Estimation of the potential fisheries production in the Korean waters based on biomass size-spectrum model and Ryther's method.

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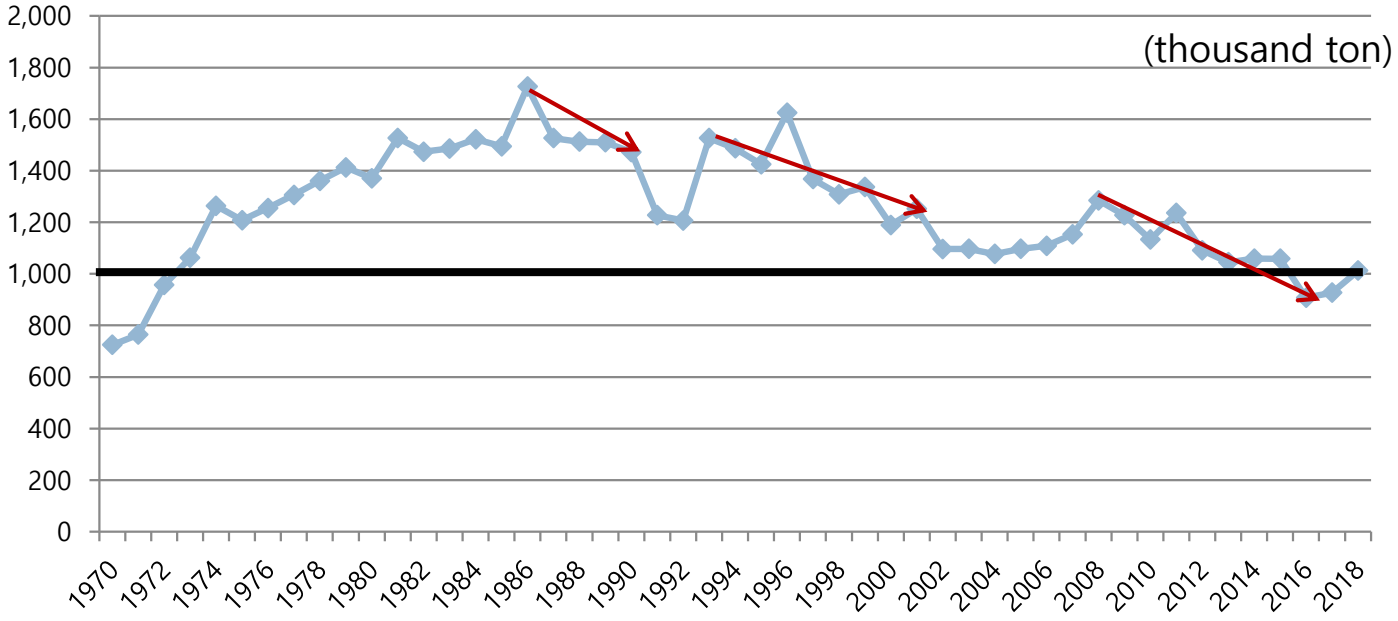
Introduction

- Annual fisheries production in the Korean waters (1972-2018)
  - Steadily decrease since the late 1980s



Ref. : http://www.kostat.go.kr/portal/korea/index.action

Objective

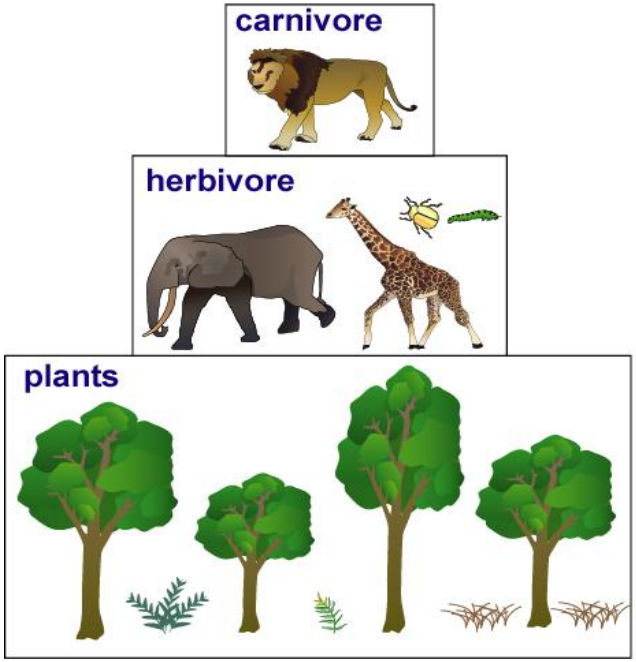
- Estimation of the potential fisheries production in the Korean waters based on biomass size-spectrum model with satellite-derived ocean-color data

1. Estimation of total biomass of phytoplankton by size using satellite-derived ocean-color data
2. Estimation of total biomass of fish by size using 1. and BSS model
3. Estimation of the potential fisheries production in the Korean water

Materials and Methods

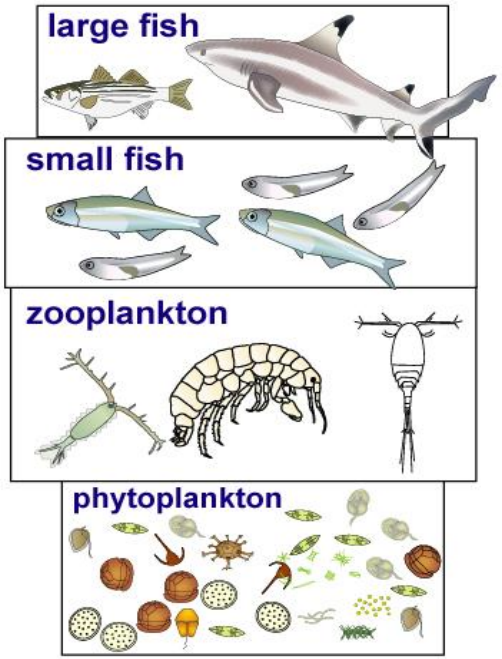
- Allometric scaling at ecosystem trophic level

Terrestrial ecosystems



Eltonian Pyramid

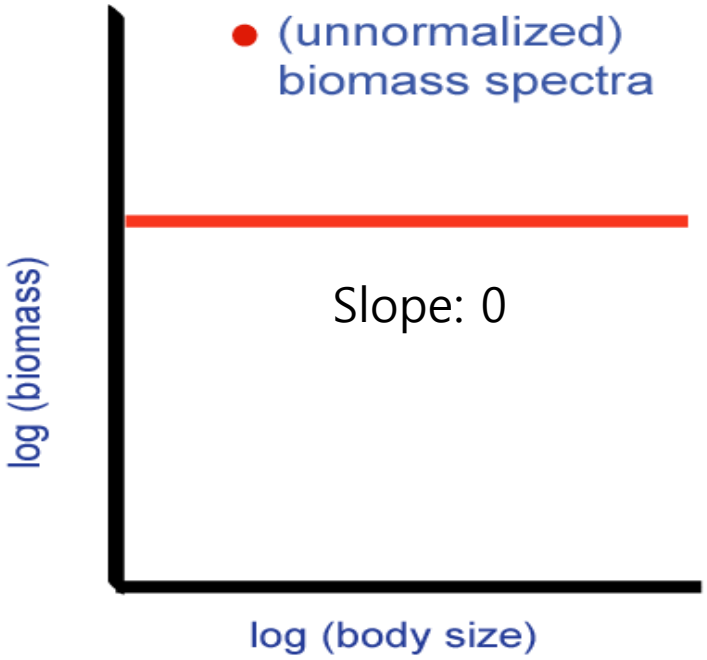
Aquatic ecosystems

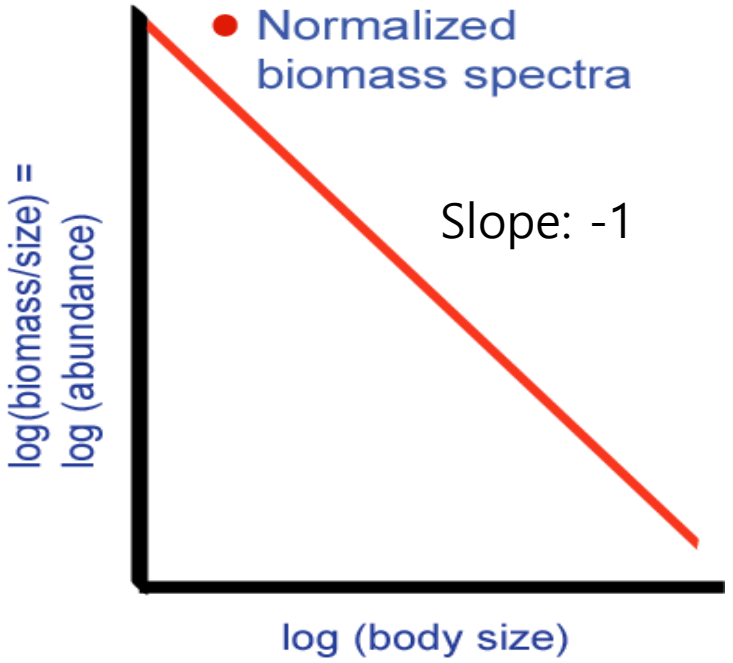


Aquatic food chain

Materials and Methods

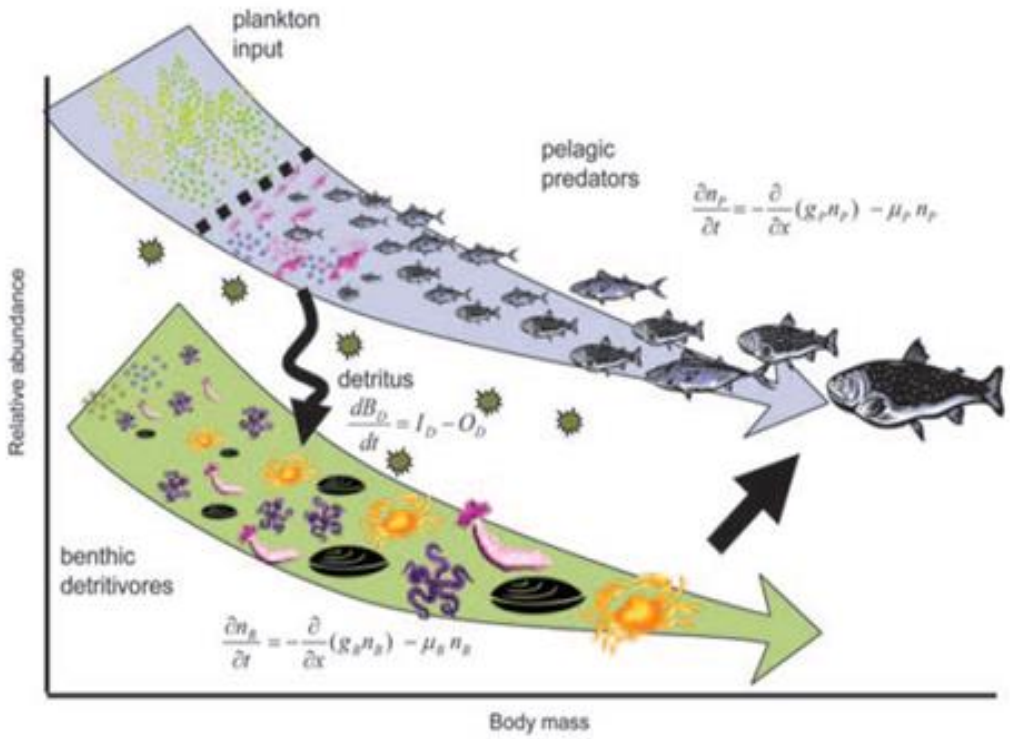
- Basic principle of Biomass size-spectrum (BSS)
  - Total biomass of organisms is nearly same for each size class

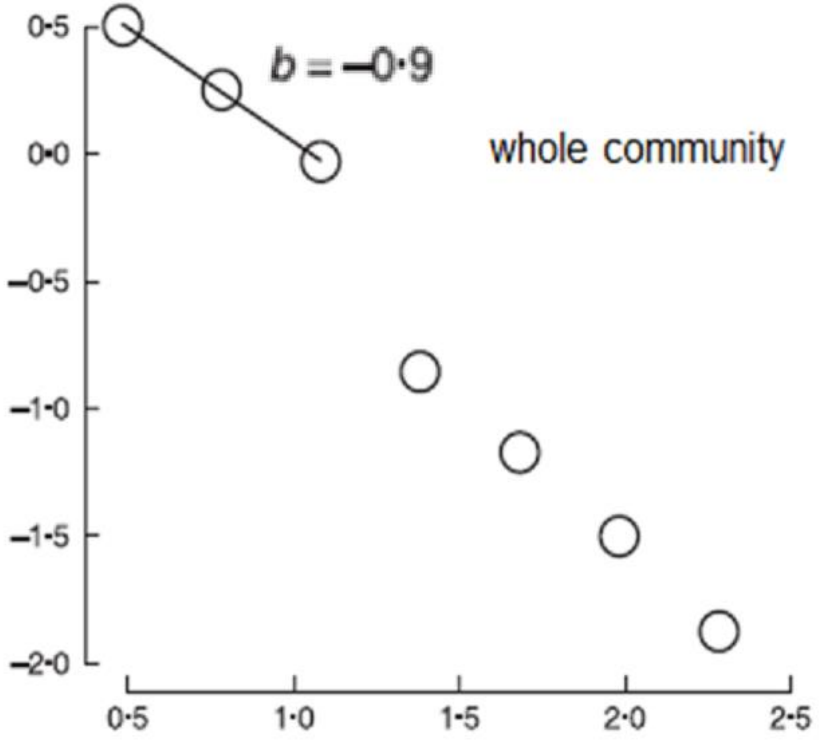




Materials and Methods

- BSS model for the North Sea
  - Considered both pelagic and benthic components.





Blanchard et al. (2009)

Materials and Methods

- Phytoplankton
  - Pico-phytoplankton – 0.2~2 μm
  - Nano-phytoplankton – 2~20 μm
  - Micro-phytoplankton – 20~200 μm

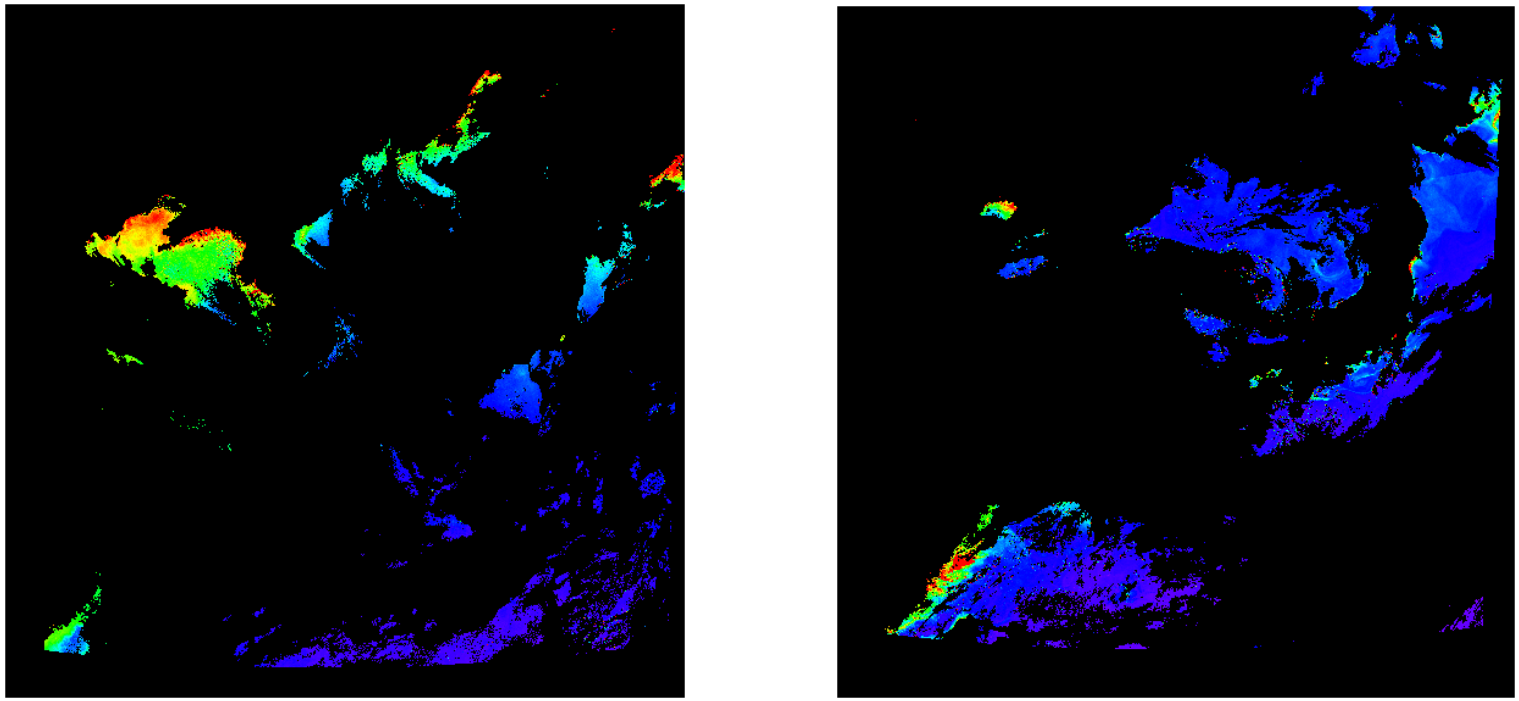
Materials and Methods

- Phytoplankton
  - weight (pgC cell^{-1}) = 0.216*volume$^{0.939}$
    (Menden & Lessard ,2000)
  - 1 g wet weight = 1.3 kcal (Banse & Mosher, 1980)
  - 1 g C = 10 kcal (Jones, 1984)

  - Pico-phytoplankton – 1.86x10^{-9} g/cell
  - Nano-phytoplankton – 9.53x10^{-7} g/cell
  - Micro-phytoplankton – 4.88x10^{-4} g/cell

Materials and Methods

- Ocean-color data in 2014 measured by the Geostationary Ocean Color Imager (GOCI)



The distribution of chlorophyll-a at 20140118 and 20140714

Materials and Methods

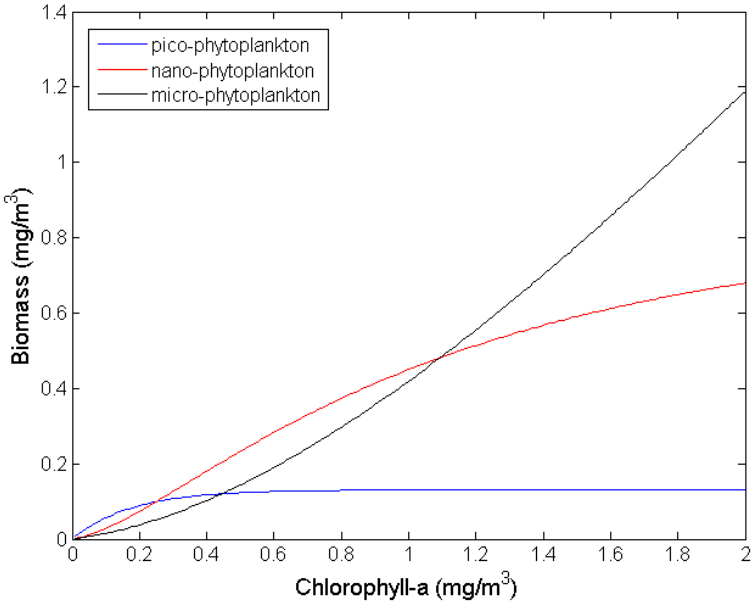
- Calculation formula of biomass of phytoplankton by size class

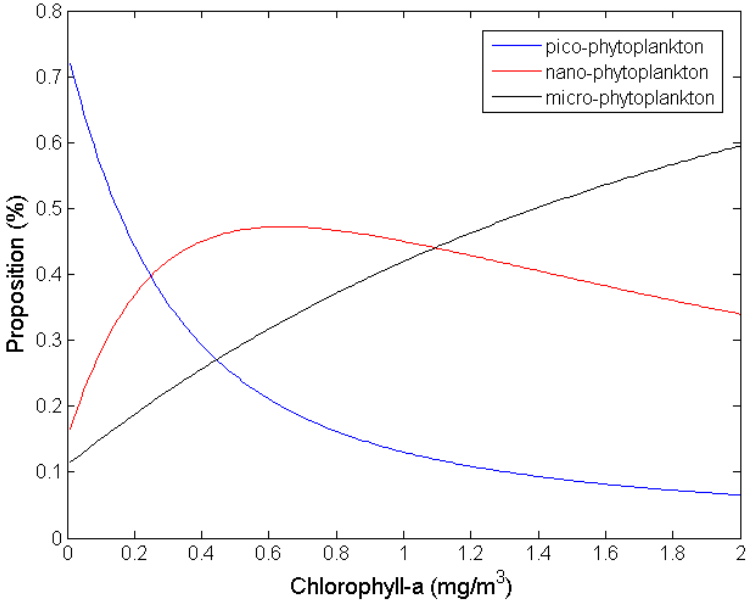
$C = C_p + C_n + C_m$	$C = C_p + C_n + C_m$
$C_{pn} = C^{m}{}_{pn}[1 - \exp(-S_{pn}C)]$	$C_{pn} = 0.9617\,[1 - \exp(-0.9248\,C)]$
$C_m = C - C_{pn}$	$C_m = C - C_{pn}$
$C_p = C^{m}{}_{p}[1 - \exp(-S_pC)]$	$C_p = 0.1308[1 - \exp(-5.659C)]$
$C_n = C_{pn} - C_p$	$C_n = C_{pn} - C_p$
$F_p = C_p/C$	$F_p = C_p/C$
$F_n = C_n/C$	$F_n = C_n/C$
$F_m = C_m/C$	$F_m = C_m/C$

Developed and provided by KIOST satellite center

Materials and Methods

- Biomass and ratio of phytoplankton by size according to chlorophyll-a amount





Materials and Methods

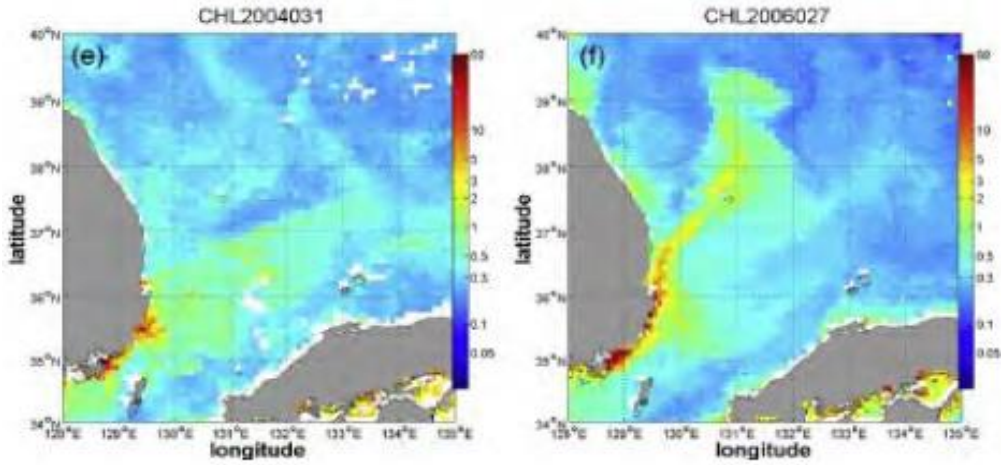
- Ryther's ecosystem method (1969)

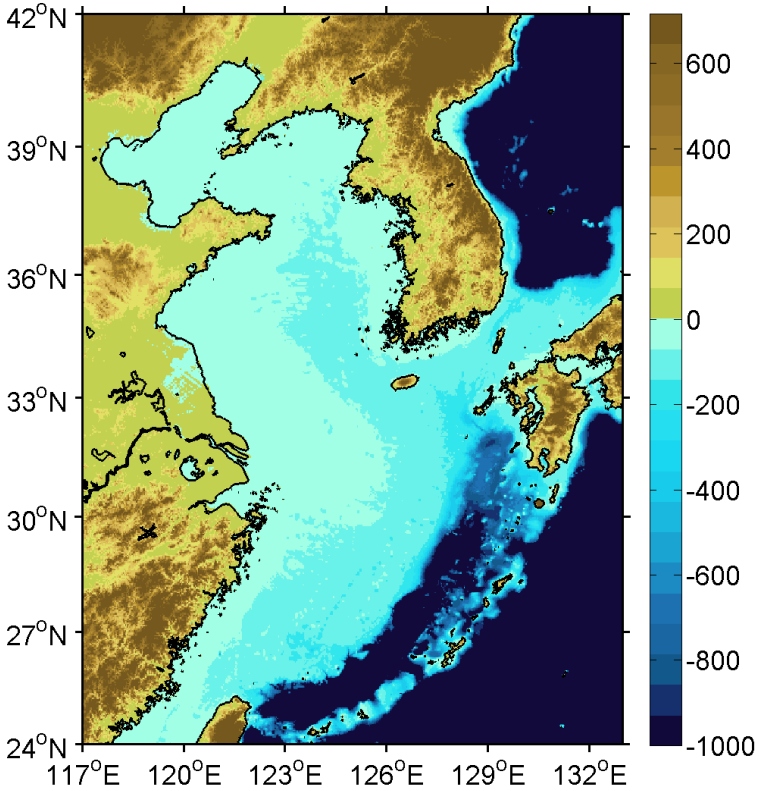
Province	Percentage of ocean	Area (km^2)	Mean Productivity (grams of carbon/m^2/yr)	Total productivity (10^9 tons of carbon/yr)
Open sea	90	326×10^6	50	16.3
Coastal zone	9.9	36×10^6	100	3.6
Upwelling areas	0.1	3.6×10^5	300	0.1
Total				20.0

Province	Primary prodution [tons (organic carbon)]	Trophic levels	Efficiency (%)	Fish production [tons (fresh wt.)]
Open sea	16.3×10^9	5	10	16×10^5
Coastal zone	3.6×10^9	3	15	12×10^7
Upwelling areas	0.1×10^9	1 1/2	20	12×10^7
Total				24×10^7

Materials and Methods

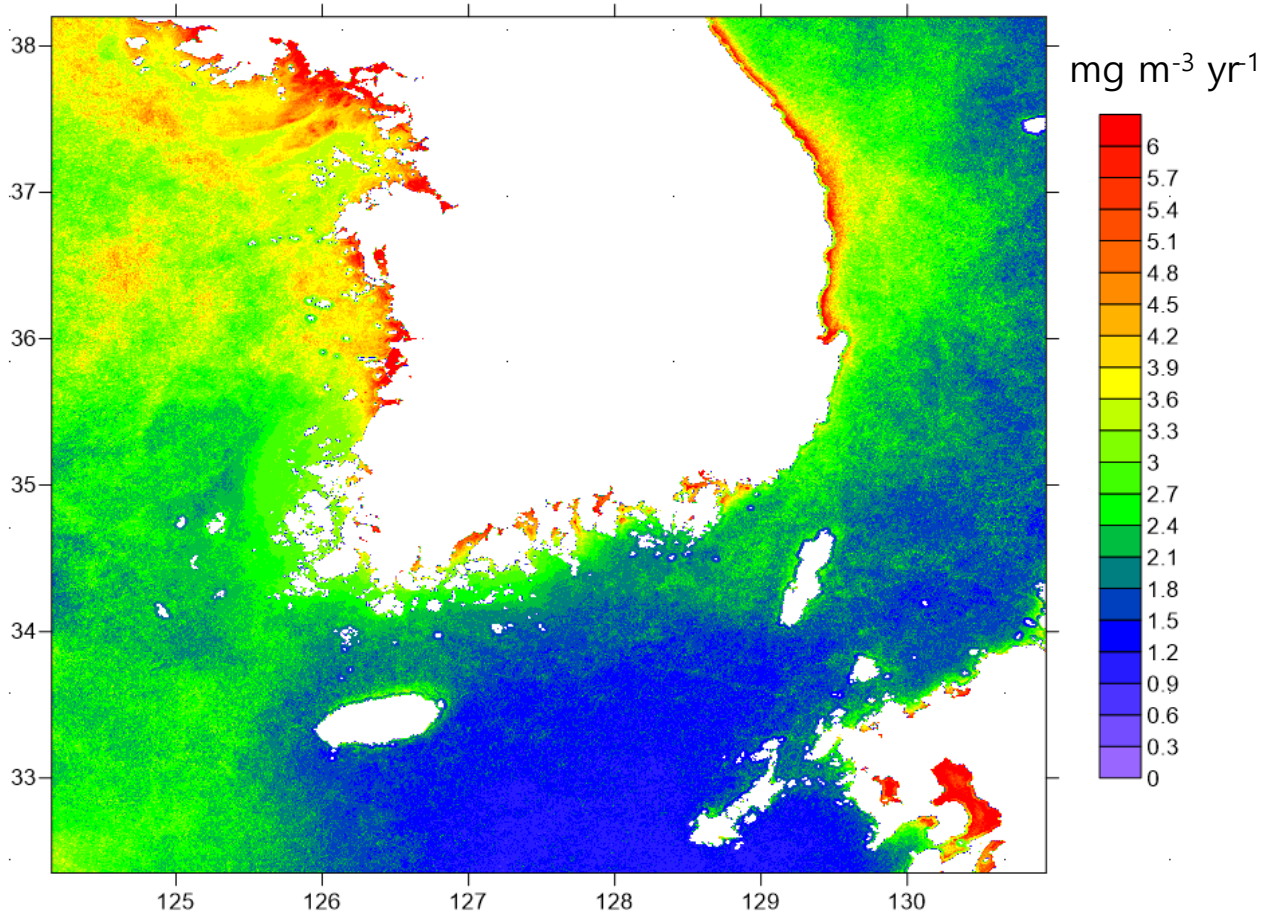
- Separation of Korea EEZ waters
  - Total area : 300,000 km^2
  - Open ocean : 95,000 km^2
  - Coastal zone : 200,000 km^2
  - Upwelling : 5,000 km^2





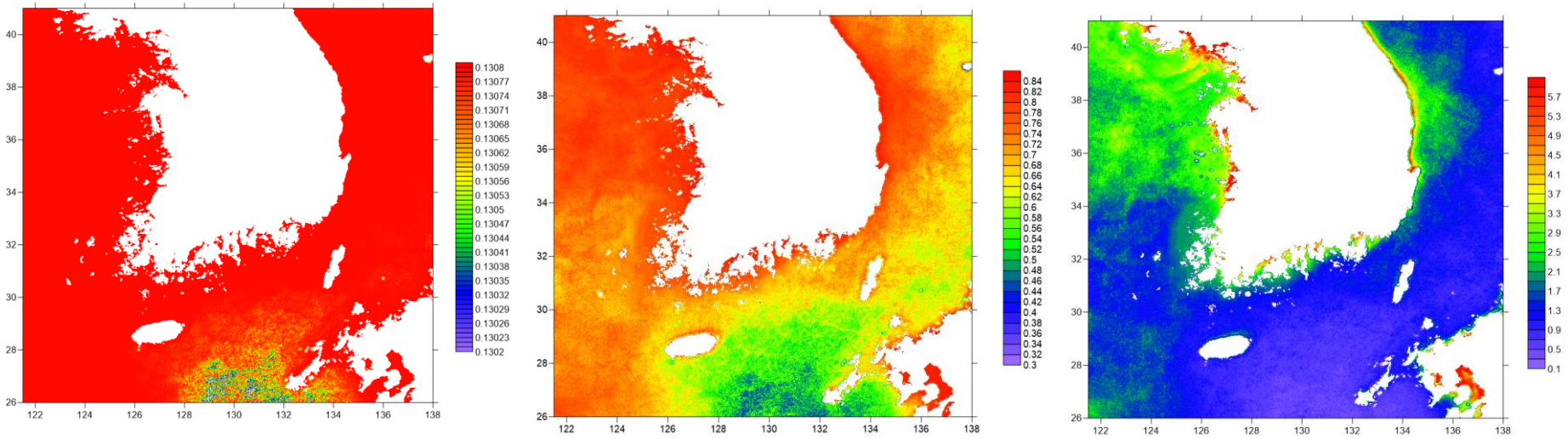
Results

- Distribution of average of chlorophyll-a in 2014



Results

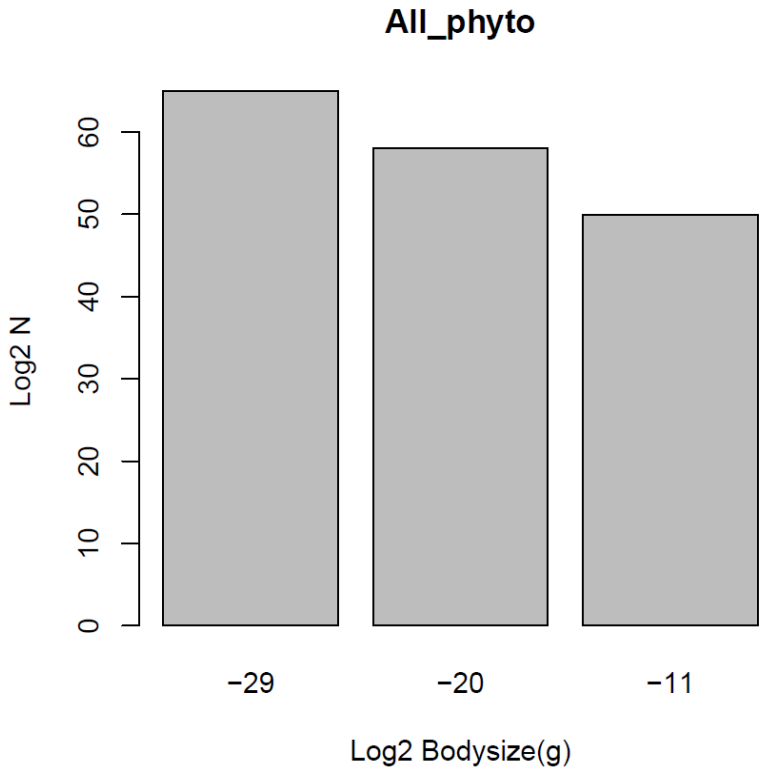
- Distribution of phytoplankton biomass by size
  - Using the GOCI data in 2014 and the calculation formula



(left-pico, middle-nano, right-micro, mg/m^3)

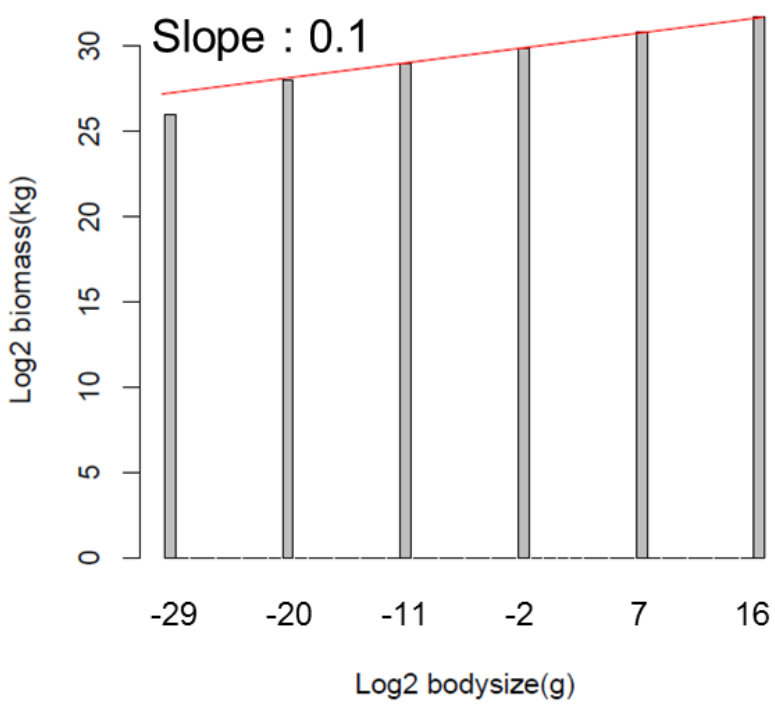
Results

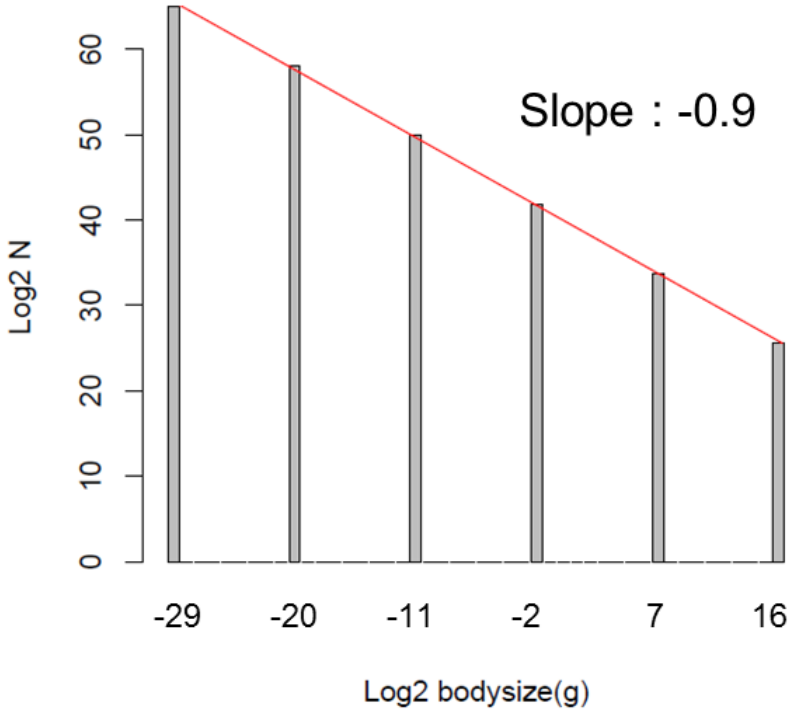
- Total biomass and abundance of phytoplankton by size in the Korean waters



Results

- BSS model for 2014 Korean waters considering pelagic and benthic system





Results

- Total annual potential fisheries production based on BSS model was ca. 5.28 million tons
  - P/B ratio : $P(w) = \beta(w) * 10^{0.44-0.26\log_{10}(w)}$

    (Banse& Mosher, 1980)

		Slope = -0.9					
log2(mass) (g/cell)	mass (g/cell)	log2(N)	N	Biomass (ton)	P/B	Production (ton)	
-29	1.8626E-09	65	3.59E+19	66,873			
-20	9.5367E-07	58	2.87E+17	273,597			
-11	4.8828E-04	50	1.07E+15	520,934			
-2	0.25	42	3.81E+12	952,721	3.69	3,514,601	Total(ton)
7	128	34	1.39E+10	1,777,840	0.73	1,295,367	(0.25g~66536g)
16	65536	26	5.06E+07	3,317,567	0.14	477,430	5,287,399

Results

- Total annual potential fisheries production using Ryther's ecosystem method was ca. 2.5 million tons
- The actual maximum catch is about 1 million tons

	EZZ Area	Mean productivity (grams of carbon/m^2/yr)	Total productivity (tons of carbon/yr)
Open ocean(East sea)	95,000 km²	50	4,750,000
Coastal zone(Yellow+south sea)	200,000 km²	100	20,000,000
Upwelling area	5,000 km²	300	1,500,000
Total	300,000 km²		24,750,000

Total productivity (tons of carbon/yr)	Trophic levels	Efficiency (%)	Fish product (tons of carbon/yr)	Fish product (tons of total weight/yr)	
4,750,000	5	10	48	475	
20,000,000	3	15	67,500	675,000	
1,500,000	1.5	20	180,000	1,800,000	
24,750,000			247,548	2,475,475	2.48E+06

Summary

- The estimated the potential fisheries production based on BSS model was ca. 5.28 million tons
- The estimated the potential fisheries production using Ryther's ecosystem method was ca. 2.5 million tons
- Korean fishermen harvest about 1 million tons every year.

Future works

- Estimation of the potential fisheries production in the Korean waters based on BSS with inclusion of zooplankton measured by laser optical plankton counter

- Evaluation of climate-change effects on the potential fisheries production in the Korean waters using the biomass size spectrum model.

Acknowledgements