Kelp forest/seaweed bed as mitigation and adaptation measure: Korean Project Overview

Workshop - Coastal Blue Carbon:
Mitigation opportunities and vulnerability to change

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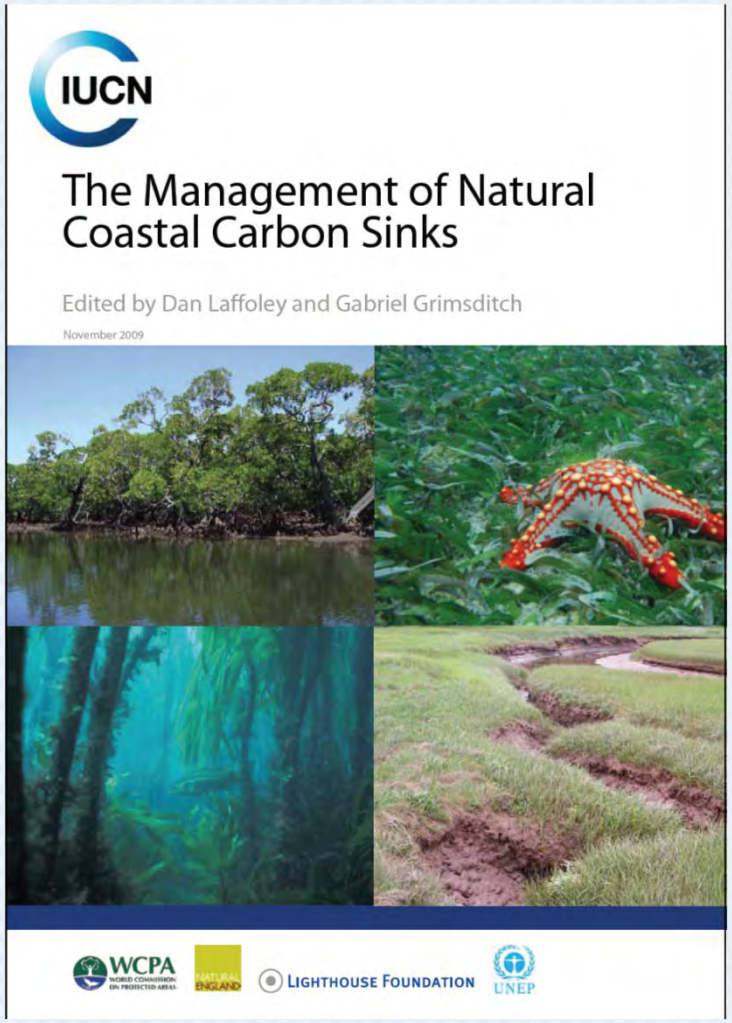
Outline

- ✓ **Introduction**
  - Blue carbon (2009) & seaweeds
- ✓ **Korean Project (2006 – 2011)**
  - AGW & Coastal CO_2 Removal Belt (CCRB, 2005)
  - Pilot seaweed A/R CDM farm (2009-11)
- ✓ **Recognition of kelp forests and seaweed beds**
  - Estimation
  - Seaweed Solution
  - Yeosu Expo: Triton Sea Forests

➢ Advertisement (Campaign slides)

...and
produce bio-fuel
during this process.

Two reports published in 2009 - The Management of Natural Coastal Carbon Sinks and Blue Carbon that brought the importance of land-ocean interface ecosystem to the attention of climate change practitioners.



Blue carbon

- Implement **win-win mitigation** strategies in marine sectors
  - Improve **energy efficiency** in marine transport, fishing and aquaculture sectors as well as marine-based tourism;
  - **Encourage sustainable, environmentally-sound ocean-based production including algae and seaweed;**
  - Ensure that investment for restoring and protecting the capacity of **blue carbon sinks** to bind carbon and provide food and income is prioritized in a manner that also promotes economic development opportunities;
  - Catalyze the natural capacity of **blue carbon sinks** to generate by managing coastal ecosystems for conditions favorable for seagrass, mangrove, and salt marshes.

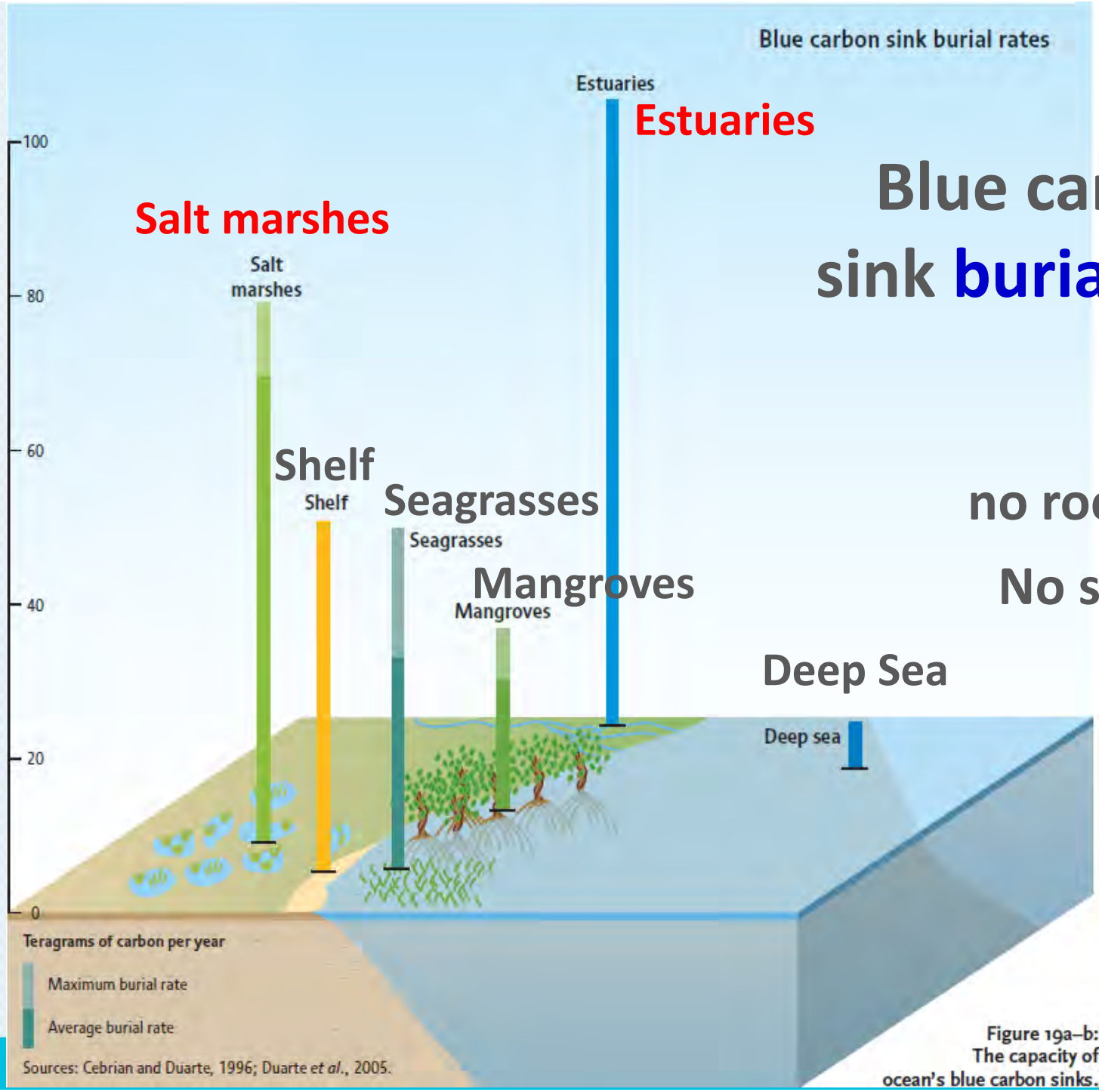
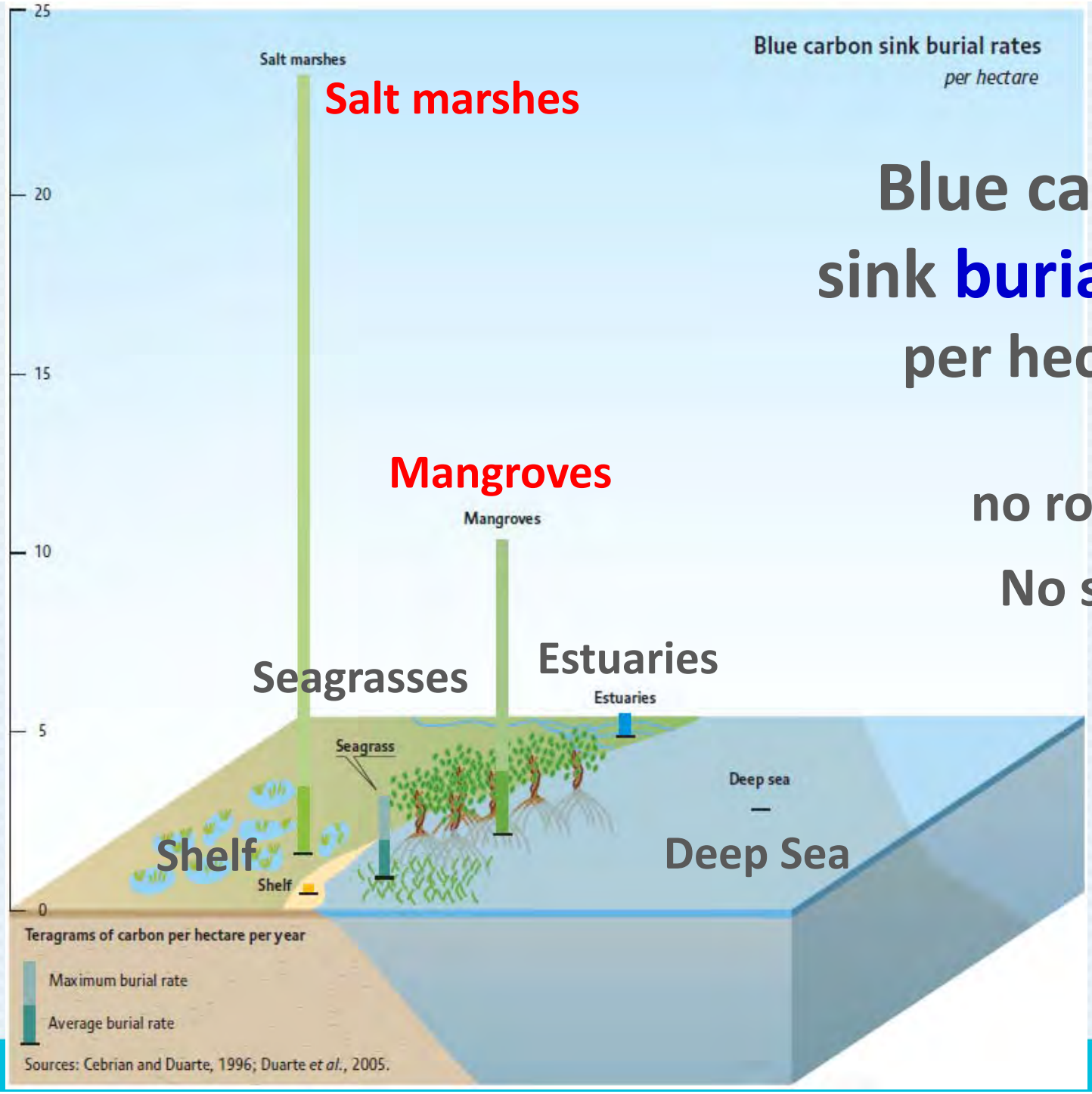


Figure 19a–b: The capacity of ocean's blue carbon sinks.

Blue carbon sink **burial** rates

no rocky shores

No seaweeds



Blue carbon sink **burial** rates per hectare

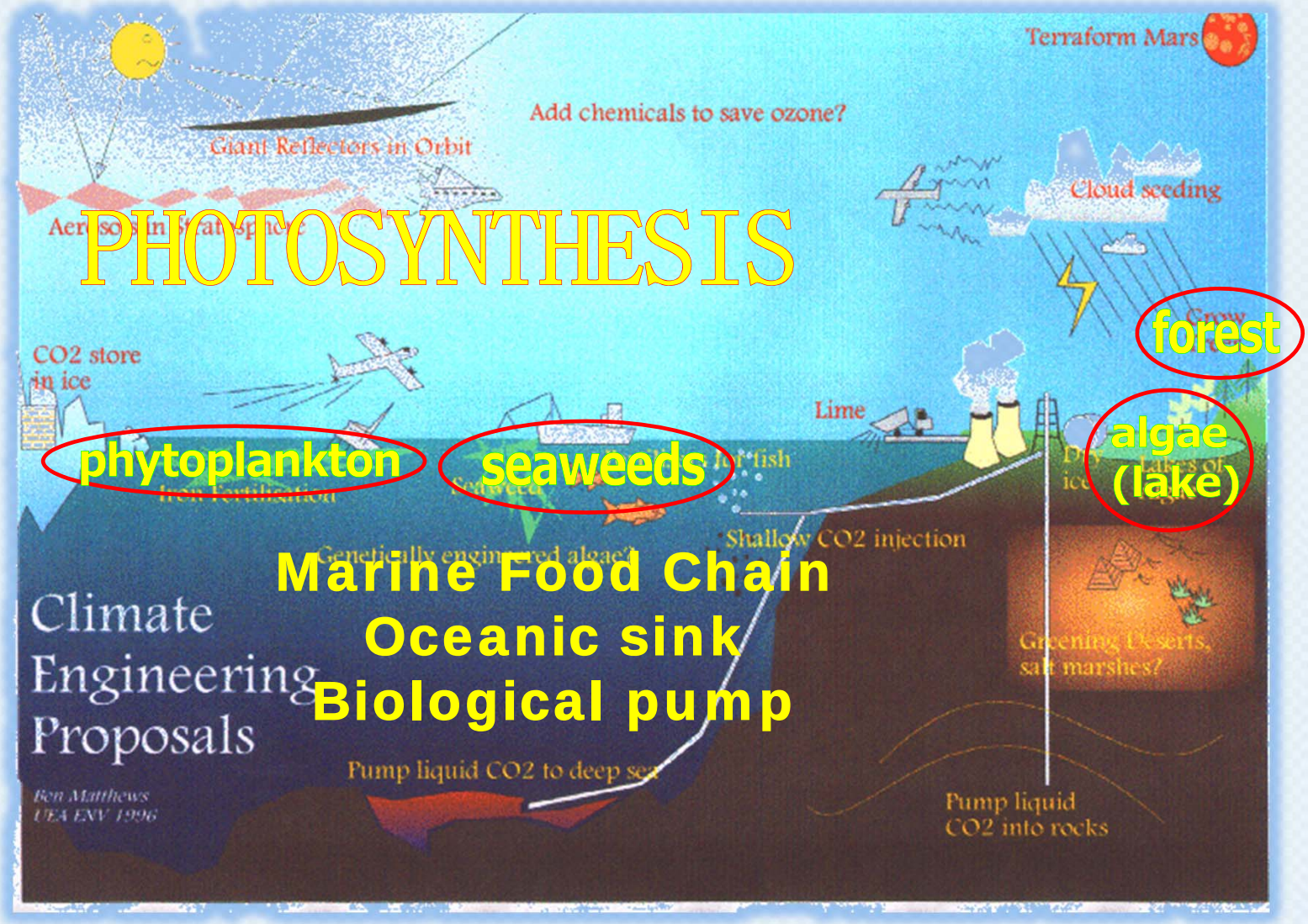
no rocky shores

No seaweeds

No soil – pros & cons

Ecosystem type	Standing carbon stock ($gC\ m^{-2}$)		Total global area ($*10^{12} m^2$)	Global carbon stocks (PgC)		Longterm rate of carbon accumulation in sediment ($gC\ m^{-2}\ yr^{-1}$)
	Plants	Soil		Plant	Soil	
Tidal Salt marshes			Unknown (0.22 reported)			210
Mangroves	7990		0.157	1.2		139
Seagrass meadows	184	7000	0.3	0.06	2.1	83
Kelp Forests	120-720	na	0.02 – 0.4	0.0009-0.02	na	na

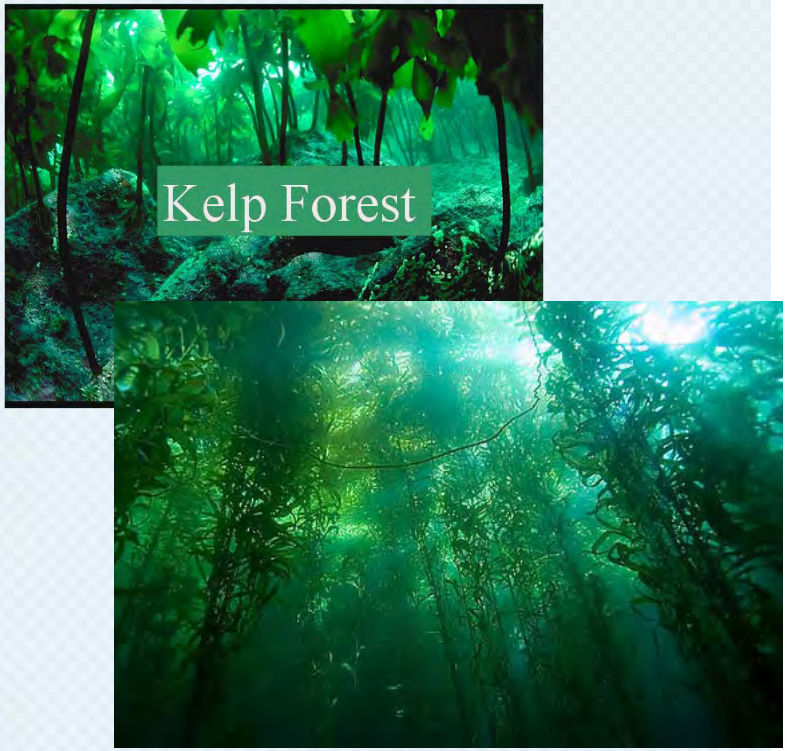
Climate Bio-Engineering

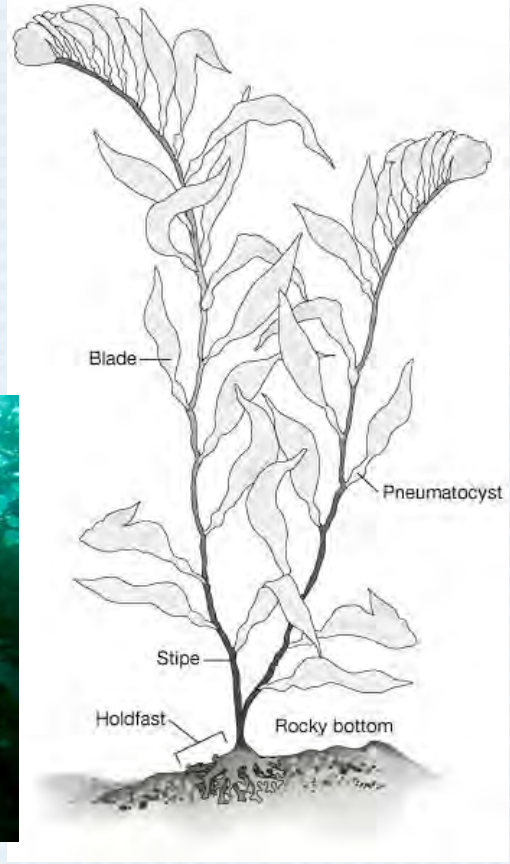


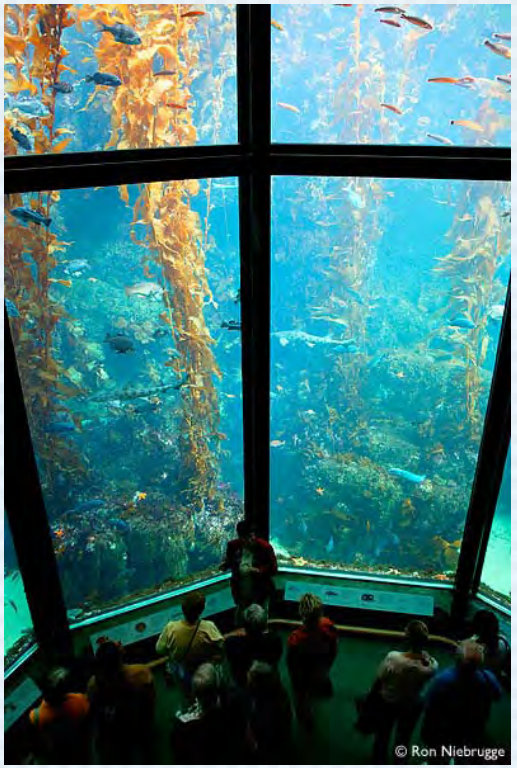
http://www.chooseclimate.org/cleng/part2.html

Kelp Forest

- Kelp forests are found on rocky bottoms and provide habitat for many organisms
- Gant brown bladder kelp *Macrocystis* has a strong holdfast and gas-filled floats
- *Macrocystis* can grow up to **0.6 meter** (2 feet) per day







Mitigation - Sink

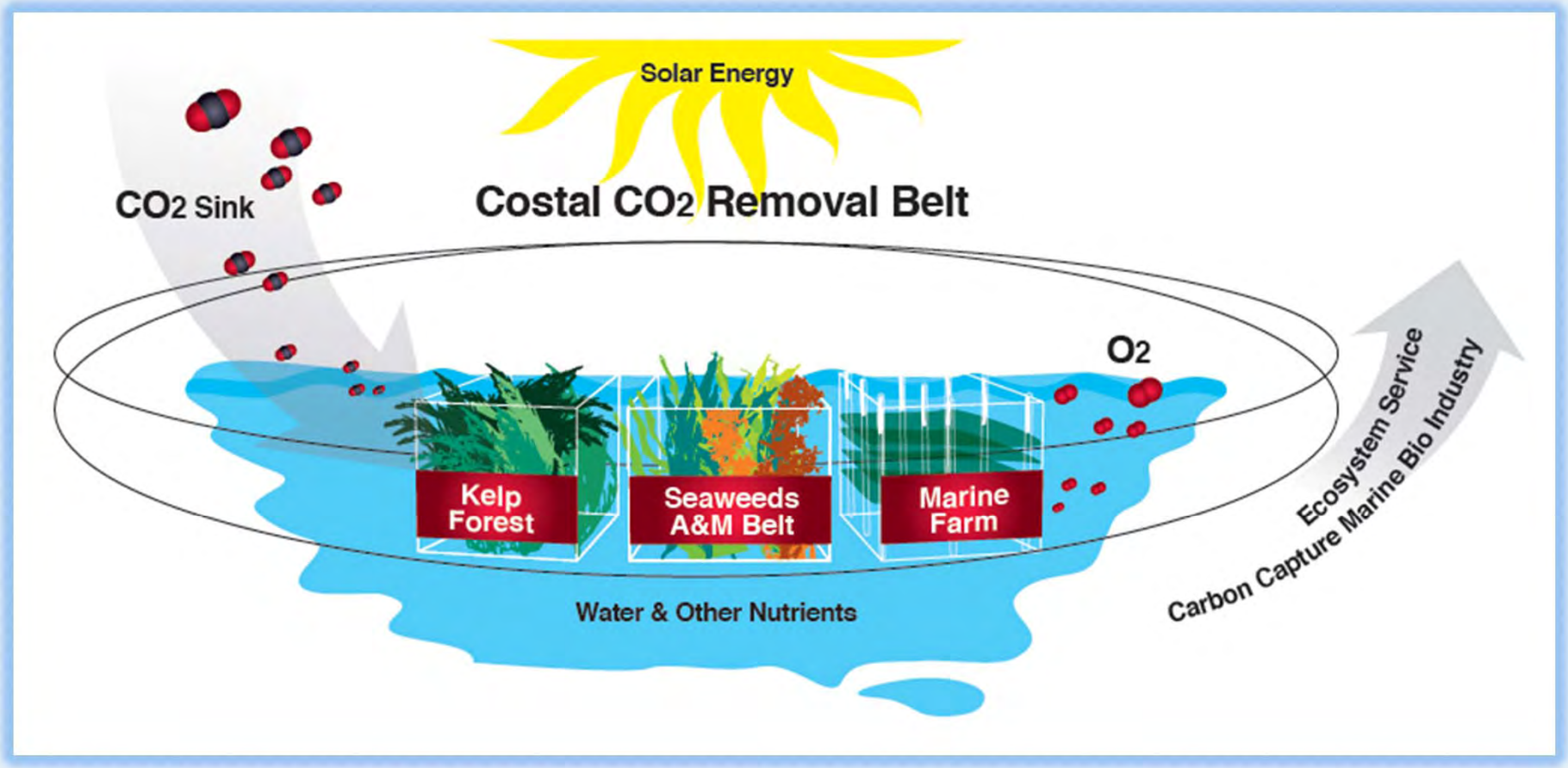
Marine Algae for Carbon Sequestration

- No toxic species
- Long-life span
- High growth rates
- High photosynthetic rates
- High carbon content
- C:N:P: ratio = 550:30:1 *(Atkinson & Smith, 1983)*

LULUCF

CUCUCAV

Coastal CO_2 – removal belt (CCRB)



Schematic diagram “Seaweed A & M belt” in CCRB (Chung, 2005)

A stands for *Adaptation* and *M* for *Mitigation*

Coastal CO_2 removal belt (CCRB)

Conceptual definition

- ✓ the coastal region
- ✓ natural and/or man-made plant community which conducts removing CO_2 like in forest
- ✓ various levels of the spatio-temporal scales

Operational definition

- ✓ additionally constructed man-made marine plant community which is managed by CDM (M&A) project
- ✓ definite scale of area or volume designated in the PDD with approval of UNFCCC EB
- ✓ various levels of the spatio-temporal scales


Greenhouse Gas Emissions Reduction
Using Seaweeds
Pilot Implementation of
the Coastal CO_2 Removal Belt
(CCRB) in Korea
해조류를 이용한
온실가스 저감연구 사업
Greenhouse Gas Emissions
Reduction using Seaweeds
[참여연구기관]
국토해양부, 해양수산기술진흥원,
부산대학교, 인천대학교, 성균관대학교,
수산과학원, 부경대학교, 동서대학교,
Ecoeye, RIST, RCC, Pegasus Int.

Project outline

Project overview (Algae and Global Warming: AGW)

The Korean Ministry of Land, Transport & Maritime Affairs (formerly MoMAF)
Project period: 2006-2011 (5 yrs)
Total budget : 6 b Korean Won (ca 5 m US$)

Seaweed Solution & Seaweed Initiative

Innovative research on seaweed biology & ecology
Bench marking: A/R => Seaweed CCRB
LULUCF => CUCUCAV (Coast Use/Change Aquatic Vegetation)
Blue - REDD (Deforestation in Developing Countries)

Challenge!

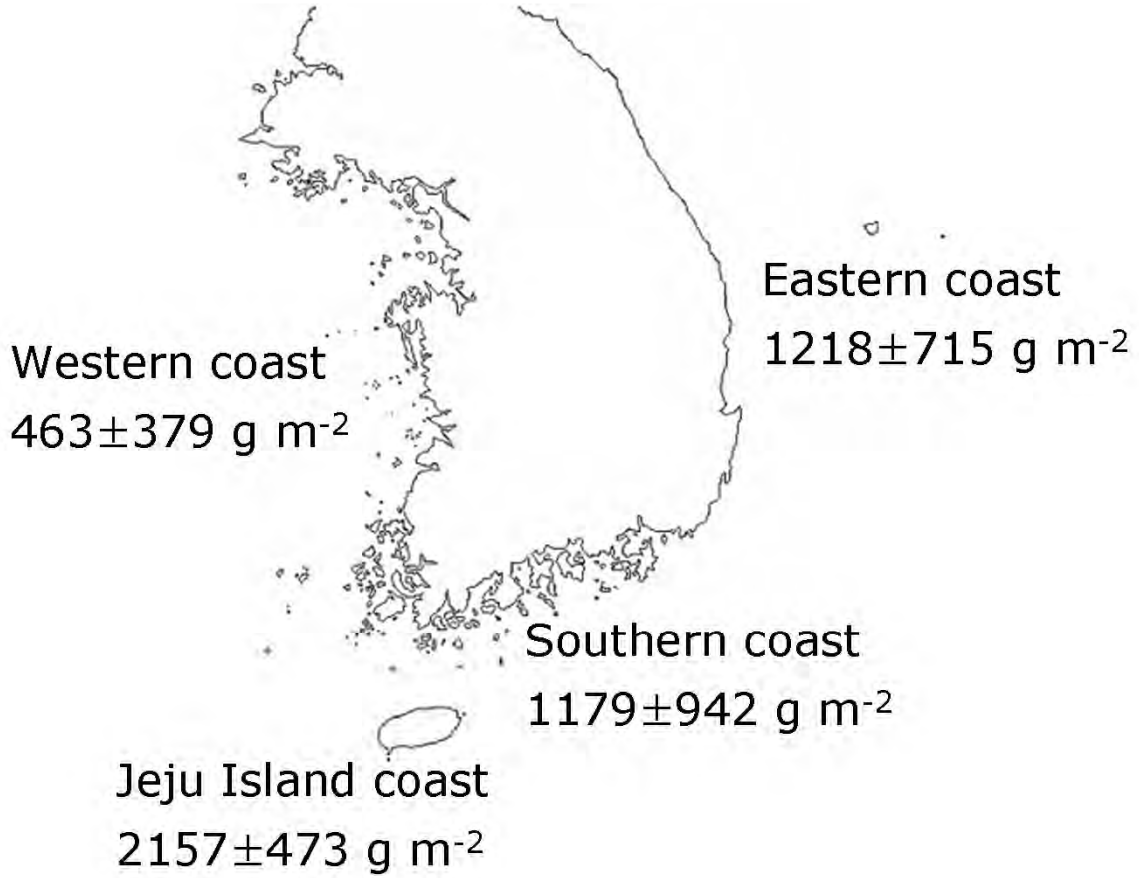
New Code and Methodology
Baseline/Monitoring of CCRB
Estimation of GHG emissions reduction using seaweed sinks

Wild seaweed biomass (rank): baseline study

Seasonal survey
Near-synaptic coverage
Non-destructive method
(biomass rank/estimation)

- **10 Core site**
- **20 Satellite site (1st yr)**
- **20 Satellite site (2nd yr)**
- **(No.) : Biomass Rank**
- **Seagrass survey**

Wild seaweed biomass



Regional average biomass densities of five dominant species


해조류를 이용한 온실가스 저감연구사업단 - Windows Internet Explorer
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한국해조생물량
개요 분포 생물량
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생물량 등급분포도
해양을 이용한 친환경 CO2흡수원
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생물량등급 분포도
종별 출현자료
조사지점별 순위
생물량 상관계수
01 OUTLINE
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해조생물량 지도,

J Appl Phycol
DOI 10.1007/s10811-010-9604-9

Using marine macroalgae for carbon sequestration: a critical appraisal

Ik Kyo Chung · John Beardall · Smita Mehta · Dinabandhu Sahoo · Slobodanka Stojkovic

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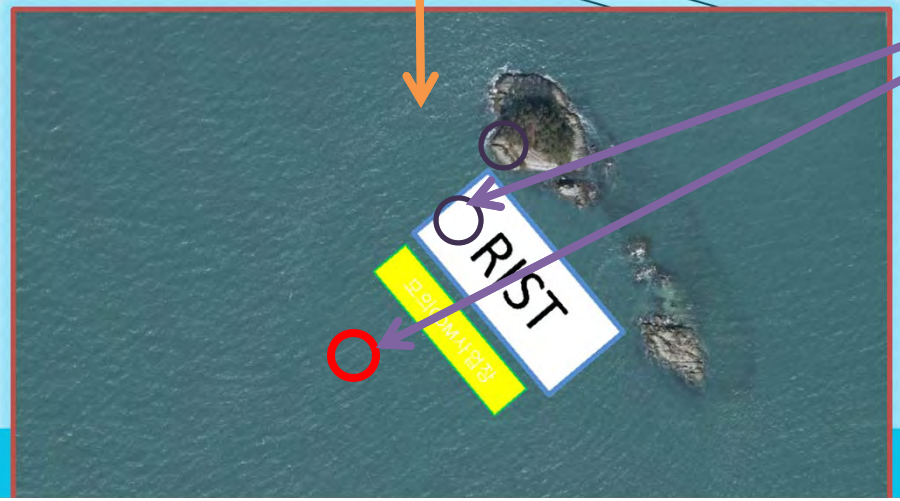
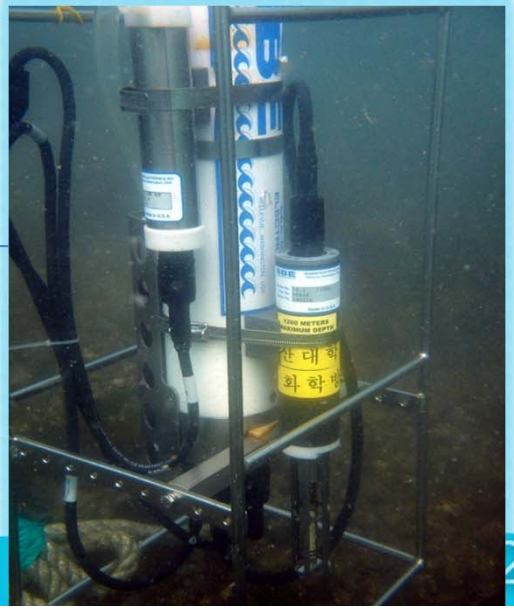
Pilot Seaweed CDM (M&A) Farm Study





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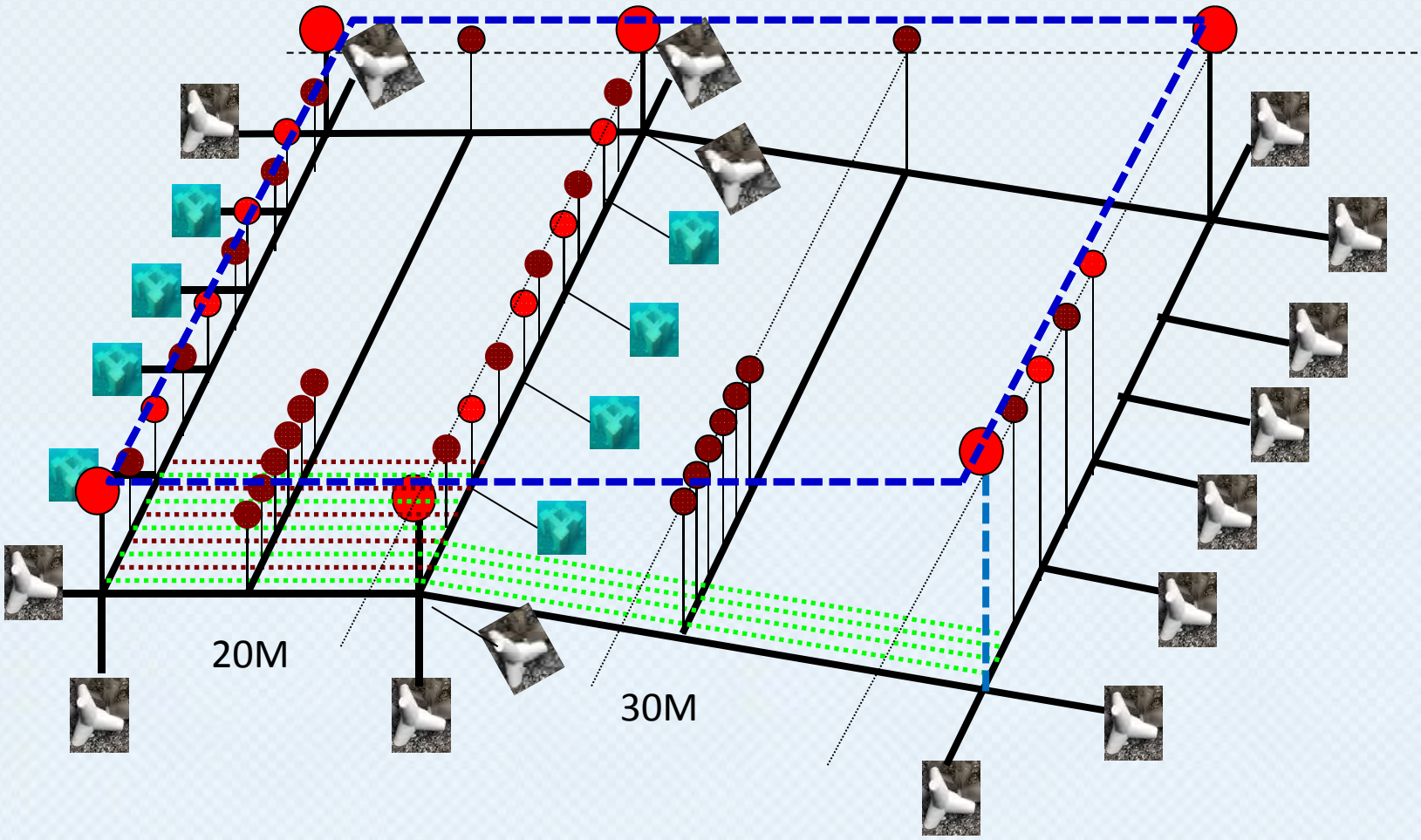
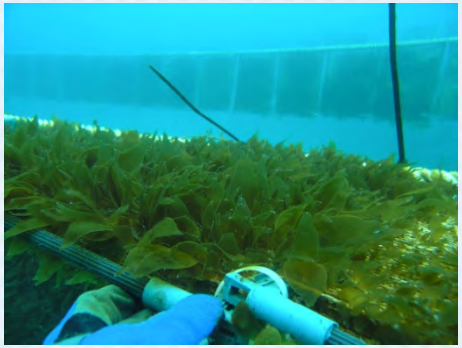
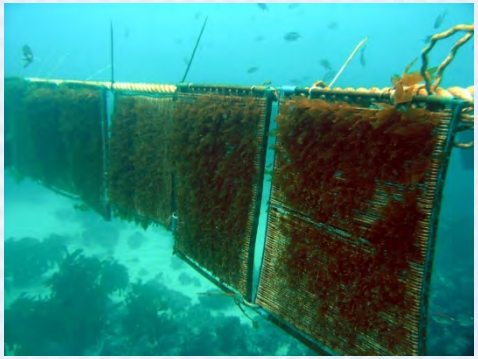
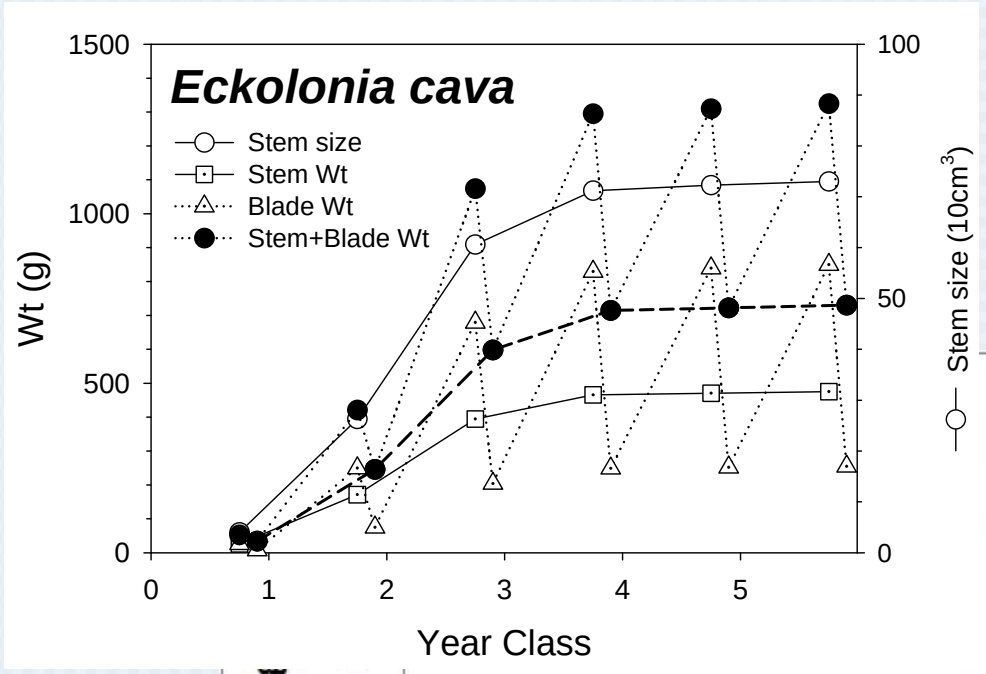


Boundary (buoys); **Density** (biomass /m rope); **Depth**

Pilot Seaweed CDM (M&A) Farm Study

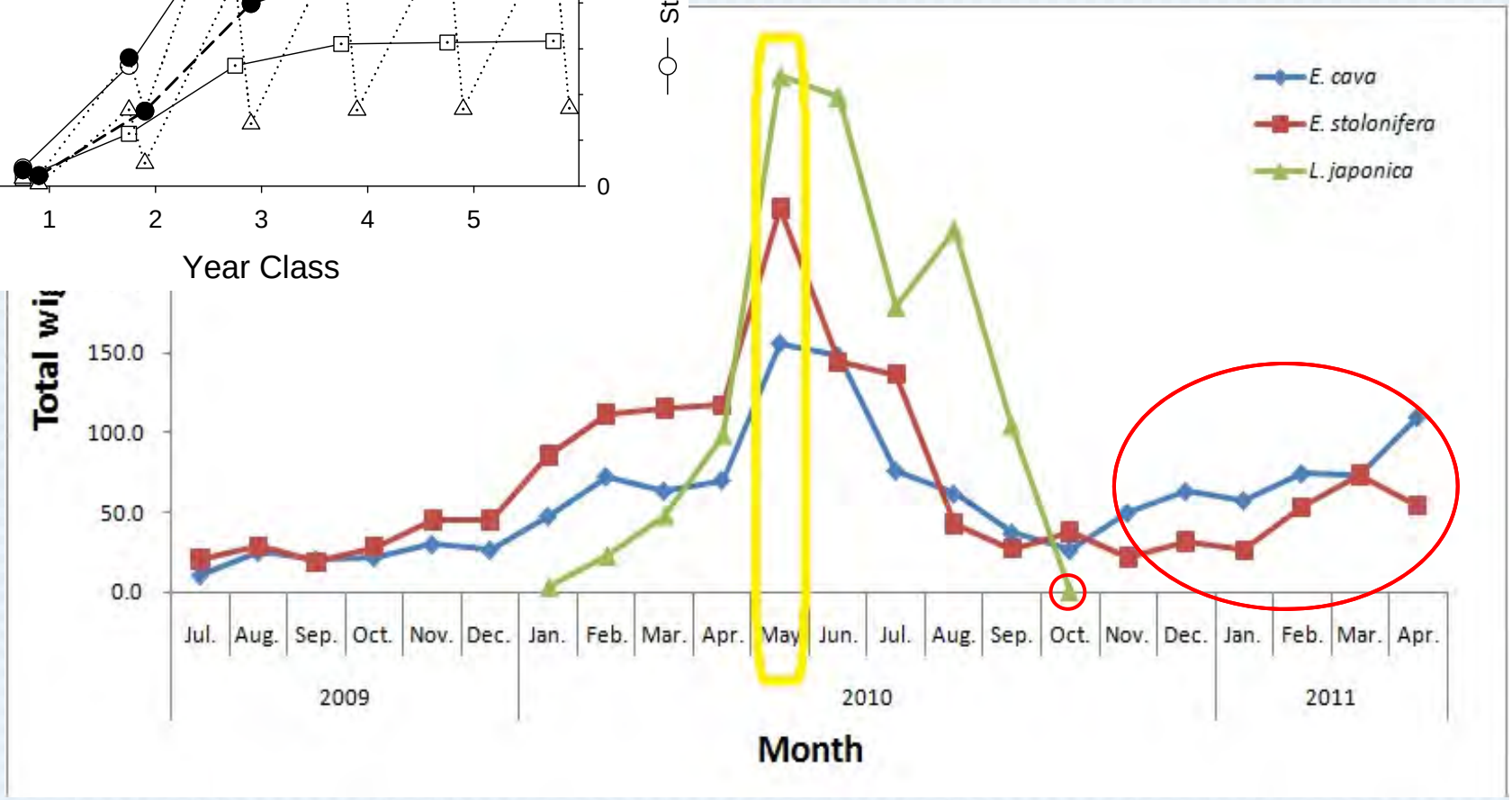






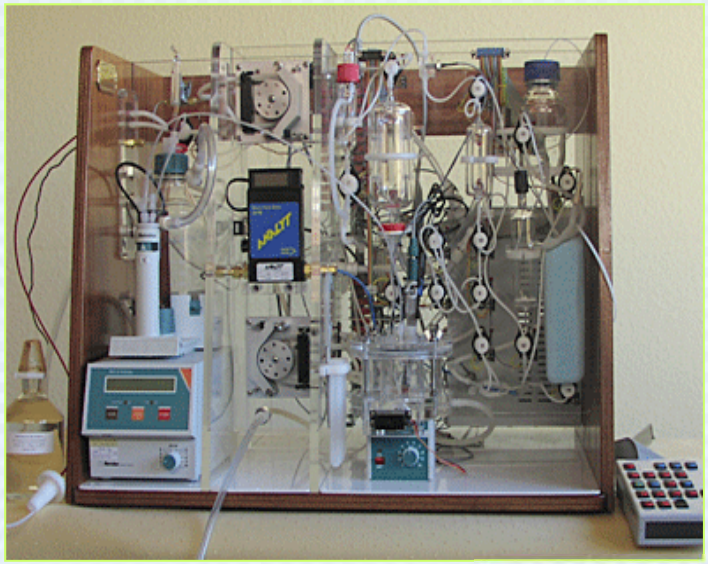
SEAWEED BIOMASS

≈ 16 ton CO_2e ha^{-1} yr^{-1}



$\Delta TIC_{seaweed} = TIC_{control} - TIC_{seaweed}$

- **Measuring Instrument: VINDTA 3C (Versatile INstrument for the Determination of Total inorganic carbon and titration Alkalinity)**
- **TIC: Coulometric method & Alkalinity; Titration method**
- **Thermodynamic model estimation CO_2 : CO_2SYS program**



Measurement of 2 parameters (TIC, TA)

Using Thermodynamic Model

$TA = [HCO_3^-] + 2[CO_3^{2-}] + [H_2BO_3^-] - [H^+]$

$TIC = [HCO_3^-] + [CO_3^{2-}] + [CO_2(g)]$

$pH = -\log[H^+]$

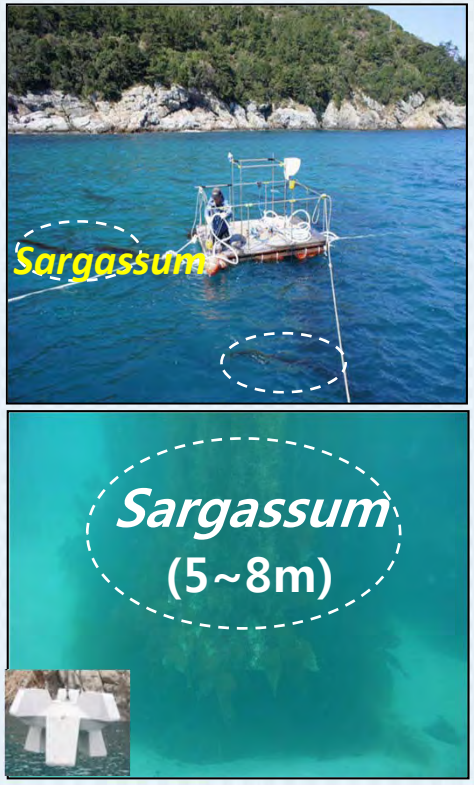
pCO_2 **calculation**

$15.7 \sim 16.6\ tCO_2 \cdot ha^{-1} \cdot yr^{-1}$

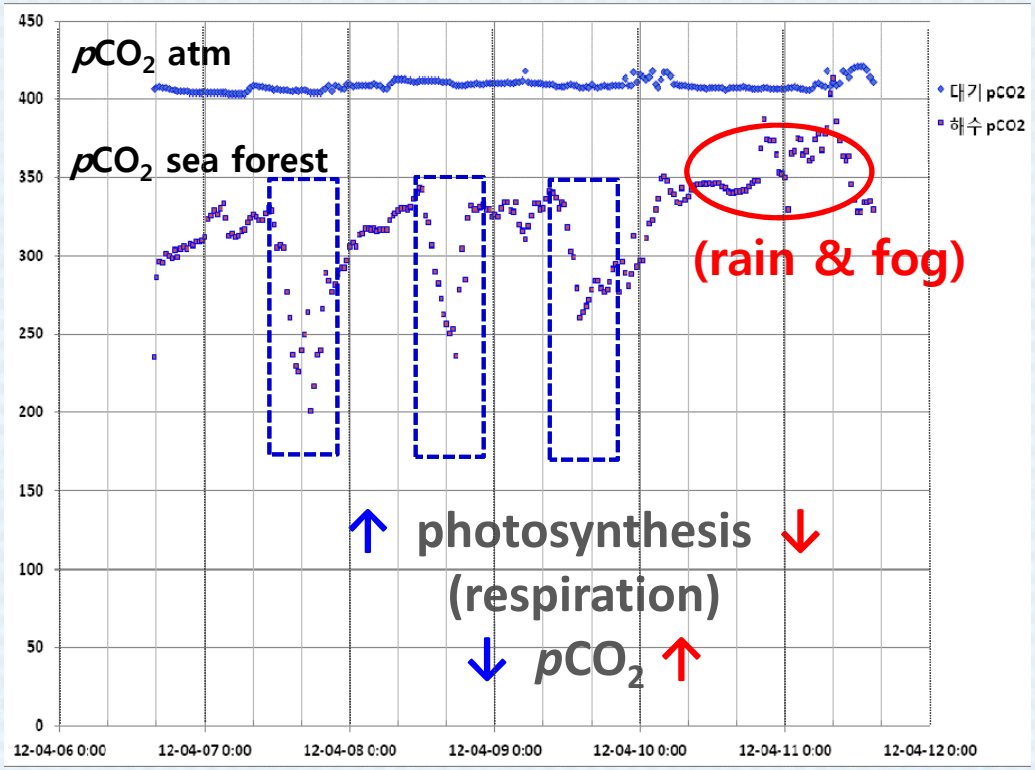
Triton Sea Forest

- **Real time pCO_2 monitoring** (CDMA transmission)
- **Seaweed ecology (April 6, 2012)**
  - density: without *Sargassum* avg. 4 kg·m^{-2} ~ (+ *Sargassum*) max. 30 kg·m^{-2}
  - coverage: over 90% (*Ecklonia*, *Sargassum*, *Colpomenia*, *Codium*, etc.)
  - many recruits of young fronds

Triton Seaweed Reef



pCO_2 Monitoring



Triton Sea Forest

- **Chemical property**
  - ✓ More Fe and CaO
    - ✓ Fe trace element
    - ✓ Ca, Fe chelating agents

(단위: wt%)

구 분	SiO_2	CaO	Al_2O_3	T-Fe	MgO	S
slag	33.1	40.0	13.7	0.4	8.6	0.3
Triton	11.2	41.5	1.4	20.0	6.5	0.1

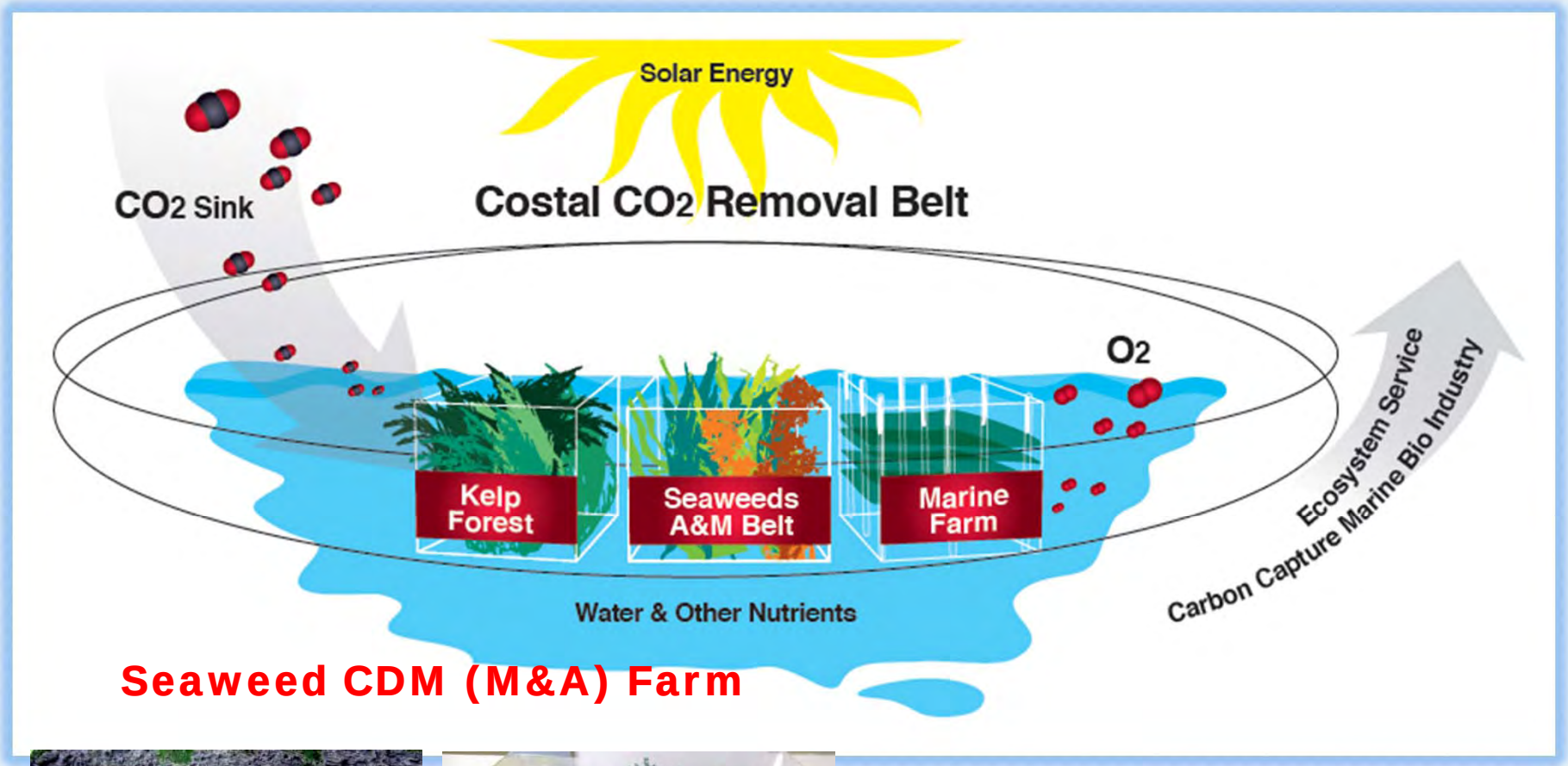
- **No adverse effects on biota**
  - ✓Harmful substances/leakage assessment, bioassay (bacteria, plankton, benthos, fish)
  - ✓Seaweed spore germination, settlement, growth, food safety assessment

Type A

Type T

Hybrid Type

Coastal CO_2 – removal belt (CCRB)



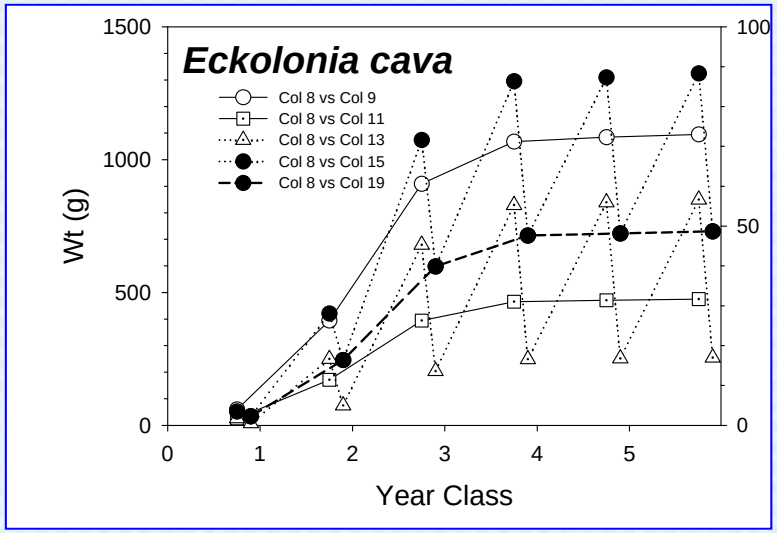
Seaweed CDM (M&A) Farm

Boundary? – buoy
No soil
Expandability (offshore)

Coastal CO_2 – removal belt (CCRB) : summary

biomass

16 $tCO_2e \cdot ha^{-1} \cdot yr^{-1}$



DIC (pCO_2)

15.7~16.6 $tCO_2 \cdot ha^{-1} \cdot yr^{-1}$

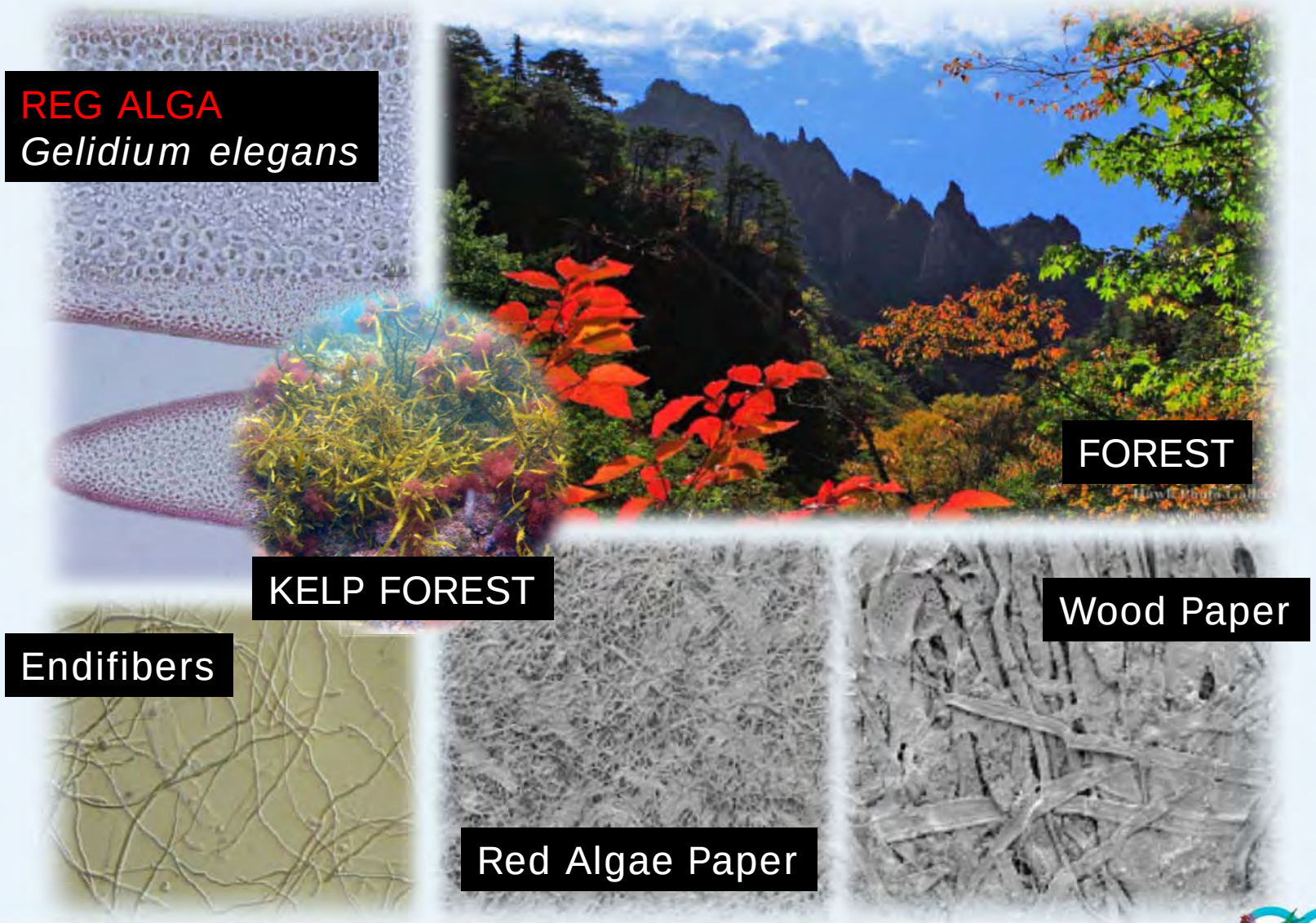
$$\Delta TIC_{seaweed} = TIC_{control} - TIC_{seaweed}$$

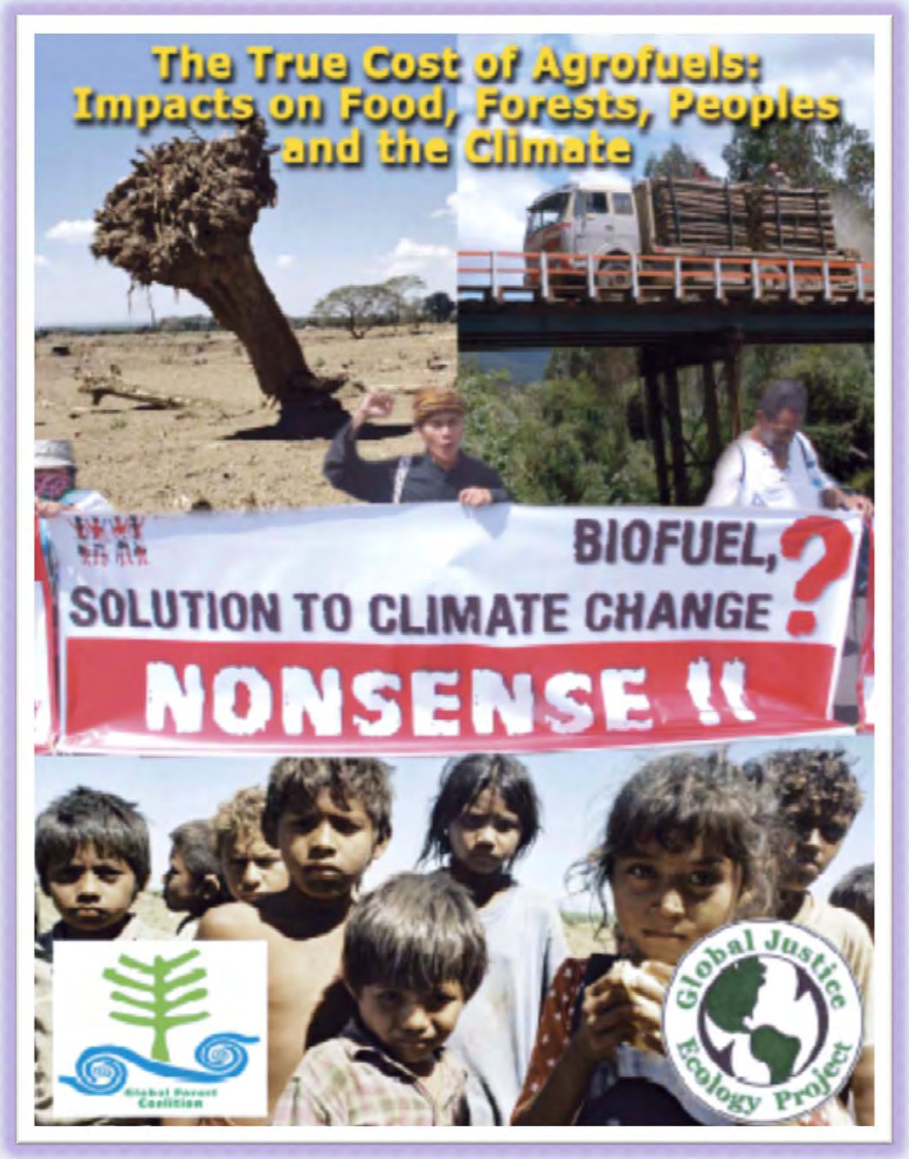
~10 $tCO_2e \cdot ha^{-1} \cdot yr^{-1}$

New Paradigm & New Era

RED ALGAE PAPER

REDD & Blue REDD





Seaweed Bio-fuel Make Sense!

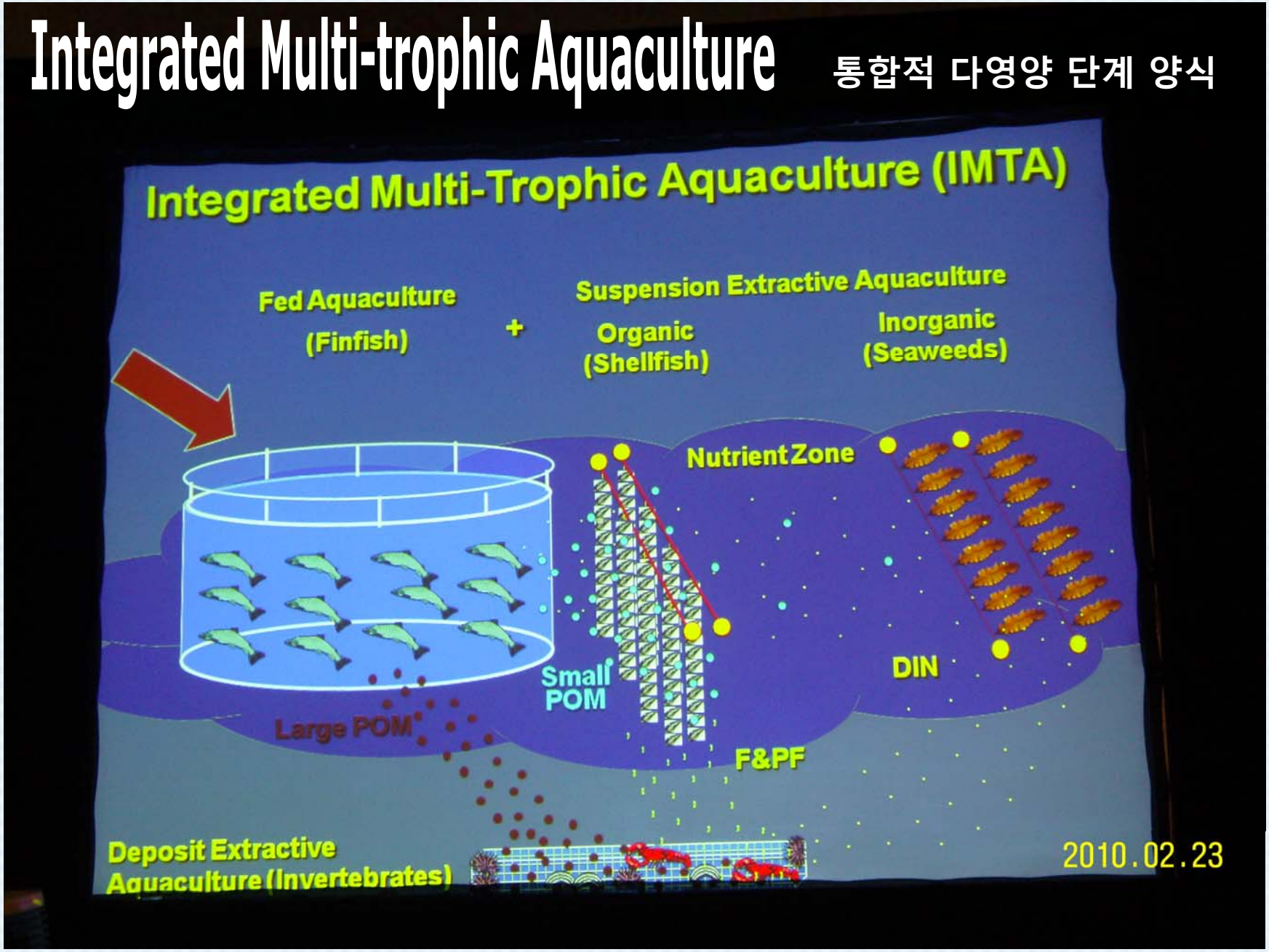
Soil

Water

Fertilizer

Food

Integrated Multi-trophic Aquaculture 통합적 다영양 단계 양식



Chopin (2010, WAS)

Asian Network for Using Algae as a CO_2 Sink

Agenda 21 for Green Paths to the Future

Seaweed Solution – Sink and Swim!

Seaweeds are promising organisms as adaptation and mitigation measures against global warming.

Solution:

(1) Red algae paper;

(2) Seaweed biofuel; and

(3) Seaweed sink.

The Korean project

"GHG Emissions Reduction Using Seaweeds"

COP17/CMP7
UNITED NATIONS
CLIMATE CHANGE CONFERENCE 2011
DURBAN, SOUTH AFRICA

Working Together
Saving Tomorrow Today
28 November - 9 December 2011

SeaweedSolution: Sink&Swim

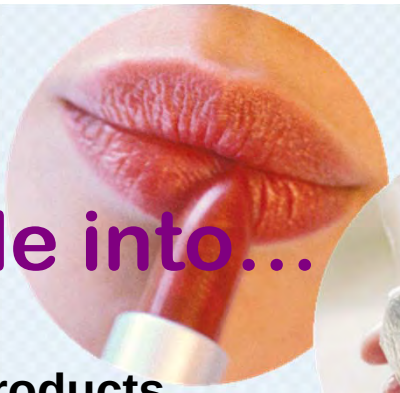
Summary

- ✓ Climate Change & Blue carbon
  - Win – win
- ✓ Korean Project (2006 – 2011)
  - Coastal CO_2 Removal Belt (CCRB, 2005)
  - Pilot seaweed CDM (adaptation & mitigation) farm
- ✓ Recognition of kelp forests and seaweed beds
  - ~10 $tCO2_e \cdot ha^{-1} \cdot yr^{-1}$ (biomass & DIC)

- **Seaweed Solution**
  - Sink; Biofuel; Algal Paper, etc.
  - Carbon-zero (negative) town
    - Implementation of seaweed solutions (M & A)
    - w/Renewable ocean energy (windmill, wave, etc.)
    - Seaweed-based integrated multi-trophic aquaculture

Did you know?

Seaweeds can be made into…



- **Foods/ Household Products**
  - Food thickening agents in ice creams, salad dressings
  - Algin ingredients in some breads, beers, puddings and more
  - Seaweed paper
  - Seaweed extracts in some herbs and vitamins
- **Bio-fuel & Paper**

- **Personal Care Products**
  - Algin ingredients in makeup, soap, toothpaste, and shampoo
  - Seaweeds extracts in facial masques, massage gels, and bath products
- **Medicines**
  - Seaweed ingredients in medicines used to treat tuberculosis, arthritis, colds, influenza and other infections
  - Seaweed-derived agar, a substance used in the culture of bacteria and other microorganisms
  - Seaweed-derived agarose in chromatography to purify proteins, DNA, and other substances

Seaweed Solution!

Carbon **Sequestration** (sink)

Red Algal Pulp/Paper

Seaweed Biofuel

New **Paradigm** & New Era

C-Negative Ocean Village

Acknowledgements:
Korean MLTM
MRI/PNU
APPA