YSLME

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Session 5: Mainstreaming coastal wetland and marine biodiversity into spatial planning

Coastal wetland ecosystem services in Republic of Korea

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Biology, Environment & Human for Our Sea

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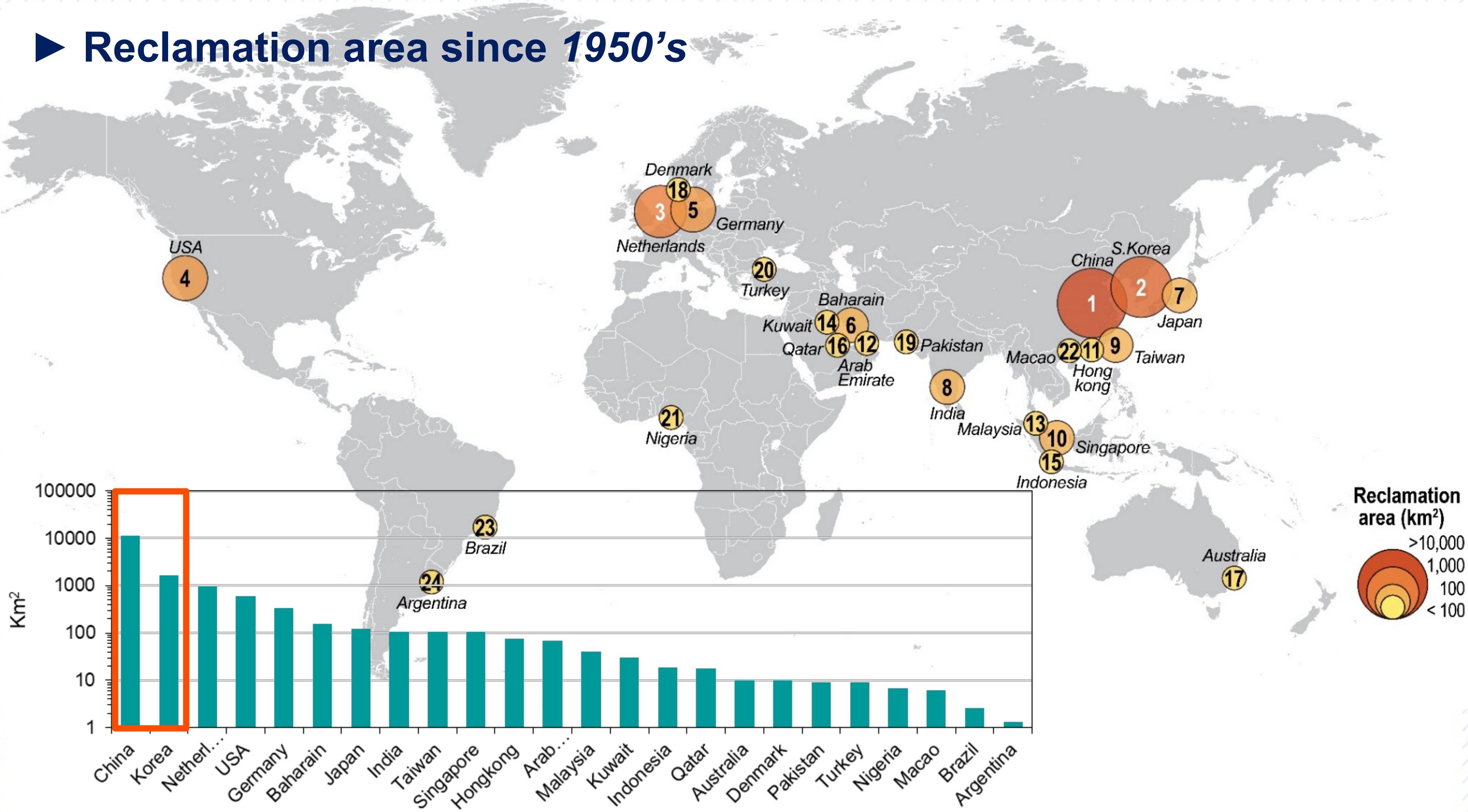
Biology, Environment & Human for Our Sea

1. Introduction: General Background

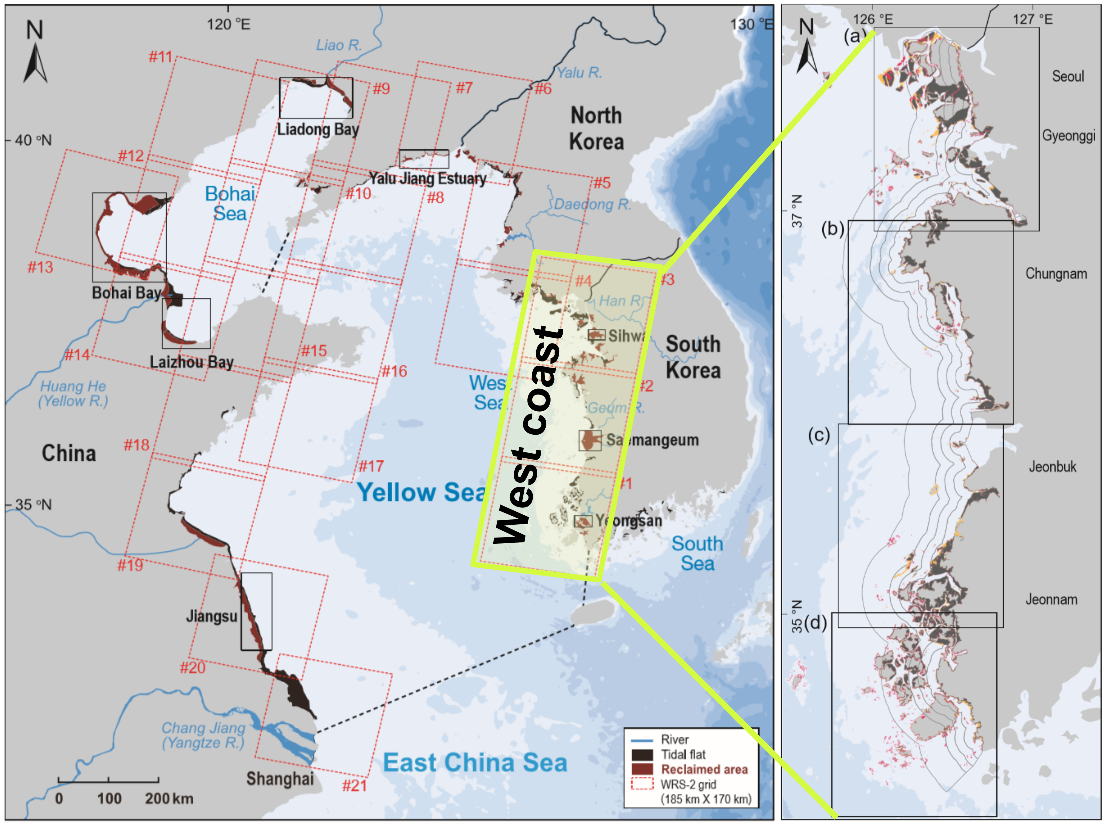
► Reclamation area since *1950's*



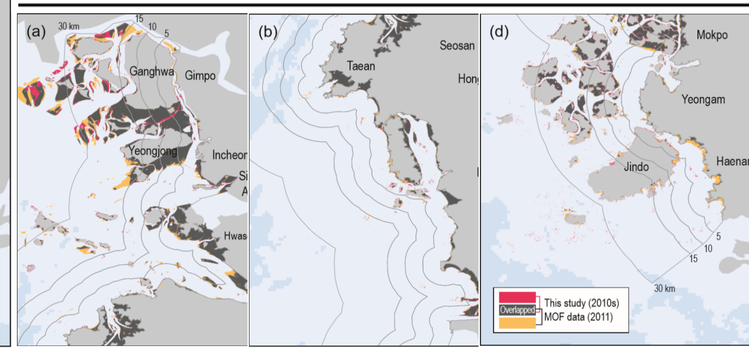
- Tidal flat, a key factor on ecosystem service value resulting in restoration and climate change
- Loss of 13,000 km^2 tidal flat of the Yellow sea since1950s due to reclamation

1. Introduction: General Background♪

Analysis of forty years long changes in coastal land use and land cover of the Yellow Sea: The gains or losses in ecosystem services. Environ. Pollut. 2018, (241), 74-84.



Region	Area of coastal reclamation (km²)						
	1980s	1990s		2000s		2010s	
China	[a]2361	[b]1178	(3539)	[b]2723	(6262)	[c,*]1105	(7367)
Liaoning	573	235	(808)	656	(1464)	253	(1717)
Hebei	170	86	(256)	431	(687)	150	(837)
Tianjin	19	17	(36)	272	(308)	92	(400)
Shandong	1284	231	(1515)	797	(2312)	345	(2657)
Jiangsu	315	609	(924)	567	(1491)	265	(1756)
South Korea	[d]368	[d]539	(907)	[d]523	(1430)	[e,**]150	(1580)
Incheon	–	46	(46)	–	(46)	–	(46)
Gyeonggi	–	211	(211)	62	(273)	–	(273)
Chungnam	230	56	(286)	14	(300)	–	(390)
Jeonbuk	–	–		401	(401)	–	(461)
Jeonnam	138	226	(364)	46	(410)	–	(410)
North Korea	[f]155	[f]218	(373)	[g]376	(749)	[***]31	(780)
Yellow Sea	2884	1935	(4819)	3622	(8441)	1286	(9727)



Kwon & Yim et al., 2018

- 1% annual loss of tidal flats; ~9,700 km2 loss expected in the 2020s
- Total carbon stock in three area of west coast of Korea (2.8 → 0.024 x 10^6 MgC, 99% loss)

1. Introduction: General Background

► Brief overview of *Marine Ecosystem services in Korea*

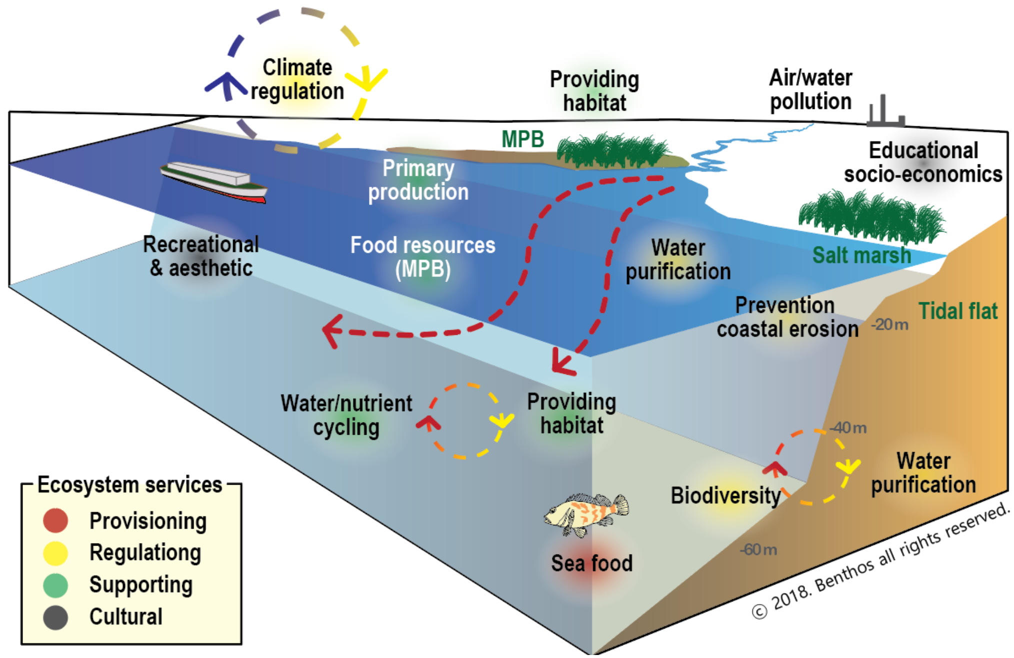
Provisioning — Wild fish for food (fish, crab, clam, seaweed)

Regulating
- *Climate change (CO_2 sequestration)
- *Flood protection, control of erosion rates
- *Mediation of waste, toxics, and nuisances — stock, removal, Mesocosm

Cultural
- Educational, heritage, entertainment
- Aesthetic, spiritual interactions
- Recreation, leisure fishing, diving

Supporting
- *Energy sources (MPB primary production — Primary production
- Materials (fibres from algae for direct use)
- *Nutrition (outputs for used for food) — MPB food sources $d^{13}C$, $d^{15}N$

*This study



- Provisioning (Wild fish for food)
- Regulating (Climate; C stock, Erosion; EPS, shear stress, **Purification; stock/removal**)
- Cultural (Recreation, leisure, etc.)
- Supporting (Primary production; MPB p.p, Nutrition; MPB d13C, d15N)

1. Introduction: General Background♪

► Ecosystem services (ES) assessment

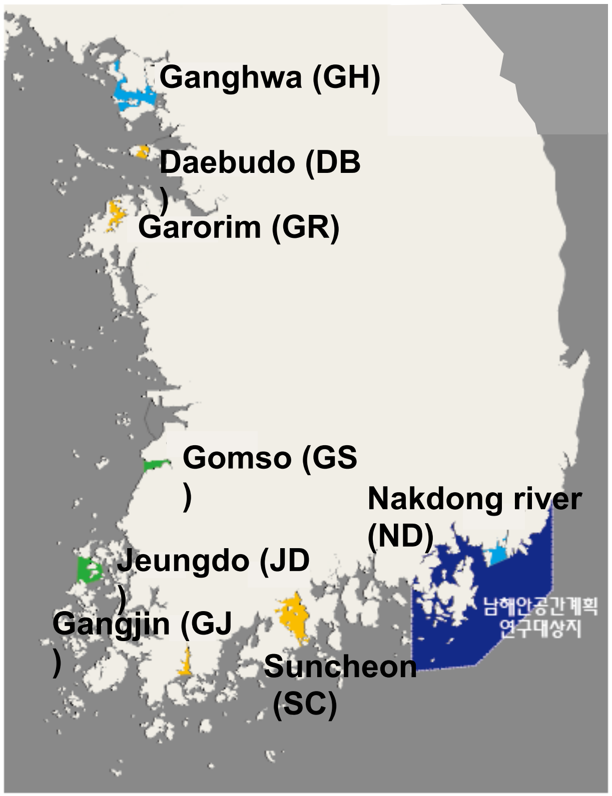
ES	Biophysical impact			Data sources (ref.)	Measurement index
	indicator	Data	Unit		
Nitrogen burial	N removal by burial	Annual sedimentation rate ($m\ yr^{-1}$) x Sediment volume ($m^2\ ha^{-1}$) x Sediment density ($kg\ m^{-3}$) x Organic N content(%)	Kg (N) $ha^{-1}\ y^{-1}$	Temmerman et al. 2004	- Annual sedimentation rate ($m\ yr^{-1}$) - Organic N content (wt %) - Volume of sediment ($m^2\ ha^{-1}$) - Dry density of sediment ($kg\ m^{-3}$)
Denitrification	N removal by denitrification	Intertidal area: 140-437	Kg (N) $ha^{-1}\ y^{-1}$	Middelburg et al. 1995a Broekx et al. 2011	- Denitrification rate ($mmol\ N\ m^{-2}\ yr^{-1}$)
Phosphorus burial	P removal by burial	Intertidal area: 4-56	Kg (P) $ha^{-1}\ y^{-1}$	Vymazal 2007 Broekx et al. 2011 Adams et al. 2012	- Annual sedimentation rate ($m\ yr^{-1}$) - Organic P content (wt %) - Volume of sediment ($m^2\ ha^{-1}$) - Dry density of sediment ($kg\ m^{-3}$)

Boerema et al., 2016

- Purification of organic matter deals with N burial, denitrification, and P burial in tidal flat
- Important value of N burial and denitrification

2. Materials and Methods♪

▶ *Study area: West coast of Korea*



1. Coastal Environments

Estuary

Mud flat ✚ **Sand flat**

2. Sea water flow

open	JD and DB
Estuarine	GH and ND
Inside	GR, GS, GJ and SC

3. Habitat characteristics

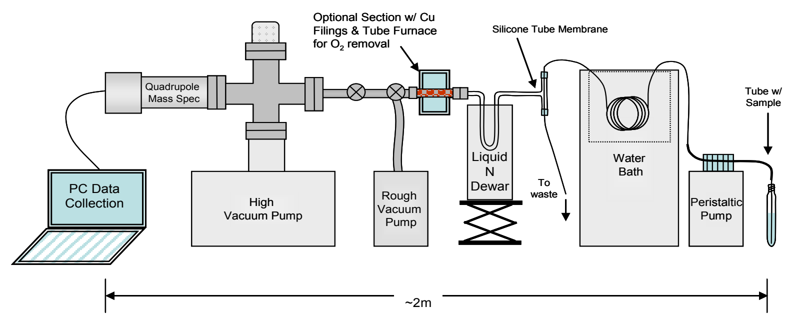
Bare flat | **Vegetated flat**

- 8 regions of Korean tidal flats for purification value and primary productivity
- Performed with various habitat characteristics to enhance resolution for tidal flat value

▶ Measurement of N burial and denitrification

Surface sediment sampling

Core sediment sampling



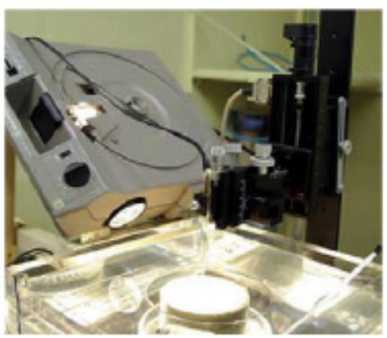
EA-IRMS, MIMS analysis

- Analysis of N burial and denitrification from surface and core sediment
- Denitrification was assessed using MIMS (Membrane Inlet Mass Spectrometer)

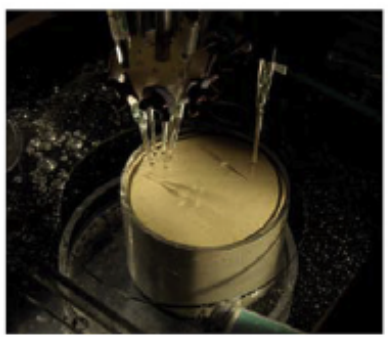
► Primary production of microphytobenthos (MPB) : Oxygen Electrode

MPB samples at Daebu mudflat

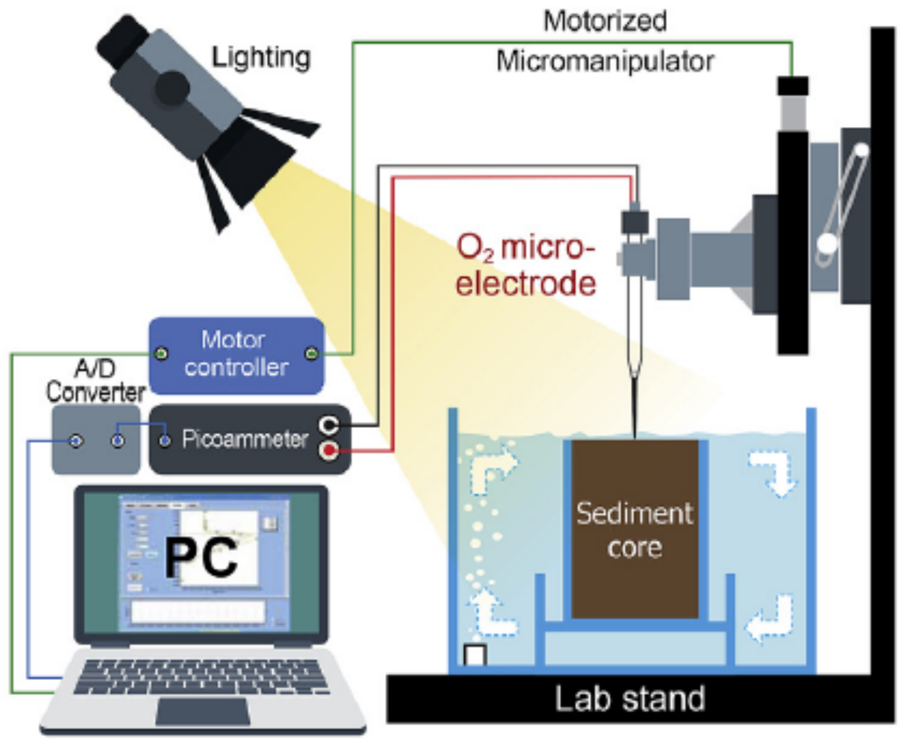
Sediment sample in Plexiglas tube



Laboratory measurements



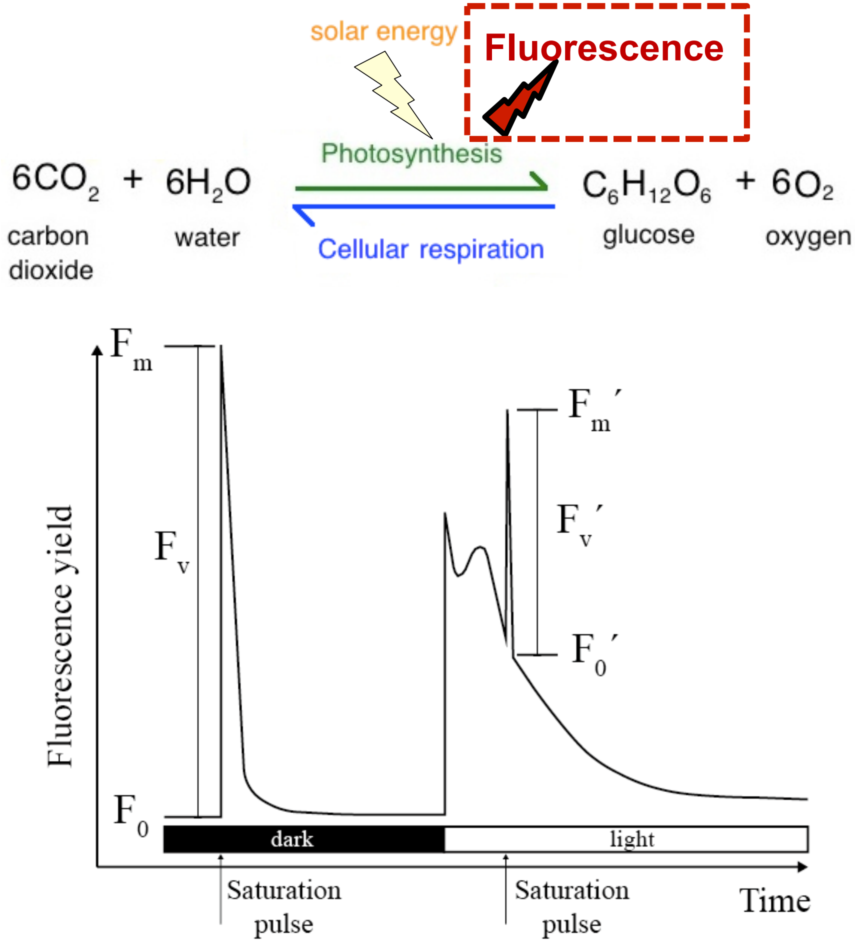
Oxygen microprofiling method



• Use of oxygen electrode for measuring MPB productivity of photosynthetic oxygen

2. Materials and Methods♪

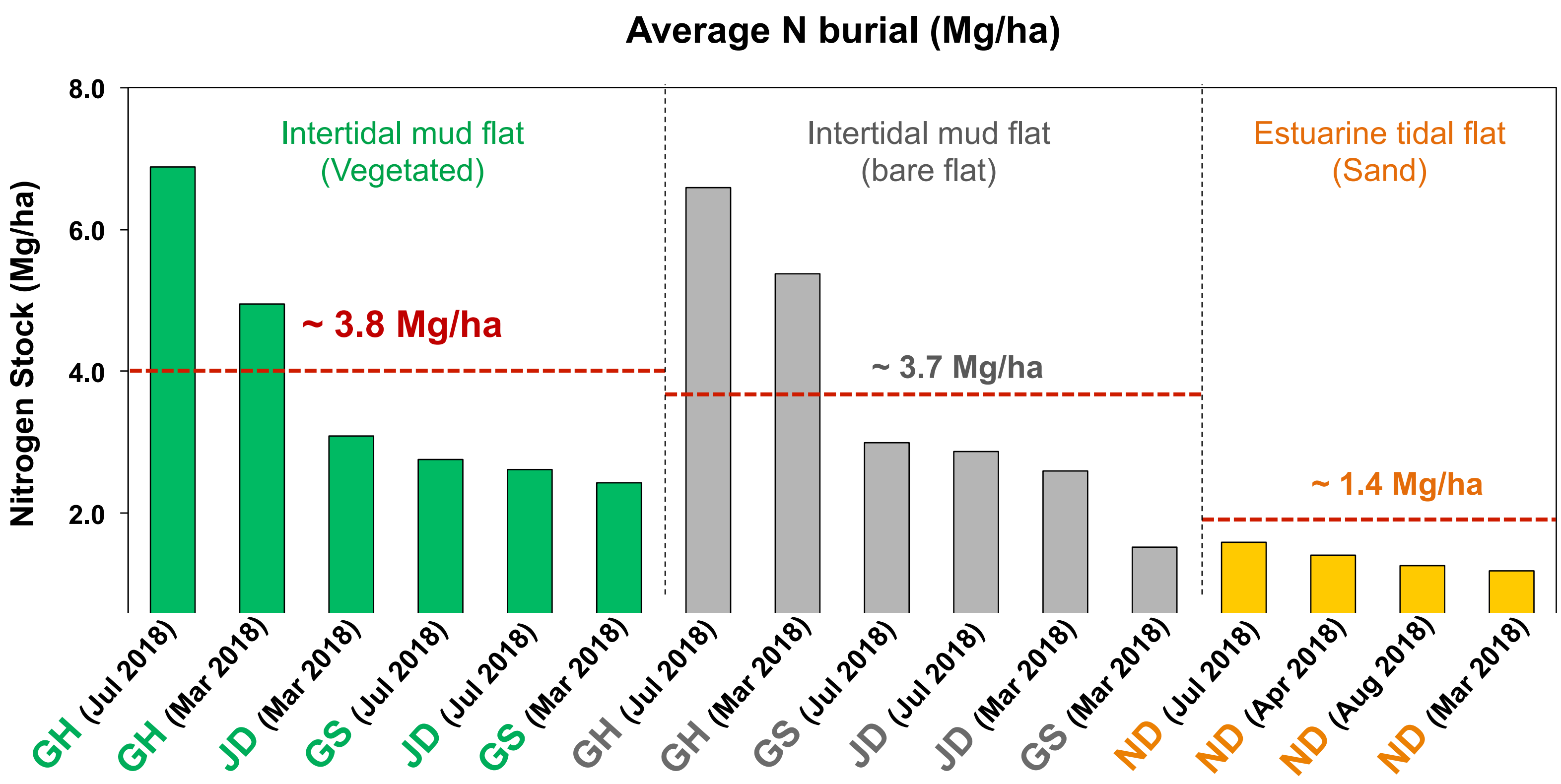
► *Primary production of microphytobenthos: Diving PAM II*



- Methods of measuring MPB biomass by fluorometer during photosynthetic activity in MPB

3. Results and discussion♪

▶ Purification efficiency in the west coast of Korea

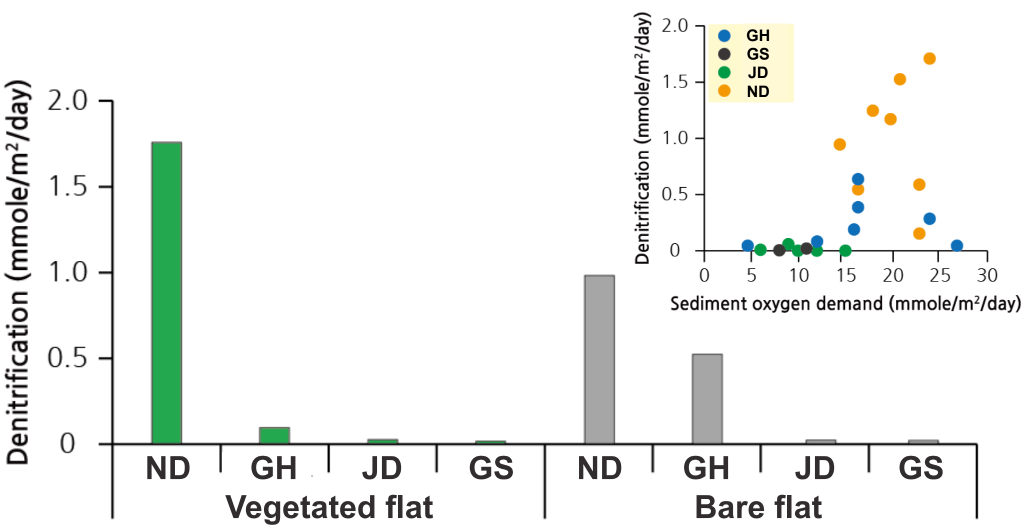


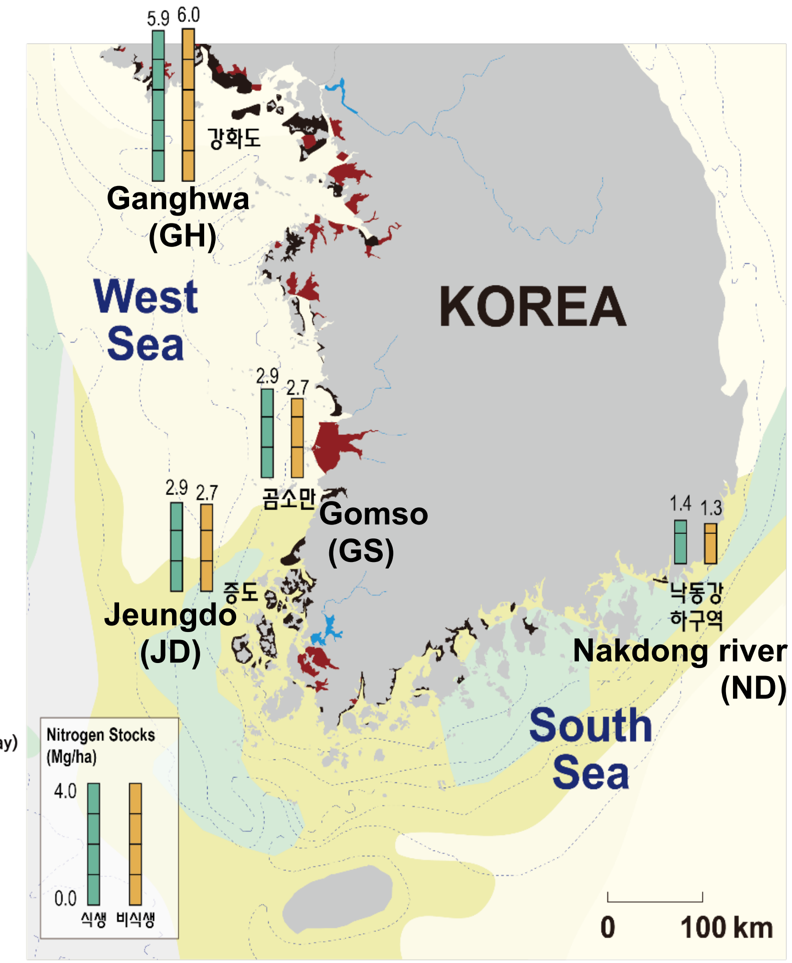
- Difference of N buried amount according with regions and habitats
- the vegetation area showed higher nitrogen stock and/or denitrification rate than bared area
- muddy tidal flats were showed higher purification efficiency than sandy tidal flats

3. Results and discussion♪

▶ N burial, denitrification

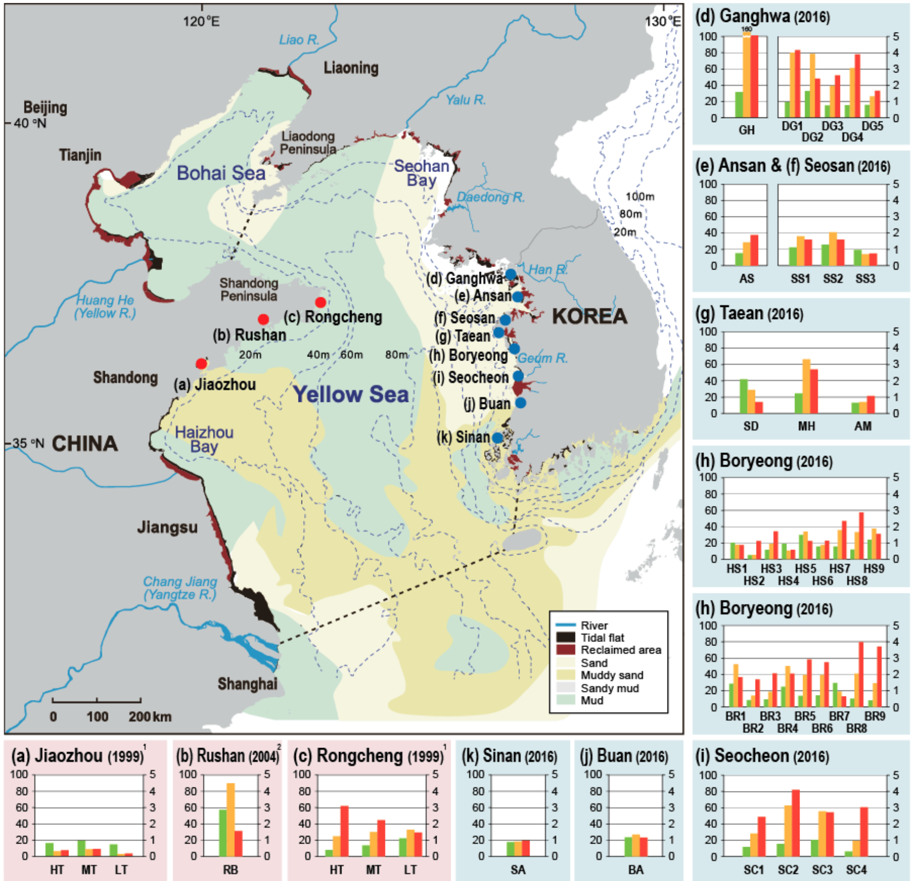
Nitrogen Stocks (Mg N ha^{-1})			
Region	Vegetated flat	Bare flat	Mean
GH	5.9 (±1.4)	6.0 (±0.8)	**5.9 (±0.9)**
GS	2.6 (±0.2)	2.3 (±1.0)	**2.4 (±0.7)**
JD	2.9 (±0.2)	2.7 (±0.3)	**2.8 (±0.2)**
ND	1.4 (±0.3)	1.3 (±0.1)	**1.4 (±0.2)**



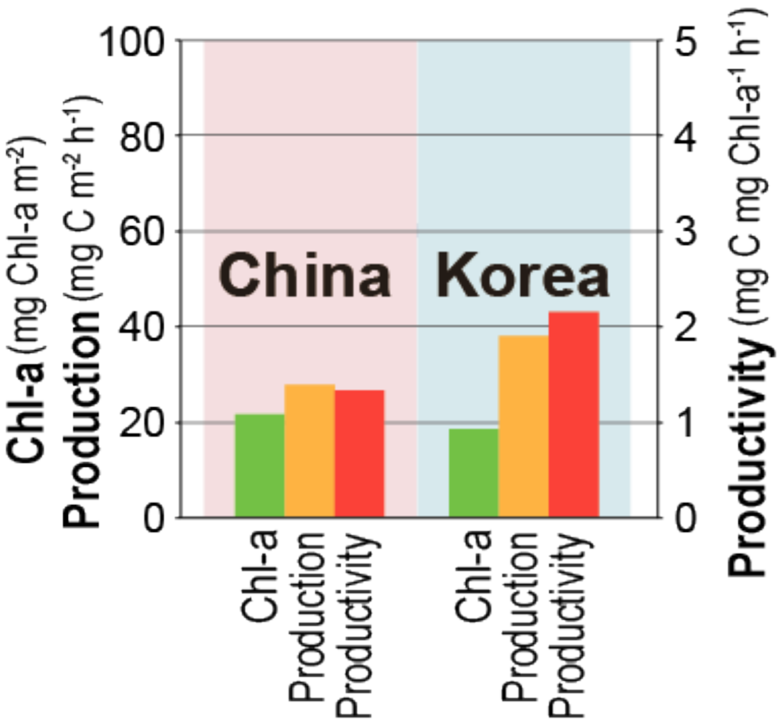


- Great denitrification observed in ND sand flat which is supplied by organic matter and oxygen
- Difference of amounts of N buried among the regions relatively than habitats

► MPB biomass and productivity: Spatial variation



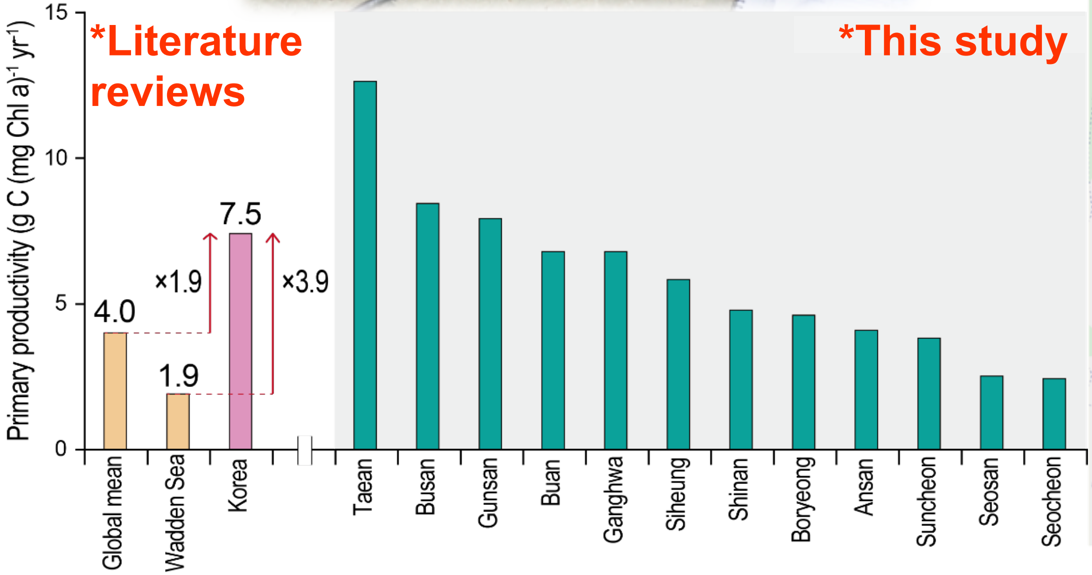
References: [1]Ning et al. 2003; [2]Yin et al. 2006

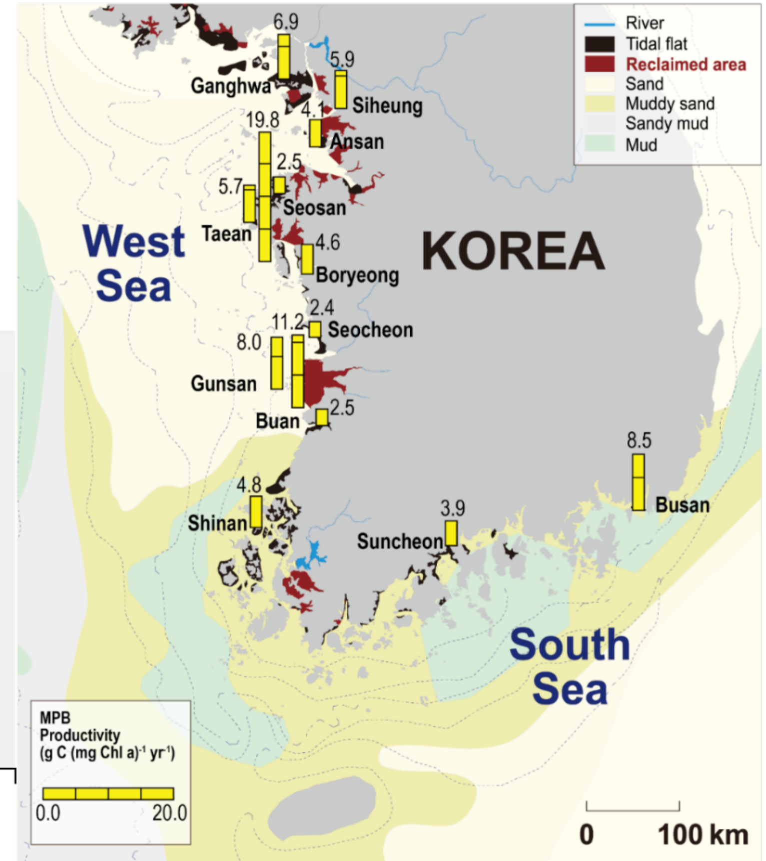


- Spatial variation of MPB productivity is influenced by diverse environmental factors
- Higher productivity of *Chl-a* production in Korea 2.2 mg C (mg Chl-a)$^{-1}$ h^{-1} than China

3. Results and discussion♪

▶ Primary productivity in Korea – Diving PAM II

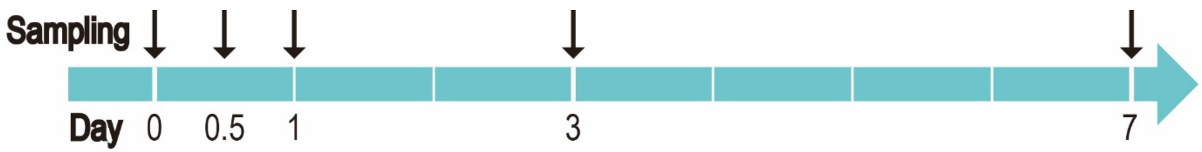


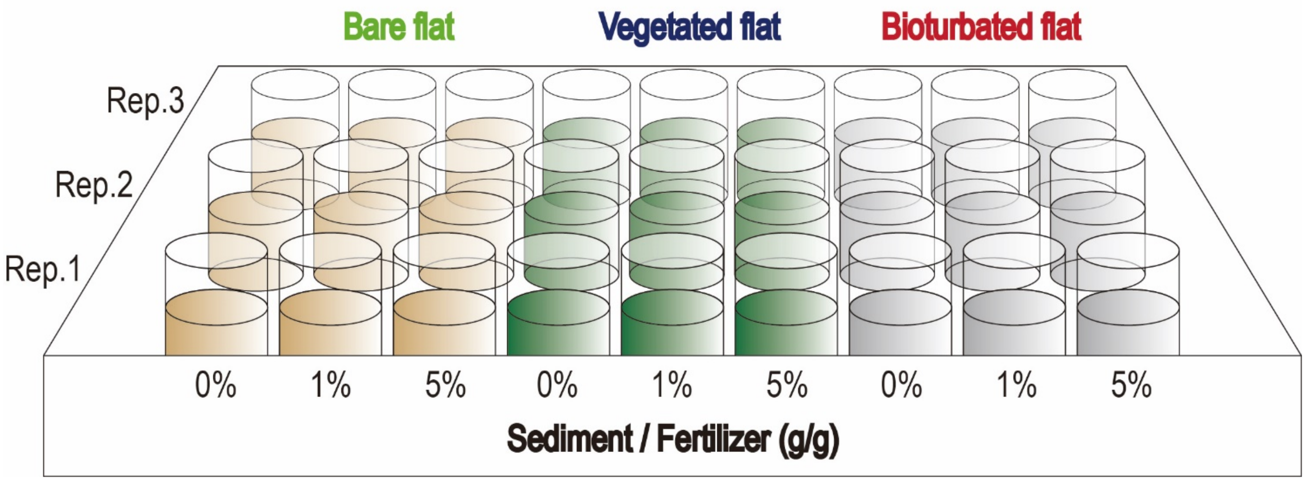


- The primary productivity of tidal flats in Korea; 2.4-19.8 g C (mg Chl a)$^{-1}$ yr^{-1}
- 1,9 times higher than the global average primary productivity values, which is 3.9 times higher than the Wadden Sea region

3. Results and discussion

► Purification efficiency of tidal flat: a mesocosm study



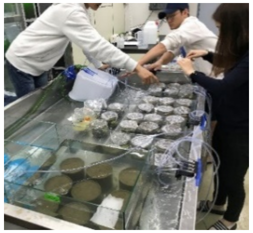
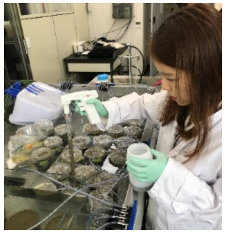


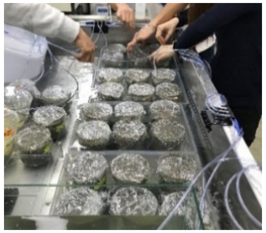
Experimental condition

Temp.	20 °C
Substrate	non fertilizer (1, 5%)
Sediment	bioturbated flat bared flat vegeted flat

End point

COD	water
TOC/TN	sediment
Bacteria	sediment
LOI	sediment

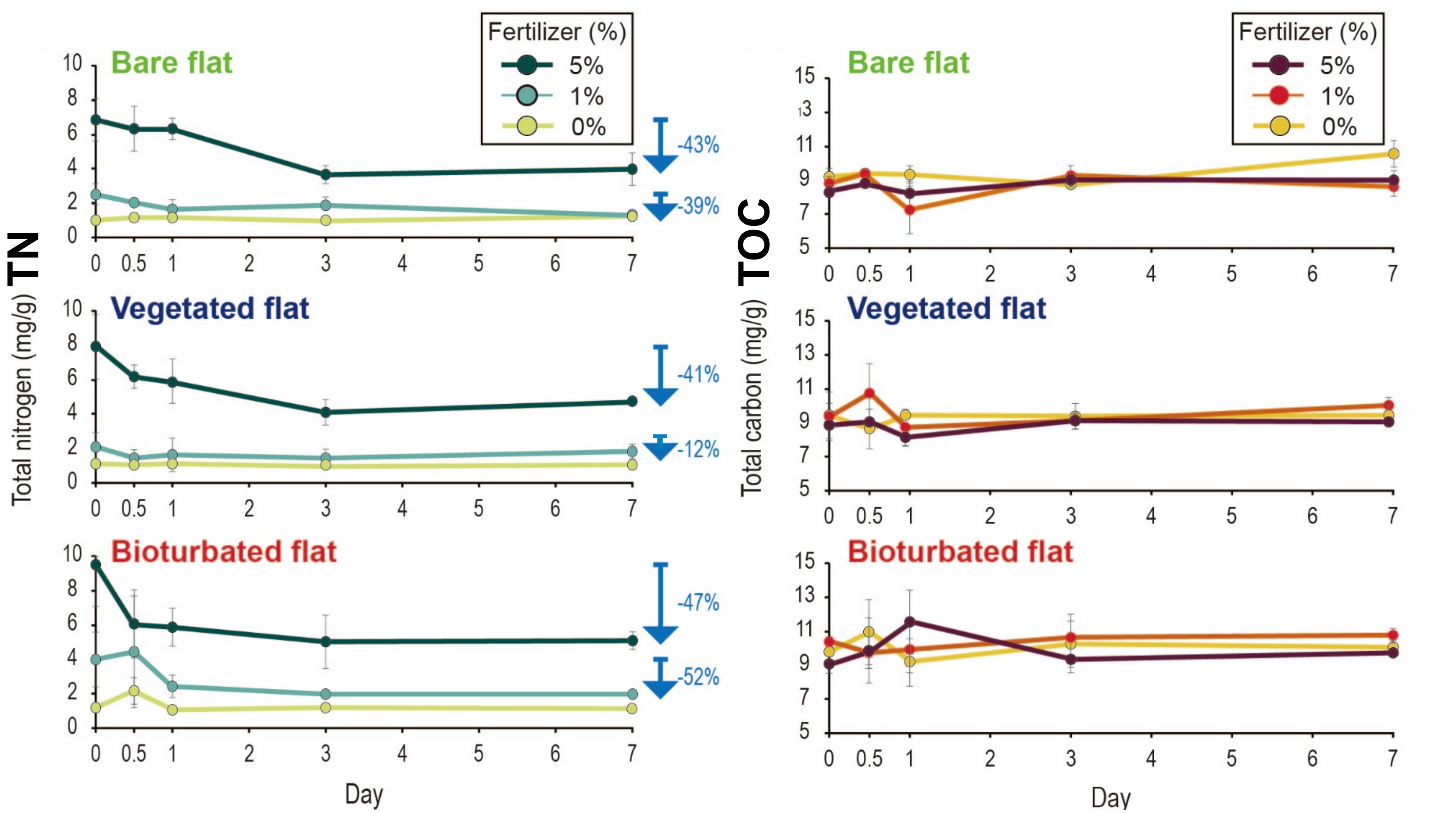






- Purification of organic matter capacity in tidal flat: LOI, TOC, TN, COD assessment
- Analysis along with sediment type, tide, fertilizer conc., and microbial community

3. Results and discussion♪

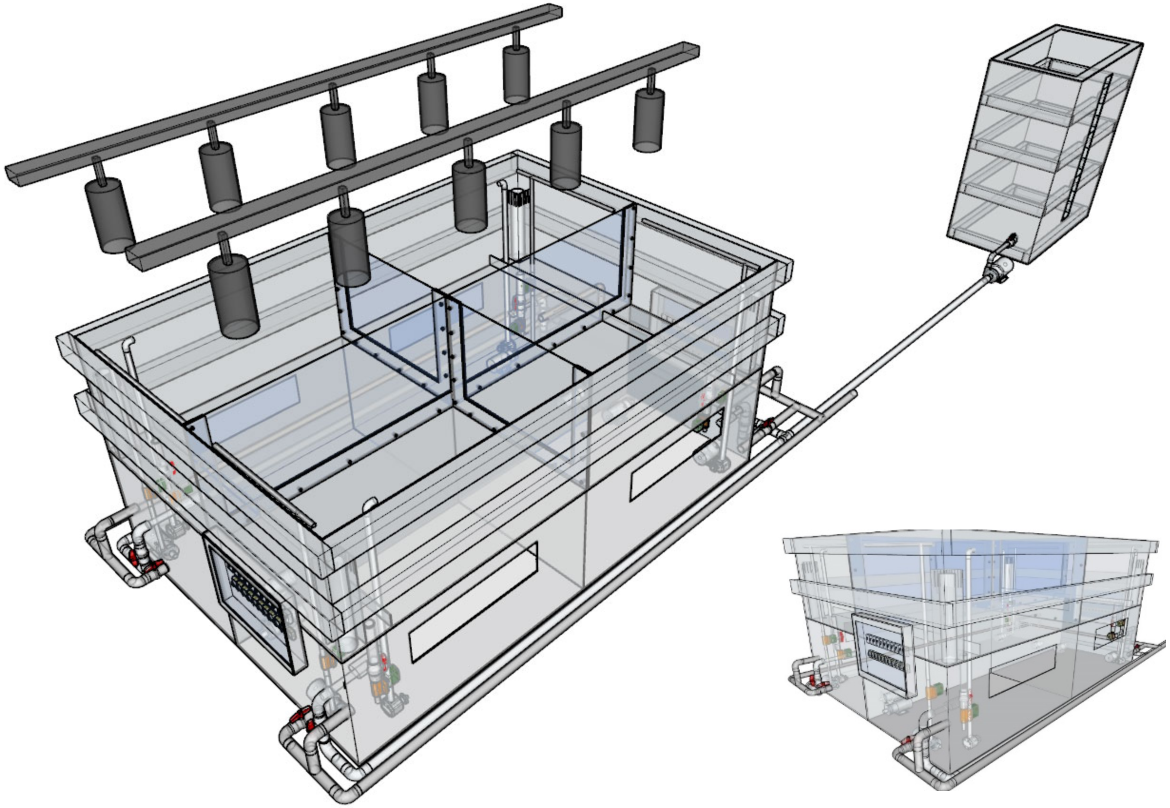
► Mesocosm study: natural purification

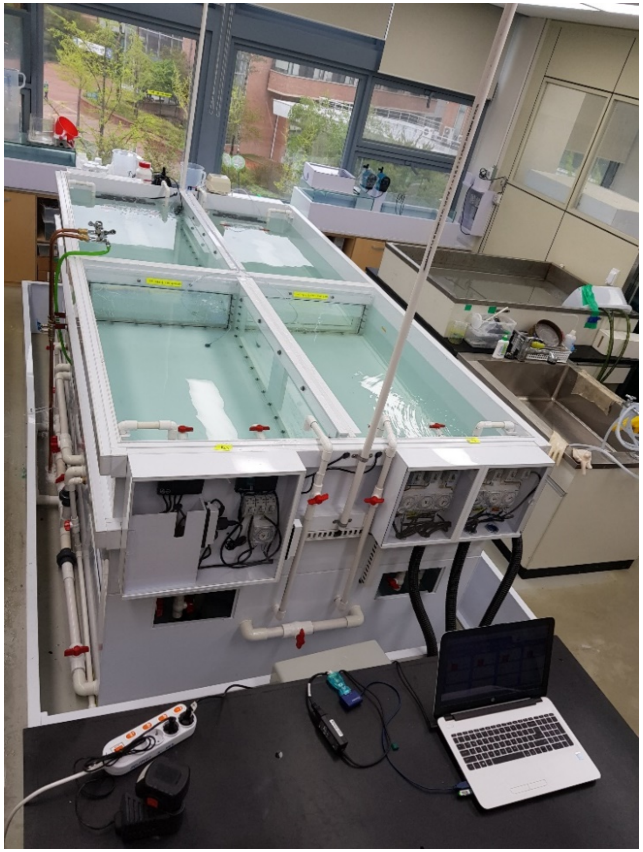


- Total N removal up to 52% (bioturbated flat + 1% fertilizer)
- N was rapidly purified within 3 days (**bioturbated** > **bare** > **vegetated**)

4. Further study♪

► *Mesocosm study mimicking marine environment*





- Results of mesocosm: Comparison in denitrification along with seasons and habitats
- Purification capacity of tidal flat in extremely changed environment
- Containing of 4 Individual tubs under control of tub size, tide and wave

5. Summary♪

- ✓ Higher **N stock and/or denitrification** rate than bared areain the **vegetated area** than bared area, and as well **mud flat** > sand flat
- ✓ Tidal flat demonstrated purification capacity to **remove TN up to 52%** within 7 days in the mesocosm study
- ✓ Primary productivity in Korean tidal flat is **2.4-19.8 g C (mg Chl a)$^{-1}$ yr^{-1}**
- ✓ **The primary productivity of tidal flats** has been found to be 1,9 times higher than the global average primary productivity values, which is 3.9 times higher than the Wadden Sea region

Thank You for your attention

谢谢

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Acknowledgement

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Indoor mesocosm (sand only)
Indoor mesocosm (oil-coated gravel on sand)
Indoor mesocosm: self-purification
BENTHOS
Biology, Environment & Human
for Our Sea
State of the Art
Mesocosm
Outdoor mesocosm: sedi. sampling
Outdoor mesocosm: oiled sediment + purification techniques
HYUNDAI
Outdoor mesocosm: nutrient dosing

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