Emergy Value Maps as a Decision Support Tool for Marine Spatial Planning in Korea

The 3rd YSLME Science Conference
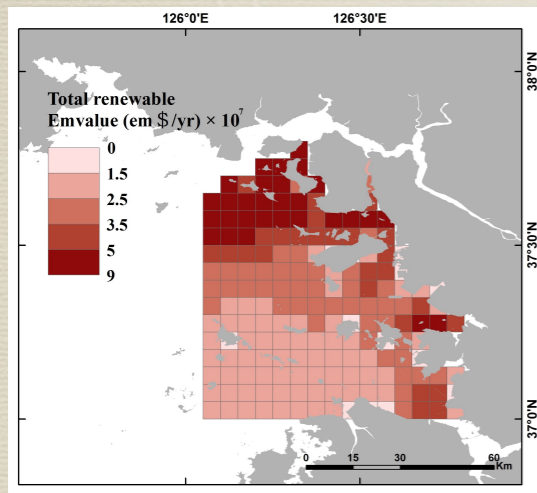15~19 July 2019
Qingdao, PR China

Daeseok Kang, Pukyong National University
Naryeong Kim, Pukyong National University
Jongseong Ryu, Anyang University
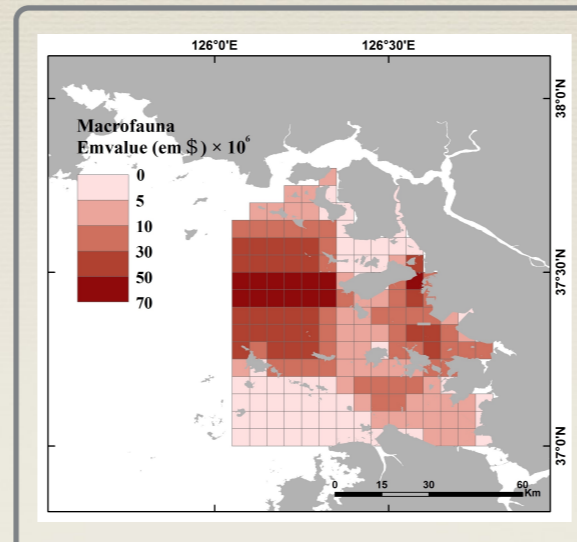Jungho Nam, Korea Maritime Institute

Contents

- **Introduction**
- **Methods**
- **Results**
- **Future Works**

- Value maps as a decision support tool for marine spatial planning in Korea
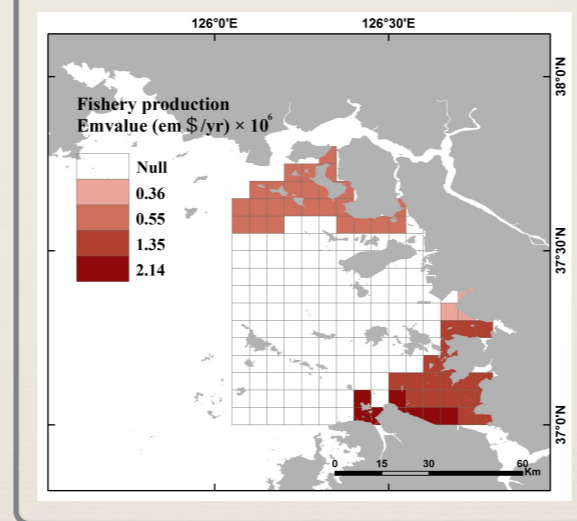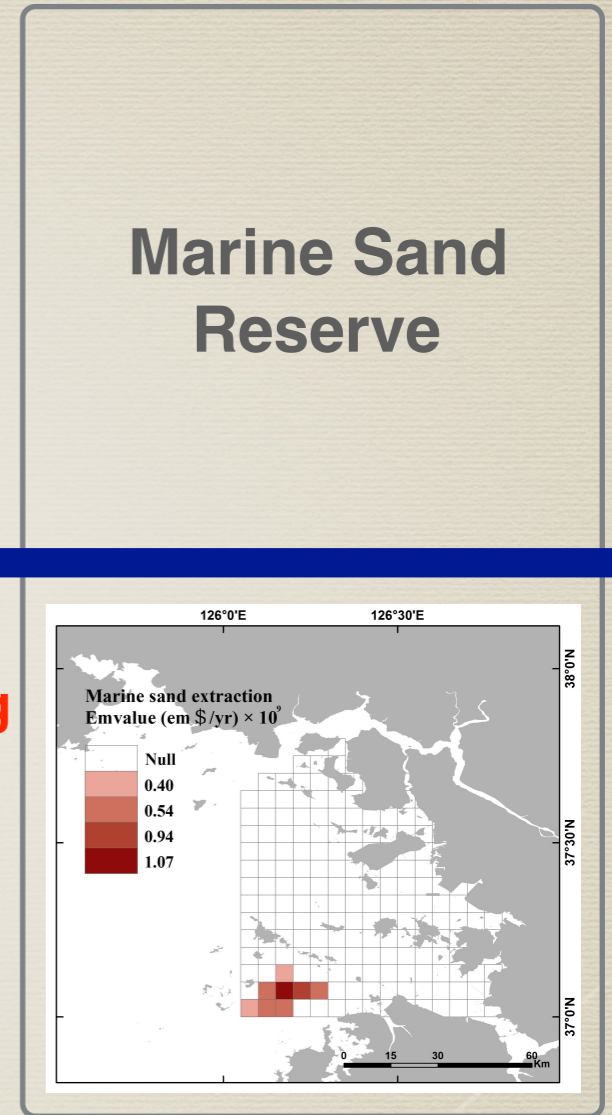
Environmental support

Natural Capital

Ecosystem Services

Marine Sand Reserve

Conflicting uses

Fishery production

Marine sand extraction

Source : Kang et al. (2015)

- Background of the study
  - Emergy methodology adopted as one of ecosystem valuation tools for the marine spatial planning framework of Korea

- Objectives of the study
  - Classification of marine ecosystem services
  - Quantification of marine ecosystem services
  - Conversion factors to calculate emergy quantity of ecosystem services
  - Emergy valuation and construction of value maps

Structure and functions of ecosystems
Ecosystem services identification

Emergy Valuation

Spatial Mapping

Emergy Value Maps

Marine Spatial Planning
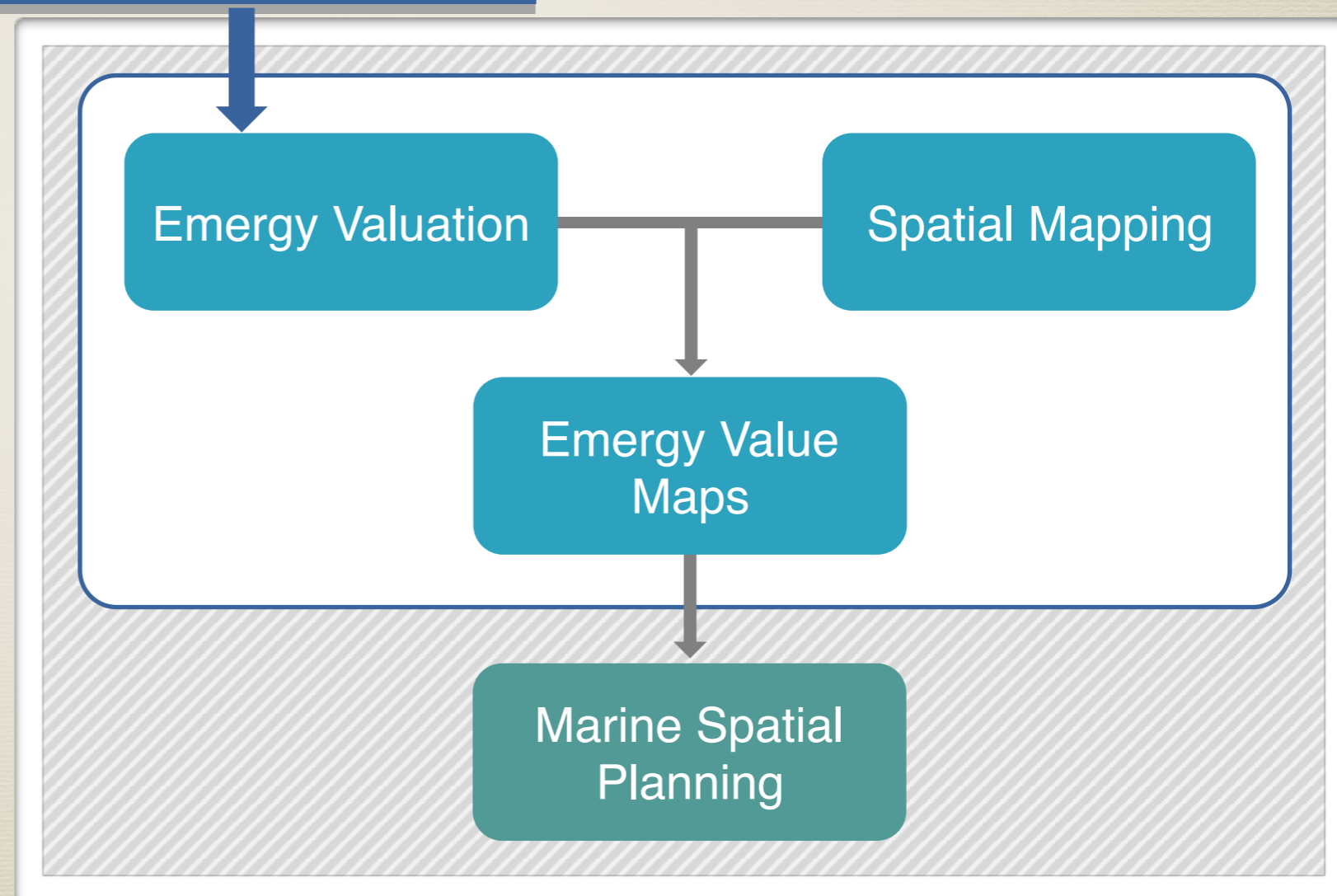
Source : MOF (2016)

⊙ Emergy methodology: a donor-based approach to the valuation of ecosystem services

" Value (or price) of the dish? "

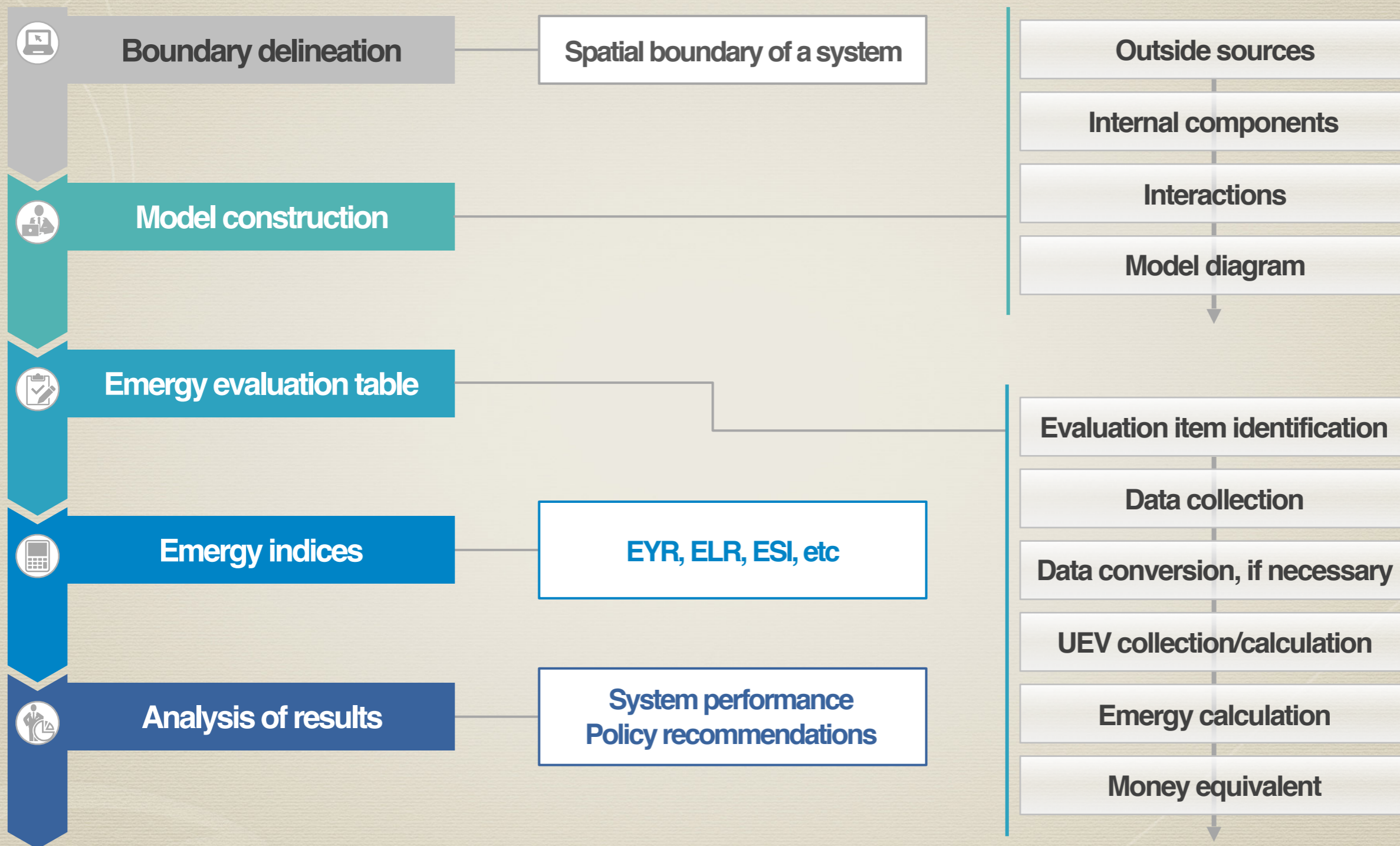| Donor-based approach	Receiver-based approach

» Sum of inputs to produce it
» Value (or price) proportional to inputs
» Emergy valuation
   - Biophysical approach
   - Nature's work + Human efforts
	» Utility for a consumer
	» Willingness-to-pay proportional to the utility
	» Economic valuation
	   - Preference-based approach

Source : MOF (2016)

Emergy evaluation procedure

Boundary delineation	**Spatial boundary of a system**

Outside sources

Internal components

Interactions

Model diagram

Model construction	

Emergy evaluation table	**Evaluation item identification**

Data collection

Emergy indices	**EYR, ELR, ESI, etc**

Data conversion, if necessary

UEV collection/calculation

Analysis of results	**System performance** **Policy recommendations**

Emergy calculation

Money equivalent

Source : MOF (2016)

Procedure for the construction of emergy value maps

|	Environmental Inputs	Stored Resources	Ecosystem Services	Purchased Inputs	
Raw Data Map	Annual inputs (sun, tide, river, etc)	Stock (biomass, sand reserve, etc)	Annual production (fishery, mining, etc)	Purchased inputs (fuel, equipments, labor, etc)	Statistics, literature, and estimation
Energy, Mass, Money Map	Annual inputs (J/yr, g/yr, $/yr, etc)	Stock (J, g, $, etc)	Annual production (J/yr, g/yr, etc)	Purchased inputs (J/yr, g/yr, $/yr, etc)	Multiplied by Unit Emergy Value
Emergy Map	Emergy Flow (sej/yr)	Emergy Storage (sej)	Emergy Flow (sej/yr)	Emergy Flow (sej/yr)	Emergy divided by Emergy-money ratio
Emvalue Map	Environmental Flow Value Map	Stored Resource Value Map	Ecosystem Services Value Map	Purchased Input Value Map	

Source : Kang et al. (2015)

Procedure for the construction of emergy value maps

ex) Fishery production (capture fishery) (MOF, 2016)
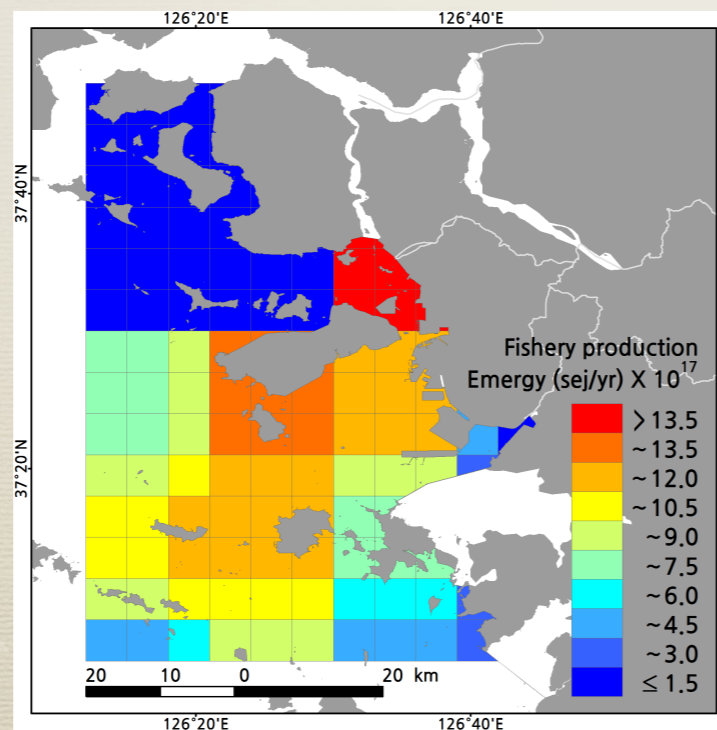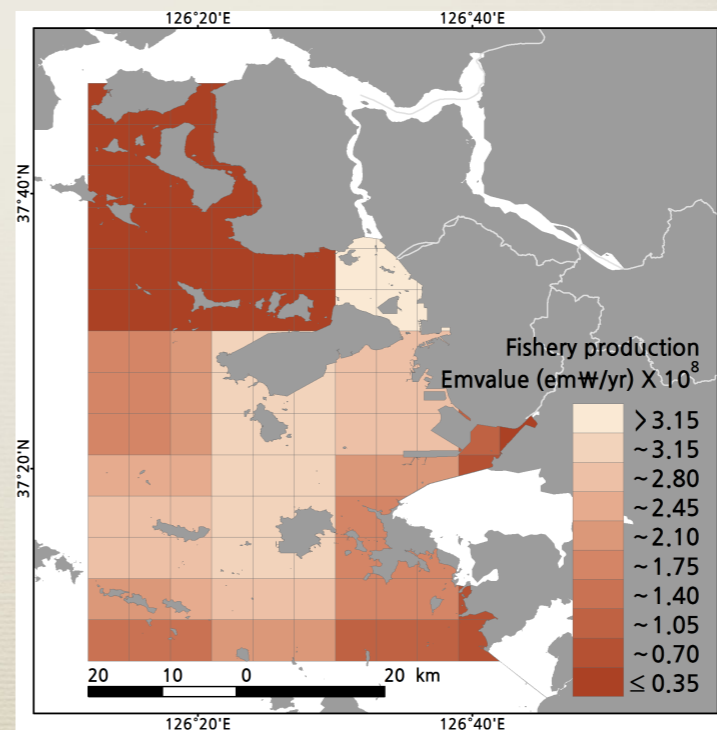
Raw data map
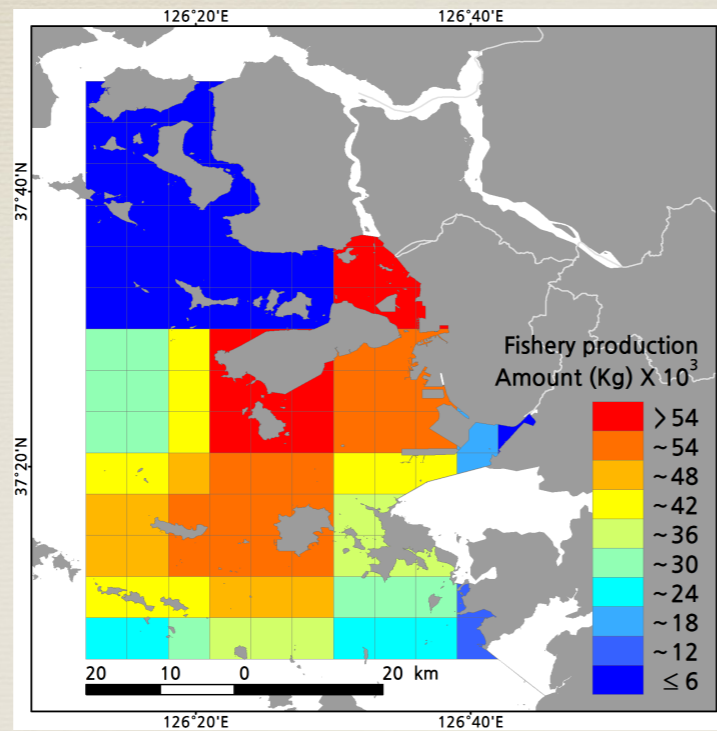
Energy map
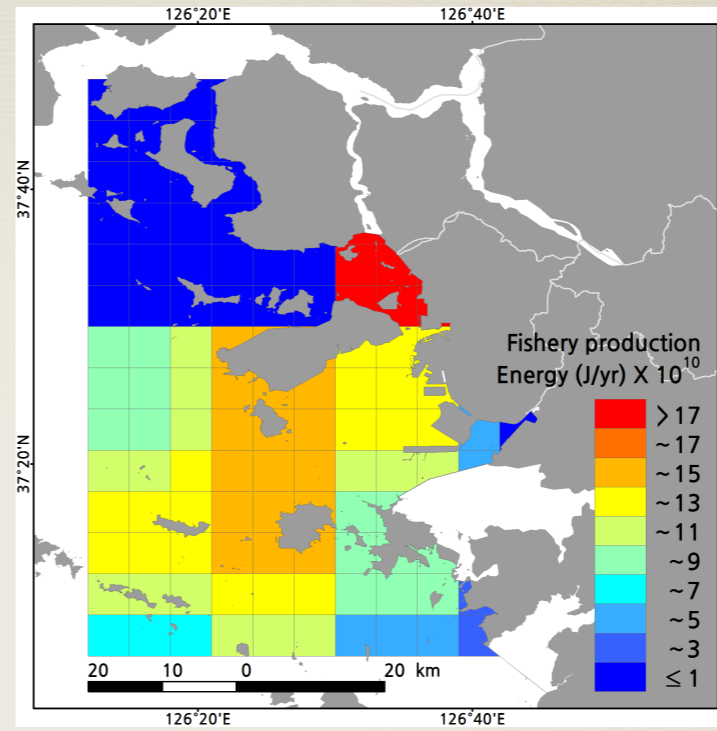
Emergy map

Emvalue map

- Calculation of **unit emergy value**
  - Unit emergy value (UEV) : **conversion factor** to calculate emergy quantity of a good or service from biophysical data
  - UEV = Emergy input (sej/yr) / Production (J/yr, g/yr, etc)
    - ex) UEV of GPP = Annual emergy input (sej/yr) / annual GPP (J/yr)
    - ex) UEV of fishery products = Emergy of food consumed (sej/yr) / Secondary production (J/yr)
- Calculation of **emergy quantity** of ecosystem services
  - Emergy (sej/yr) = Raw data (J/yr, g/yr, ₩/yr, etc) × Unit emergy value (sej/J, sej/g, sej/₩, etc)
- Calculation of **emvalue**, money-equivalent of emergy quantity
  - Emvalue (₩/yr) = Emergy quantity (sej/yr) / Emergy-money ratio (sej/₩)
  - Emergy-money ratio for Korea in 2015: $4.29×10^{15}$ sej/$, $3.79×10^{9}$ sej/₩

Classification and quantification of marine ecosystem services (KIMST, 2016)

Marine Ecosystem Services			Data for emergy calculation
Provisioning	Food	Fishery products	Annual production (tons/yr)
	Genetic resources	Genetic materials for industrial purposes	Annual use of genetic materials (kg/yr)
	Raw materials	Materials for pharmaceutical industry	Annual production of raw materials (tons/yr)
		Materials for chemicals and food additives	
	Energy	Marine energy	Electricity generated per year (MWh/yr)
Regulating	Climate control	Sequestration of greenhouse gases	Annual CO_2 sequestration (ton CO_2/yr)
	Disaster prevention	Reduction of coastal erosion	Reduction of coastal erosion (tons/yr) Amount of damages prevented for coastal structures and buildings (tons/yr)
		Buffering against storm surges	Amount of damages prevented (tons/yr)
	Pollution control	Nutrient removal	Annual denitrification (kg/yr)
		Removal of hazardous chemicals/heavy metals	Net removal rates for each pollutant (kg/yr)
	Biological control	Stable community structure	Parameters need to be identified

◉ Classification and quantification of marine ecosystem services (KIMST, 2016)

Marine ecosystem services			Data for emergy calculation
Cultural	Sociocultural value	Marine cultural heritages	Number of visitors (persons/yr), Average time spent per person (hours/person)
		Coastal community	Parameters need to be identified
	Research & education	Sites of marine researches	Number of researchers participated (persons/yr), Average working hours per person (hours/person)
		Educational opportunities	Number of people participated (persons/yr), Average time spent per person (hours/person)
	Health	Place for healing and relaxing	Number of people who used coastal sanatoriums (persons/yr), Average time spent per person (hours/person)
	Aesthetic value	Inspiration for arts	Market price of arts, advertisements, and buildings (₩/yr)
		Religious inspiration	Parameters need to be identified
	Leisure & tourism	Places for leisure and recreational activities	Number of tourists (persons/yr) & Average time spent per capital (hours/person)
Supporting	Primary production	Production of organic matter	Annual gross primary production (tonC/yr)
	Nutrient cycling	Nutrient recycle	Parameters need to be identified
	Water cycle	Water cycle	Parameters need to be identified
	Habitats	Habitats for marine organisms	Sizes of habitats (m²), Parameters need to be identified

- Database of unit emergy values for marine ecosystem services

	Items	Unit	w/o services	w/ services	Source
Fishery products	Brown algae	sej/J	4.6×10^6	-	2
	Kelp	sej/J	6.4×10^6	-	2
	Red algae	sej/J	7.9×10^6	-	2
	Green algae	sej/J	2.4×10^6	-	2
	Littleneck clams	sej/J	8.1×10^6	-	this study
	Surf clams	sej/J	4.7×10^6	-	this study
	Intertidal herbivores	sej/J	1.8×10^6	-	1
	Intertidal meio/micro fauna	sej/J	4.9×10^6	-	1
	Intertidal macrofauna	sej/J	1.4×10^6	-	1
	Macrobenthos	sej/J	3.3×10^6	-	2
	Fish	sej/J	1.1×10^6	-	2
	Squids	sej/J	1.8×10^6	-	1
	Sandeels	sej/J	1.8×10^6	-	1
	Herrings	sej/J	1.8×10^6	-	1
	Greenlings	sej/J	1.8×10^6	-	1
	Shrimps	sej/J	1.8×10^6	-	1
	Cods	sej/J	1.8×10^7	-	1

- Database of unit emergy values for marine ecosystem services

	Items	Unit	w/o services	w/ services	Source
Fishery products	Rockfish	sej/J	1.8×10^7		1
	Halibuts	sej/J	1.8×10^7		1
	Soles	sej/J	1.18×10^6		1
Energy	Tidal power	sej/J	5.03×10^4	1.28×10^6	3
	Marine wind power	sej/J	5.03×10^4	5.25×10^4	4
	Wave power	sej/J	5.03×10^4	5.25×10^4	5
Minerals	Marine sand	sej/J	2.88×10^{10}	-	6

[1] Brown et al. (1993)

[2] Campbell (2004)

[3] Kim (2011)

[4] Kim and Kang (2010)

[5] Assumed the uev of wind power

[6] Odum (2000)

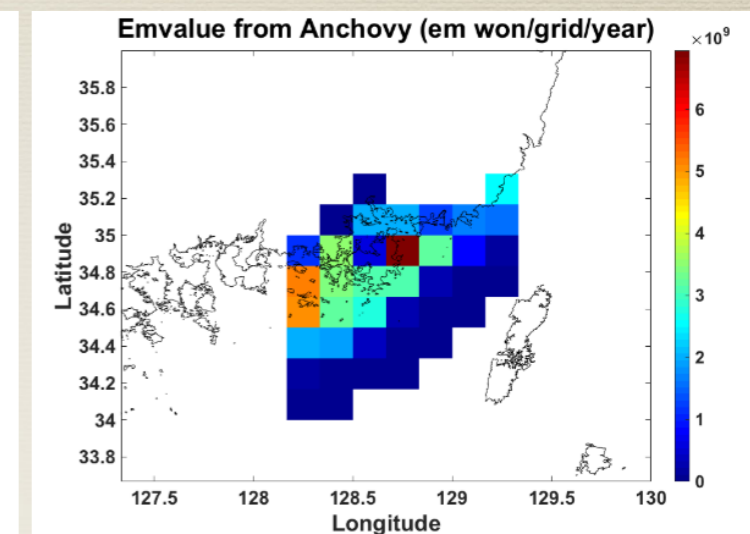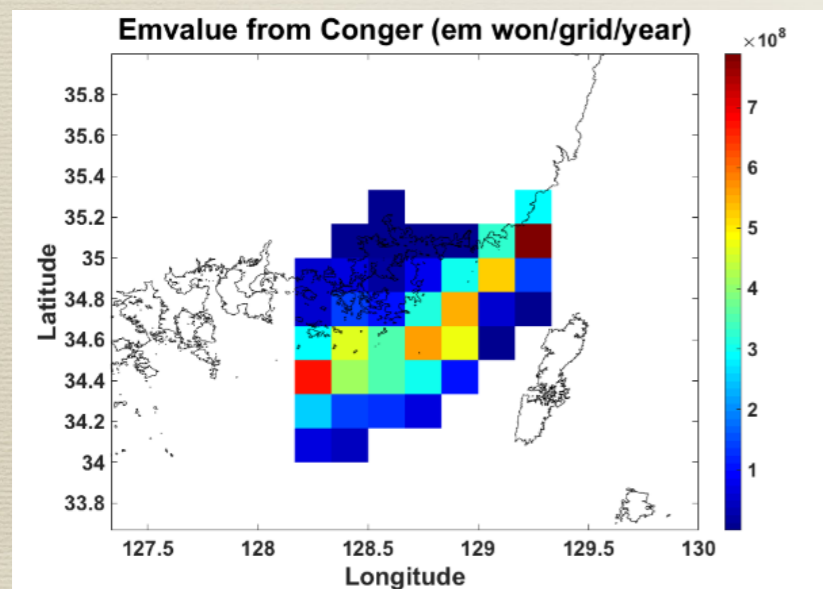Emergy value maps for the southeastern part of the South Sea

Primary production
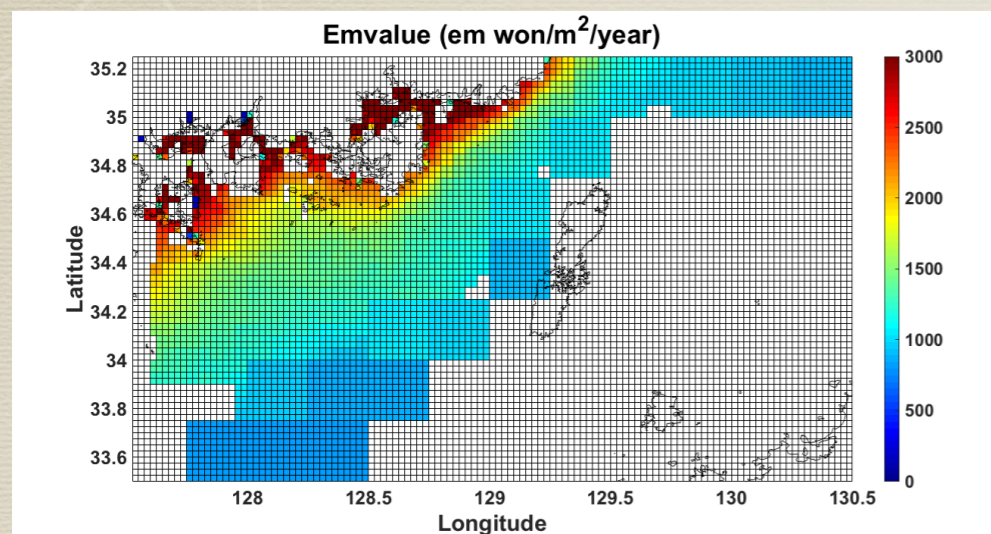
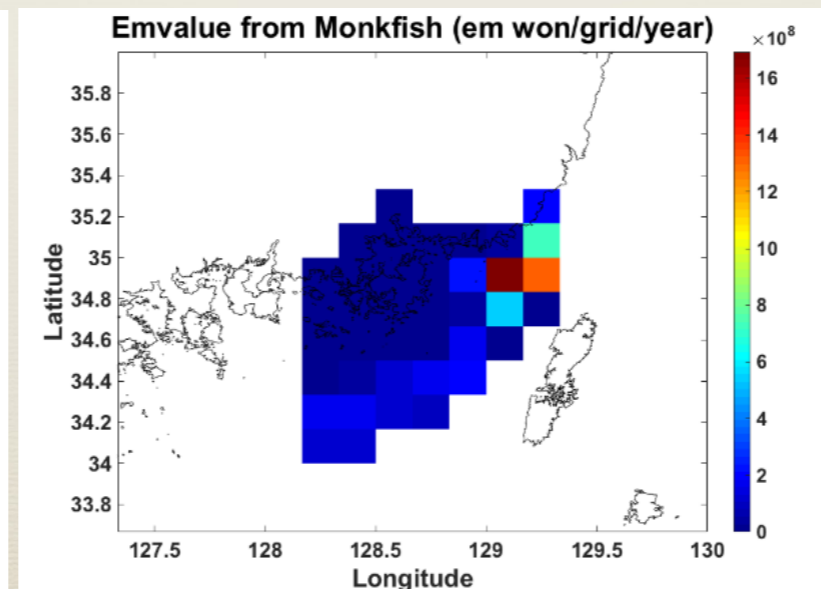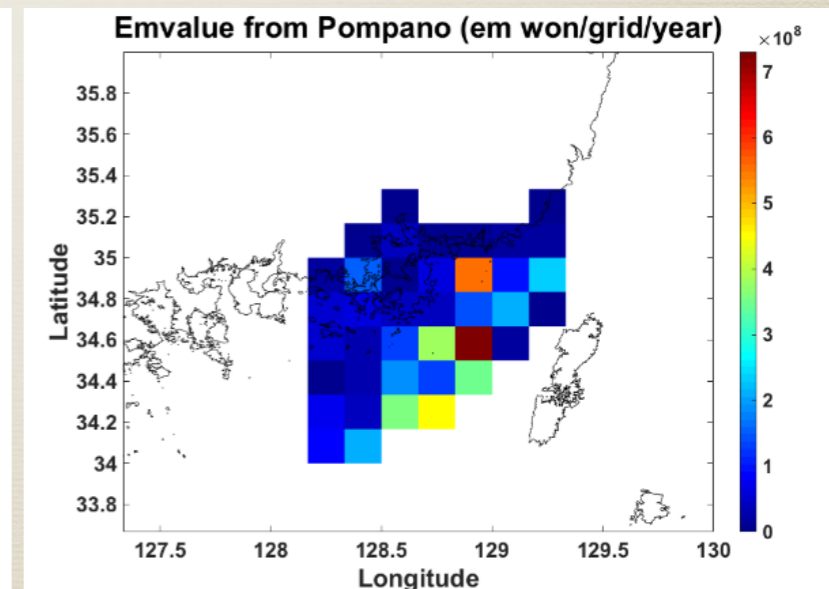## Common mackerel
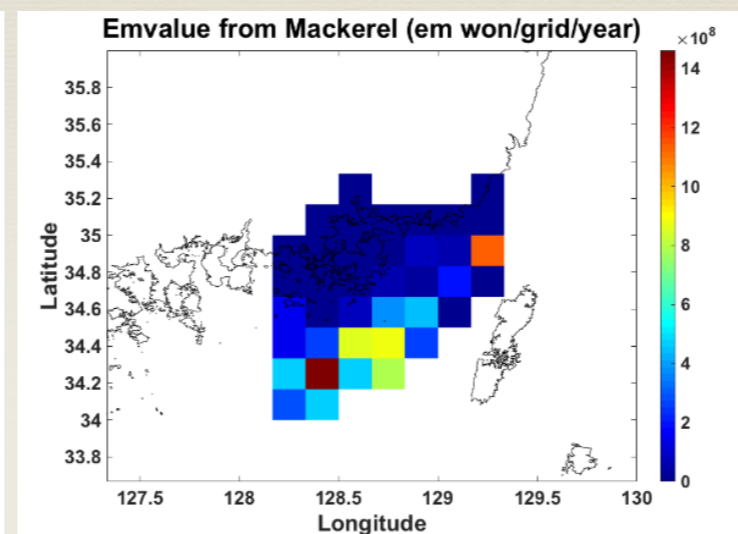
Japanese anchovy

Conger eel

Blackmouth angler

Japanese jack mackerel

- Future works needed
  - Lack of sufficient spatial biophysical data to construct value maps for ecosystem services provided by the Korean marine ecosystem
    - Very limited data and information that can be used to quantify ecosystem services
    - How to fill the data and information gaps?
  - Quantification of ecosystem services
    - How to quantify marine ecosystem services, especially culture services?
    - What are appropriate parameters for the quantification?
  - Database of unit emergy values for marine ecosystem services
    - Limitations in using unit emergy values that were calculated for marine ecosystems in other countries with different ecological characteristics
    - More works are needed to calculate UEVs, especially for provisioning services: system evaluations that require biophysical data

Thank you for your attention!