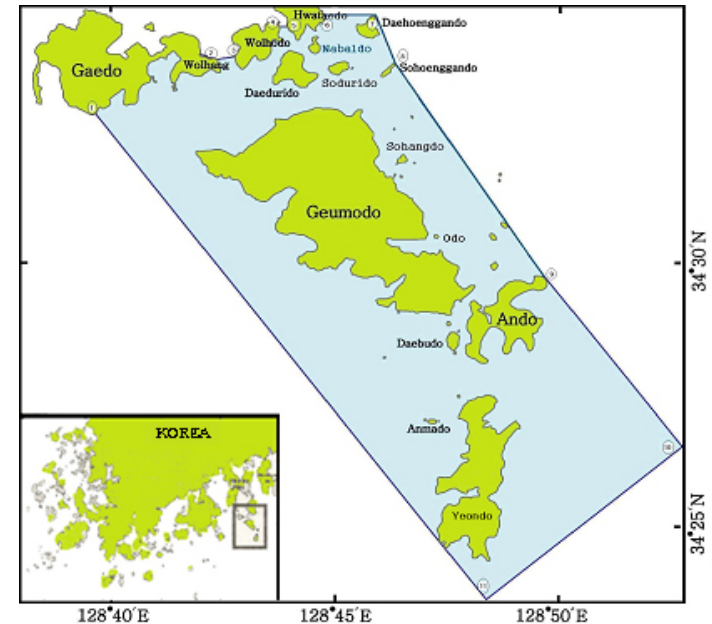
- Pole and line fishery

- Target species

- Black sea bream

- Bycatch species (6 species)

- Jacopever rockfish, Black rockfish, Red sea bream, Sea bass,
Yellow tail, Common eel



Results _ Risk score in Jeonnam marine ranching

Objectives	Indicator	2003	2007
Sustainability	1. CPUE	2	0
	2. Catch	2	0
	3. Age at first capture	0	2
	4. Habitat size	0	0
	5. FIB index	2	0
	6. FRP index	2	0
	7. Total production of ecosystem	1	0.53
Biodiversity	1. Bycatch rate	1.62	0
	2. Discard rate	2	0.09
	3. Mean trophic level	0.72	0
	4. Diversity index	0.67	0
	5. Invasive/Traditional species catch	0	0.55
Habitat	1. Critical habitat damage rate	0	0
	2. Pollution rate of spawning and nursery ground	0	0
	3. Lost fishing gear	0	0
	4. Discarded wastes	0	0
	5. Prohibited area from fishing	2	1.22
	6. No. of artificial reefs	2	0
	7. Area of artificial seaweed bed	2	0

Results



Tier 1 _ Black sea bream (*Acanthopagrus schlegelii*)

Objectives	ORI (Zone)		MI	Significance
	2003	2007		
Sustainability	1.444	0.281	80.58	***
Biodiversity	1.233	0.105	91.49	*
Habitat	0.667	0.136	79.60	**
SRI	1.114	0.174	84.41	***
FRI	1.541	0.566	63.23	-

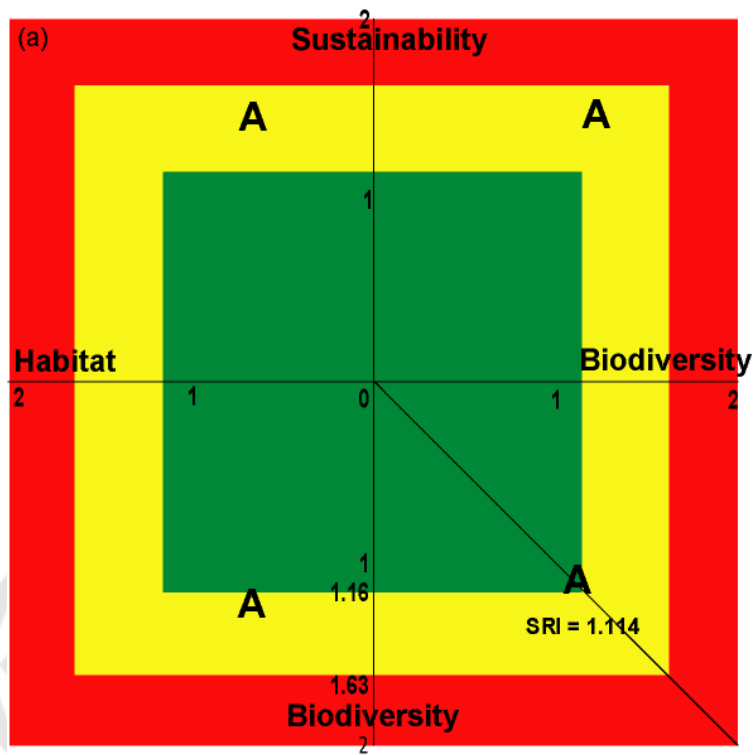
*** denotes a significant difference at $\alpha < 0.001$ level

** denotes a significant difference at $\alpha < 0.01$ level

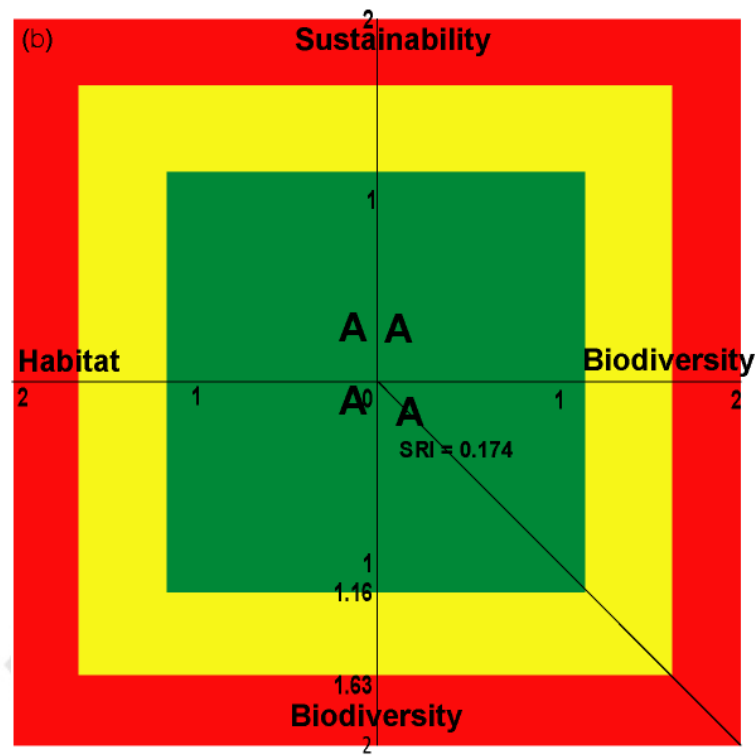
* denotes a significant difference at $\alpha < 0.05$ level

Results

ORI diagrams_Tier 1



Pre-construction (2003)



Post-construction (2007)

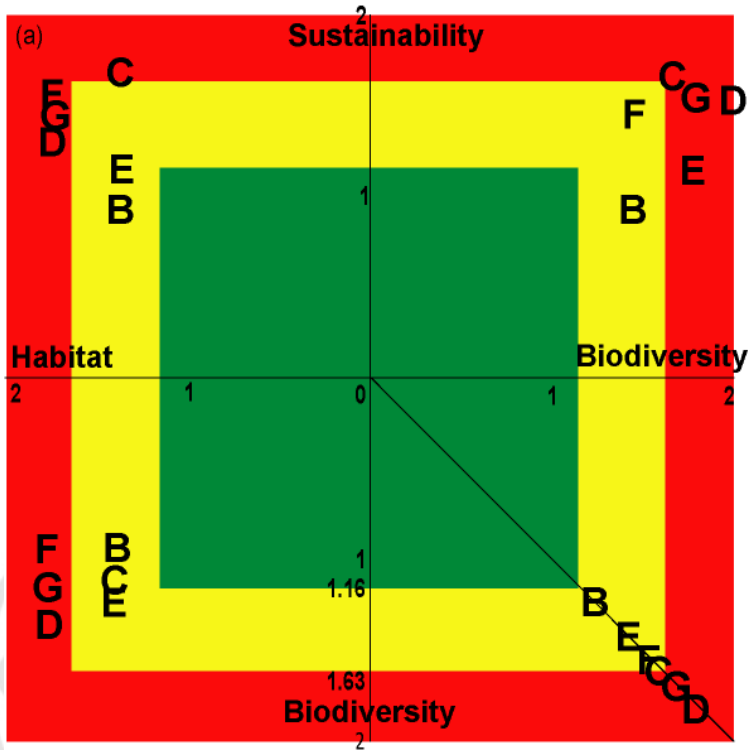
Result

Tier 2 _ Bycatch species

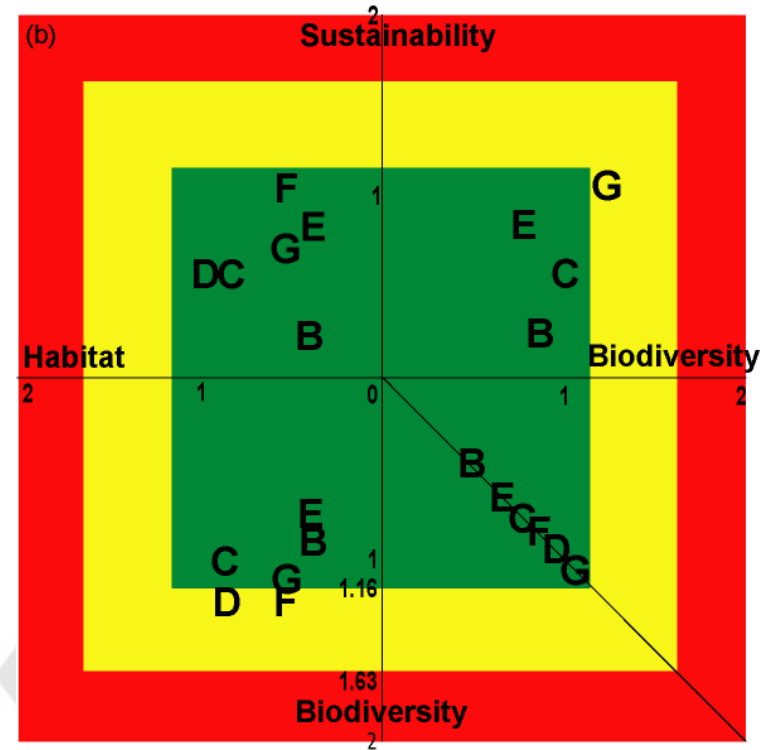
Species	SRI		MI
	2003	2007	
Black rockfish	1.246	0.486	61.01
Red sea bream	1.566	0.803	48.73
Common seabass	1.762	0.877	50.22
Jacoveper rockfish	1.430	0.662	53.68
Yellow tail	1.548	0.818	47.16
Common eel	1.688	0.934	44.68

Results

ORI diagrams_Tier 2



Pre-construction (2003)




Post-construction (2007)

Conclusion



Effectiveness of Jeonnam marine ranching area

Result of Tier 1(Black seabream)

- Improved sustainability, and SRI at 0.001 critical level
 - Improved habitat at 0.01 critical level
 - Improved biodiversity at 0.05 critical level
- 

Conclusion



- **Assessment methodology hasn't verified**
 - **More considering of reference points**
 - **Need to basic study to get information of reference points**
- **Develop the social economic effort**

