The 8th Asian Pacific Phycological Forum
APPF2017 (October 11, 2017)
Pullman Hotel, Bangsar, Kula Lumpur

CØST

Seaweed Solution and Carbon Zero Seaweed Town (**CØST**) with Asian Network of Using Algae as Mitigation and Adaptation Measure (**ANAMAM**)

부산대학교 해양연구소 / 해양학과 정익교

Asian Network for Using Algae as a CO_2 Sink


Acknowledgement
Korean Society of Phycology
Korea National Research Foundation
Korean Ministry of Maritime Affairs and Fisheries
Marine Research Institute, Pusan National University
Asian Pacific Phycological Association
2008.10.30

Commercial / Advertisement

2007

2017

Carbon Zero Seaweed Town
(CØST)

USA TODAY

Scientists: Seaweed could stem warming

By Joseph Coleman, Associated Press Writer

BALI, Indonesia — Slimy, green and unsightly, seaweed and algae are amon he humblest of plants.

A group of scientists at a climate conference in Bali they could also be a potent weapon against global warming, capable of sucking damaging carbon dioxide out of the atmosphere at rates comparable to the mightiest rain forests.

"The ocean's role is neglected because we can't see th vegetation," said Chung Ik-kyo, a South Korean environmental scientist. "But under the sea, there is a lot of seaweed and sea grass that can take up carbon dioxide."

The seaweed research, backed by scientists in 12 Asian-Pacific countries, is part of a broad effort to calculate how much carbon is being a from the atmosphere

ouse
g.

UN Climate Change Conference 2007
Bali - Indonesia

MSNBC.com

Could seaweed help battle warming?

It's great at absorbing carbon, but it also releases it pretty quickly

The Associated Press
updated 3:59 p.m. ET Dec. 10, 2007

BALI, Indonesia - Slimy, green and unsightly, seaweed and algae are amon the humblest of plants.

A group of scientists at a climate conference in Bali say they could also be a potent weapon against global warming, capable of sucking damaging carbon dioxide out of the atmosphere at rates comparable to the mightiest rain forests.

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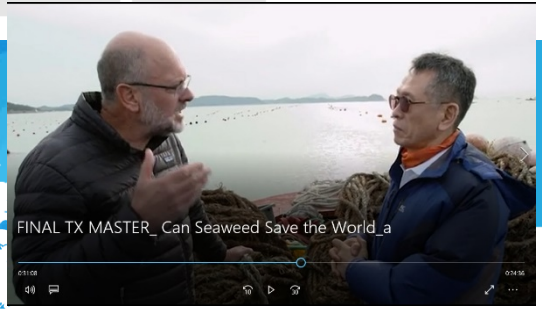
Catalyst

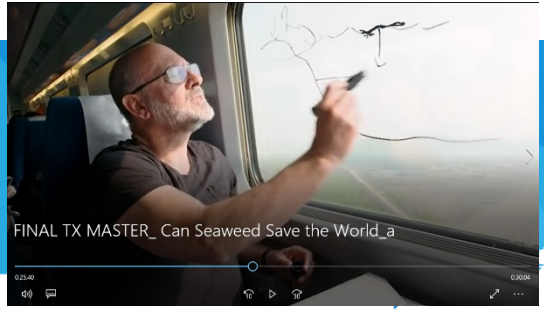
Series 18 Can Seaweed Save The World?

DOCUMENTARY

Professor Tim Flannery investigates how seaweed is helping to save the world - from growing the foods of the future, helping save the reef and even combating climate change. #ABCcatalyst

Broadcast 8:30pm Tue 22 Aug 2017. Published 3 hours ago, available until 9:32pm on 15 Aug 2020. File size approx. 451 MB



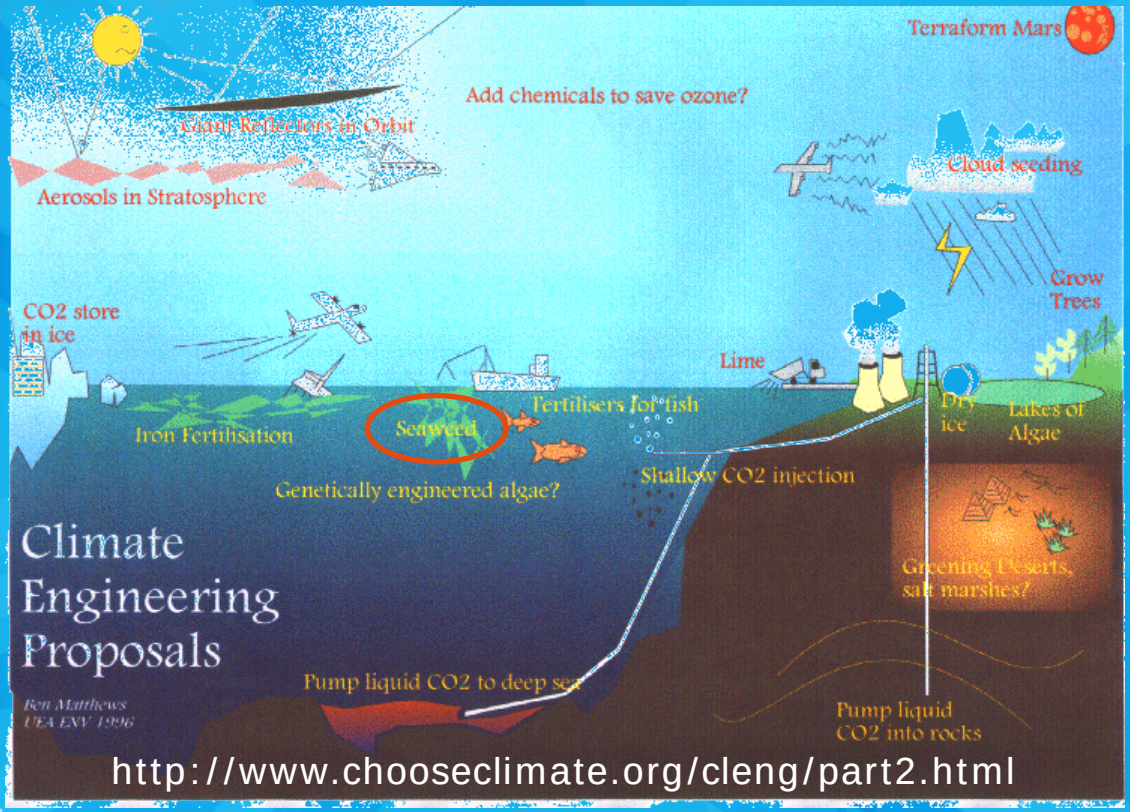


Macroalgae on the deep sea floor

Dorte Krause-Jensen (2016)

Background / Outline

- **Introduction and overview** (history)
  - *Global warming and climate change*
  - *Korean project & Coastal CO_2 Removal Belts*
  - *Asian Pacific Phycological Association (APPA) WG*
  - *Blue Carbon*
- **Seaweed Solutions**
  - *Seaweed mitigation and adaptation measures*
  - *SABs and Ecosystem Services*
- **Action plan**
  - *Carbon Zero Seaweed Town (CØST)*
  - *Asian Network of Using Algae as Mitigation and Adaptation Measure (ANAMAM)*



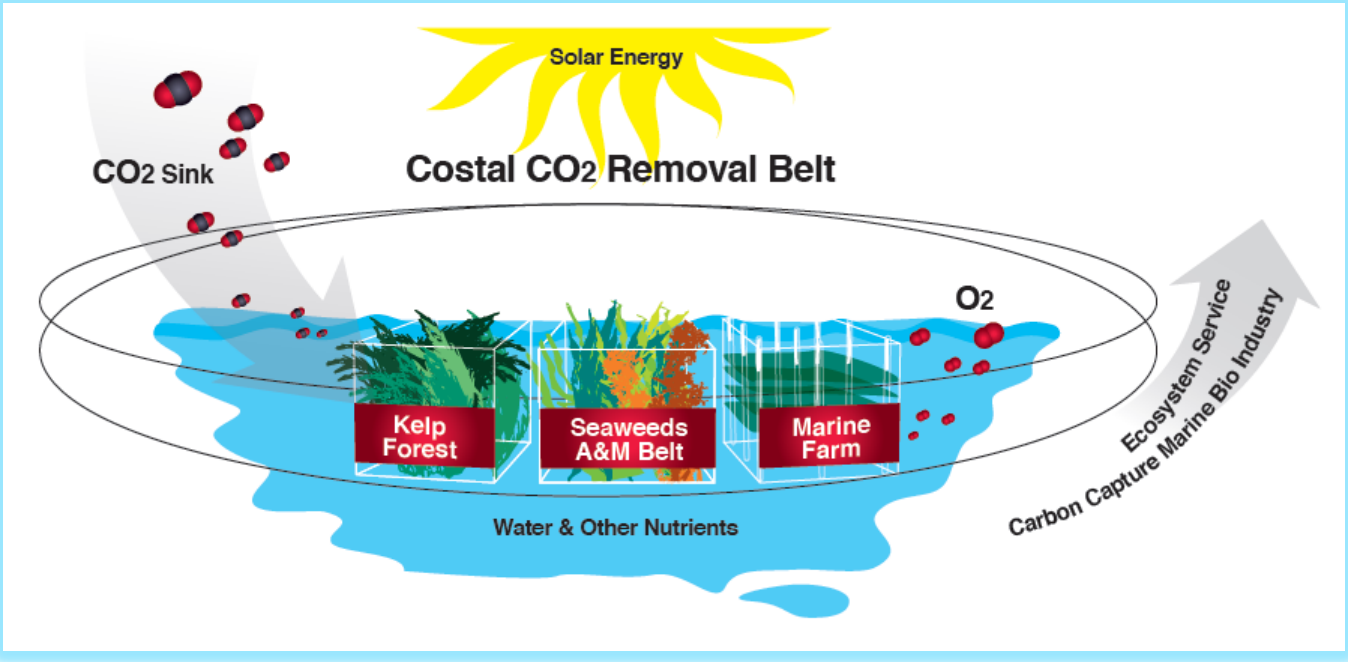
http://www.chooseclimate.org/cleng/part2.html

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.

Coastal CO_2 Removal Belt



Schematic diagram “Seaweed A & M belt” in CCRB (Chung, 2006)
A stands for *Adaptation* and *M* for *Mitigation*

Coastal CO_2 Removal Belt (2006)

- **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

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)

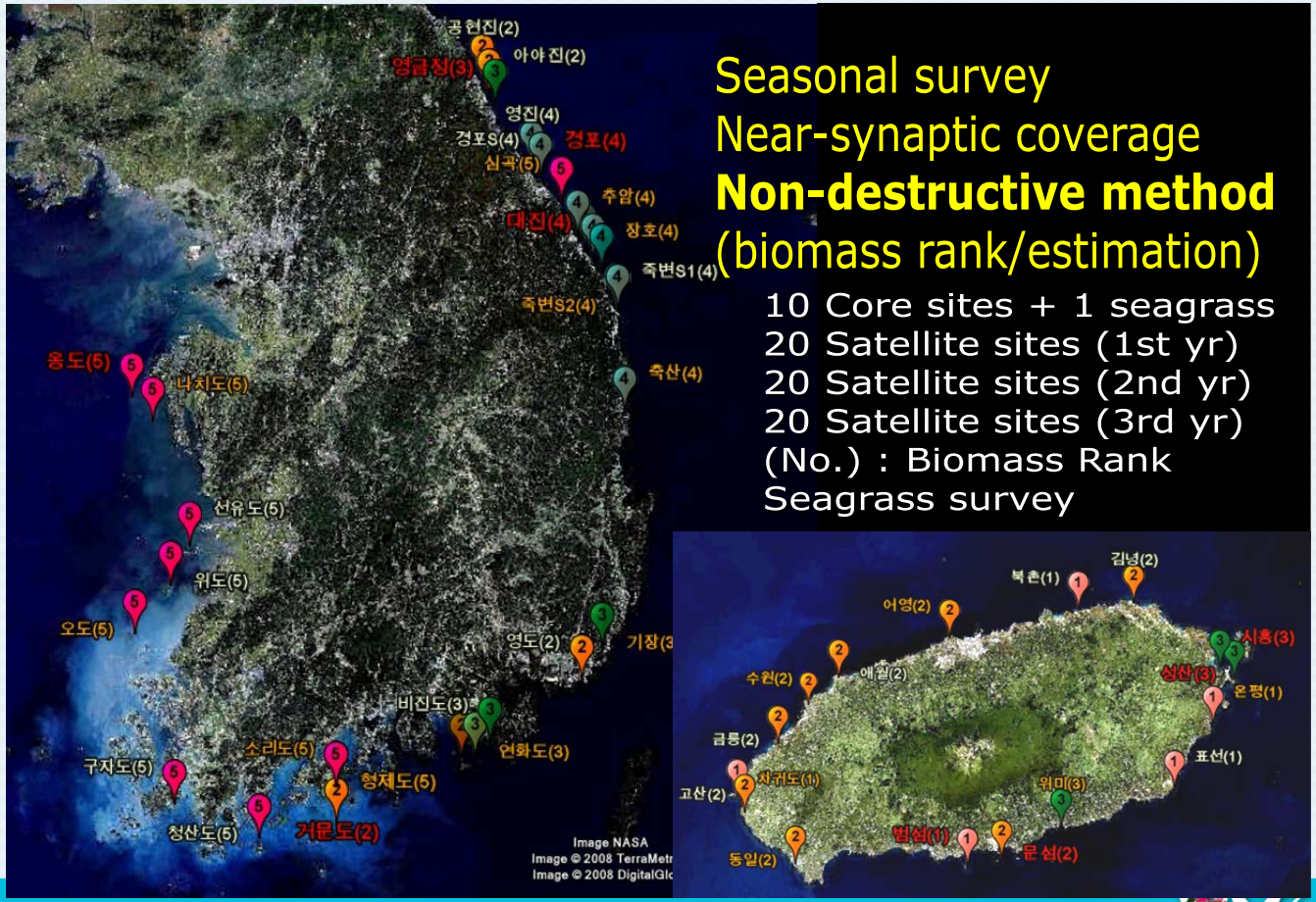
Challenge!

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

Korean project

- Background
  - Korean Society of Phycology
  - Contribution to the community
  - **APPA Network**
- New concept
  - **Coastal CO_2 Removal Belt (CCRB)**
- Results
  - Selection of species
  - Natural seaweed beds
  - Pilot Seaweed CDM Farm for MRV
    - Potential sequestrating agent (sink)

Field survey (Seaweed community: baseline/monitoring)



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

10 Core sites + 1 seagrass
20 Satellite sites (1st yr)
20 Satellite sites (2nd yr)
20 Satellite sites (3rd yr)
(No.) : Biomass Rank
Seagrass survey

Wild seaweed biomass

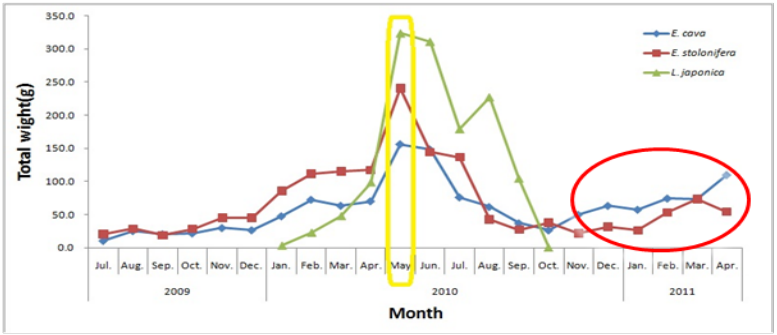
Regional average biomass densities of five dominant species

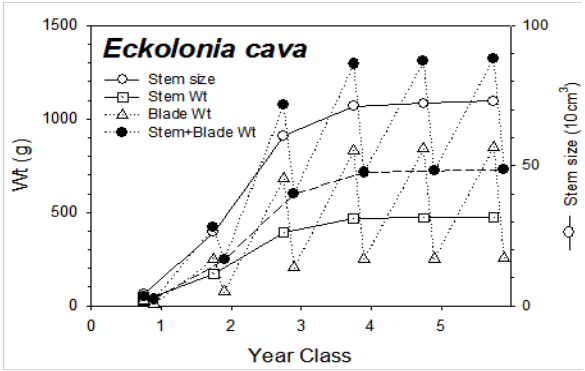

해조CDM 사업장
Seaweed-CDM Project
해조류를 이용한 온실가스 저감연구 [2006. 6 - 2011. 4]
Greenhouse Gas Emissions Reduction using Seaweeds

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

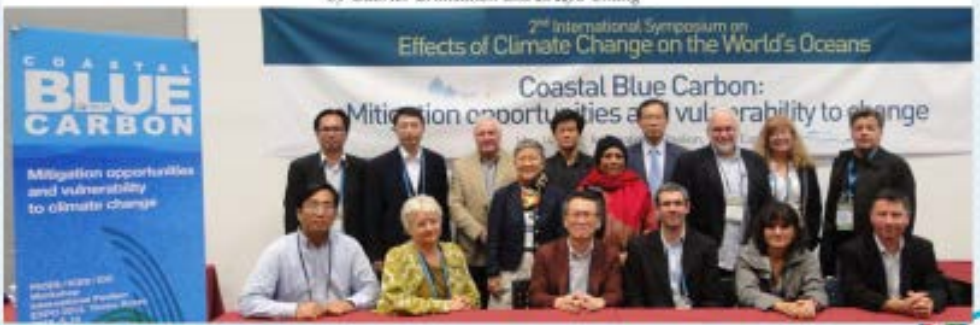
Second International Symposium
Effects of Climate Change on the World's Oceans
Yeosu, Korea
May 15-19, 2012

Symposium Scope

PICES Press Vol. 20, No. 2 — North Pacific Marine Science Organization

2012 Yeosu Workshop on "Coastal Blue Carbon"

by Gabriel Grimsditch and Ik Kyo Chung



http://pices.int/publications/pices_press/volume20/v20_n2/pp_18-20_Yeosu_W3.pdf

ICES Journal of Marine Science

ICES International Council for the Exploration of the Sea
CIEM Conseil International pour l'Exploration de la Mer

ICES Journal of Marine Science (2013), 70(5), 1038–1044. doi:10.1093/icesjms/fss206

Installing kelp forests/seaweed beds for mitigation and adaptation against global warming: Korean Project Overview

Ik Kyo Chung[1]*, Jung Hyun Oak[2], Jin Ae Lee[3], Jong Ahm Shin[4], Jong Gyu Kim[5], and Kwang-Seok Park[6]

[1]*Department of Oceanography, Pusan National University, 30, Jangjeon-dong, Geumjeong-gu, Busan 609-735, Republic of Korea*
[2]*Marine Research Institute, Pusan National University, Busan 609-735, Republic of Korea*
[3]*School of Environmental Science and Engineering, Inje University, Gimhae 621-749, Republic of Korea*
[4]*College of Fisheries and Ocean Sciences, Chonnam National University, Yeosu 550-749, Republic of Korea*
[5]*Response to Climate Change Co., Ltd., Pohang 790-390, Republic of Korea*
[6]*Material Research Division, Research Institute of Industrial Science and Technology, Pohang 790-330, Republic of Korea*

**Corresponding author: tel: +82 51 510 2279; fax: +82 51 581 2963; e-mail: ikchung@pusan.ac.kr.*

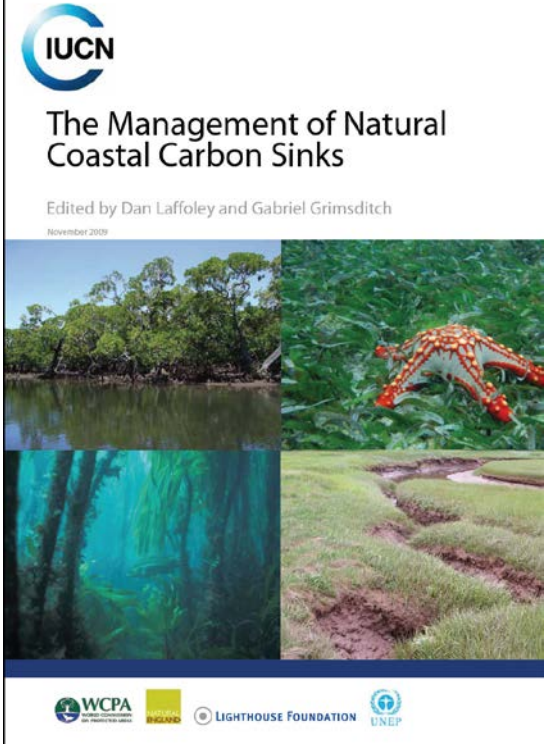
Chung, I. K., Oak, J. H., Lee, J. A., Shin, J. A., Kim, J. G., and Park, K.-S. 2013. Installing kelp forests/seaweed beds for mitigation and adaptation against global warming: Korean Project Overview. – ICES Journal of Marine Science, 70: 1038–1044.

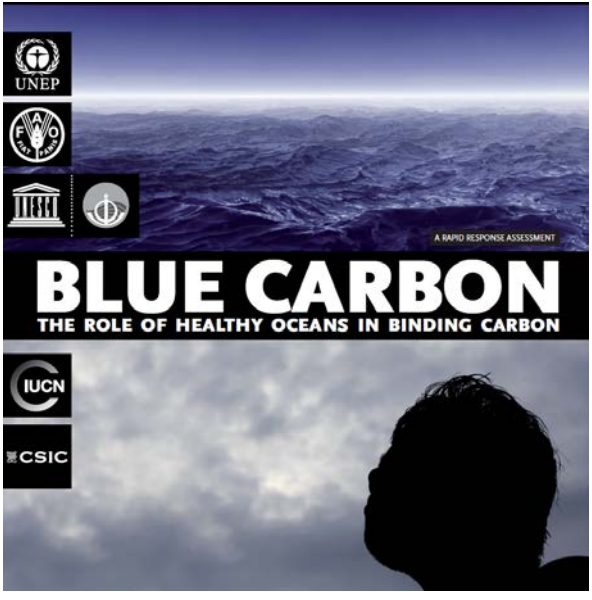
Received 28 August 2012; accepted 20 December 2012; advance access publication 11 January 2013.

Seaweed beds can serve as a significant carbon dioxide (CO_2) sink while also satisfying global needs for food, fodder, fuel, and pharmaceutical products. The goal of our Korean Project has been to develop new baseline and monitoring methodologies for mitigation and adaptation within the context of climate change. Using innovative research approaches, we have established the Coastal CO_2 Removal Belt (CCRB), which comprises both natural and man-made plant communities in the coastal region of southern Korea. Implemented on various spatial–temporal scales, this scheme promotes the removal of CO_2 via marine forests. For example, when populated with the perennial brown alga *Ecklonia*, a pilot CCRB farm can draw down ~10 t of CO_2 per ha per year. This success is manifested by an increment in biomass accumulations and a decrease in the amount of dissolved inorganic carbon in the water column.

Keywords: blue carbon, carbon sink, Coastal CO_2 Removal Belt (CCRB), kelp forest, seaweed.

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, 青炭 “蓝色”

The colors of carbon (2009)

The colors of Carbon

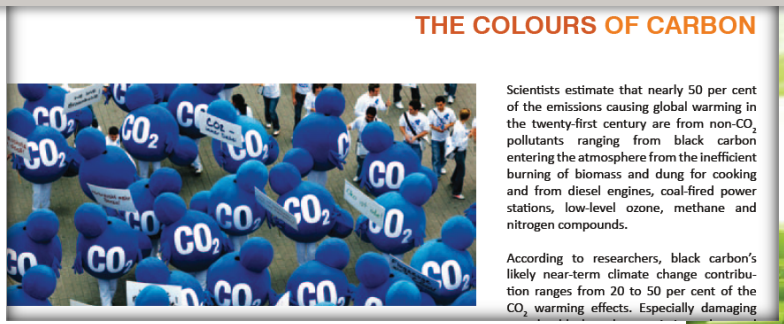
Fossil fuel burning (Brown Carbon)

Soot (Black Carbon)

Terrestrial vegetation (Green Carbon)

Carbon in Oceans (Blue Carbon)

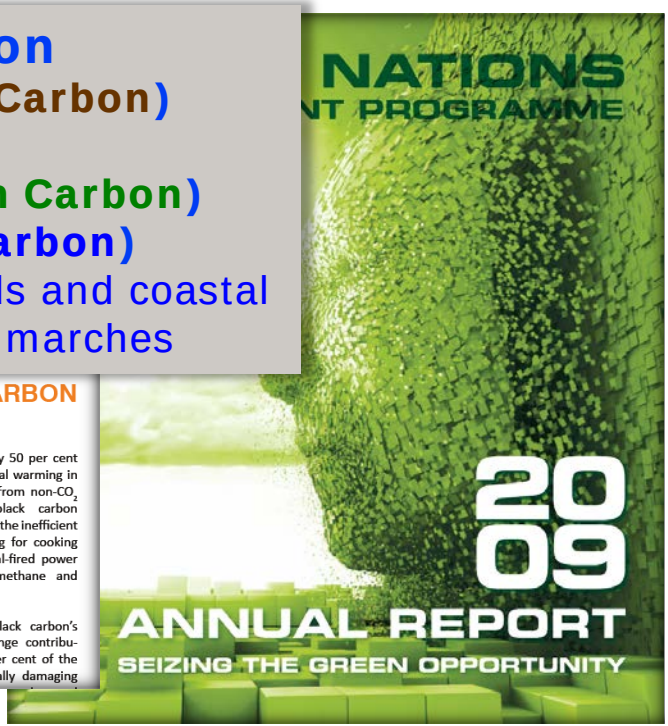
Open sea, coral reefs, seagrass beds and coastal mangroves, estuaries and salt marches



THE COLOURS OF CARBON

Scientists estimate that nearly 50 per cent of the emissions causing global warming in the twenty-first century are from non-CO_2 pollutants ranging from black carbon entering the atmosphere from the inefficient burning of biomass and dung for cooking and from diesel engines, coal-fired power stations, low-level ozone, methane and nitrogen compounds.

According to researchers, black carbon's likely near-term climate change contribution ranges from 20 to 50 per cent of the CO_2 warming effects. Especially damaging



UNEP – Blue Carbon (2009)

- 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**.

Blue carbon

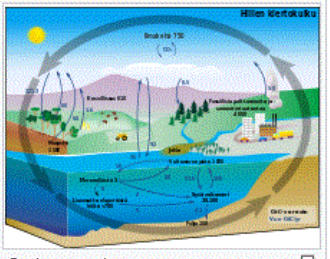
From Wikipedia, the free encyclopedia

Blue carbon is the carbon captured by the world's oceans and coastal ecosystems. The carbon captured by living organisms in oceans is stored in the form of biomass and sediments from mangroves, salt marshes, seagrasses and potentially algae.[1]

Contents [hide]

Seagrass
Mangrove
Marsh

Algae



Carbon cycle

https://en.wikipedia.org/wiki/Blue_carbon

Algae

Algae [edit]

Both macroalgae and microalgae are being investigated as possible means of carbon sequestration.[19][20][21][22] Because algae lack the complex lignin associated with terrestrial plants, the carbon in algae is released into the atmosphere more rapidly than carbon captured on land.[21][23] Algae have been proposed as a short-term storage pool of carbon that can be used as a feedstock for the production of various biogenic fuels. Microalgae are often put forth as a potential feedstock for carbon-neutral biodiesel and biomethane production due to their high lipid content.[19] Macroalgae, on the other hand, do not have high lipid content and have limited potential as biodiesel feedstock, although they can still be used as feedstock for other biofuel generation.[21] Macroalgae have also been investigated as a feedstock for the production of biochar. The biochar produced from macroalgae is higher in agriculturally important nutrients than biochar produced from terrestrial sources.[22] Another novel approach to carbon capture which utilizes algae is the Bicarbonate-based Integrated Carbon Capture and Algae Production Systems (BICCAPS) developed by a collaboration between Washington State University in the United States and Dalian Ocean University in China. Many cyanobacteria, microalgae, and macroalgae species can utilize carbonate as a carbon source for photosynthesis. In the BICCAPS, alkaliphilic microalgae utilize carbon captured from flue gases in the form of bicarbonate.[24][25] In South Korea, macroalgae have been utilized as part of a climate change mitigation program. The country has established the Coastal CO_2 Removal Belt (CCRB) which is composed of artificial and natural ecosystems. The goal is to capture carbon using large areas of kelp forest.[26]

Asian Network for Using Algae as a CO_2 Sink

J Appl Phycol (2011) 23:877–886
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

Received: 27 July 2010 / Revised and accepted: 24 September 2010 / Published online: 19 October 2010

Abstract There has been a good deal of interest in the potential of marine vegetation as a sink for anthropogenic C emissions ("Blue Carbon"). Marine primary producers contribute at least 50% of the world's carbon fixation and may account for as much as 71% of all carbon storage. In this paper, we analyse the current rate of harvesting of both commercially grown and wild-grown macroalgae, as well as their capacity for photosynthetically driven CO_2 assimilation and growth. We suggest that CO_2 acquisition by marine macroalgae can represent a considerable sink for anthropogenic CO_2 emissions and that harvesting and appropriate use of macroalgal primary production could play a significant role in C sequestration and amelioration of greenhouse gas emissions.

Keywords Blue carbon · Macroalgae · Photosynthesis · CO_2 sequestration

Introduction

The global environment is going through a period of rapid change, the pace of which is unprecedented in our geological history, and life on the planet is being threatened by elevated temperatures and ocean acidification associated with the release of greenhouse gases. While CO_2 levels and global temperatures have both been higher, sometimes much higher, in the geological past than they are at present, it is the current rate of change that will pose problems for biota. It is thus critical for the future of our planet that significant changes are made to our emissions of greenhouse gases, of which CO_2 is the greatest contributor at present.

Various solutions to the problem of excess emissions have been proposed, and many countries are making good progress in stabilising or even reducing their CO_2 outputs. However, rapid economic growth in developing countries

This work has been supported by the National Research Foundation of Korea, Marine Research Institute, Pusan National University (NRF-2013R1A1A2009359) and DIKTI Scholarship from Indonesia Ministry of National Education and Culture for CFAS.

J Appl Phycol
DOI 10.1007/s10811-016-1022-1

22ND INTERNATIONAL SEAWEED SYMPOSIUM, COPENHAGEN

Carbon dioxide mitigation potential of seaweed aquaculture beds (SABs)

Calvyn F. A. Sondak[1,2] · Put O. Ang Jr[3] · John Beardall[4] · Alecia Bellgrove[5,6] · Sung Min Boo[7] · Grevo S. Gerung[2] · Christopher D. Hepburn[8] · Dang Diem Hong[9] · Zhengyu Hu[10] · Hiroshi Kawai[11] · Danilo Largo[12] · Jin Ae Lee[13] · Phaik-Eem Lim[14] · Jaruwan Mayakun[15] · Wendy A. Nelson[16,17] · Jung Hyun Oak[18] · Siew-Moi Phang[14] · Dinabandhu Sahoo[19] · Yuwadee Peerapornpis[20] · Yufeng Yang[21] · Ik Kyo Chung[1,18]

Received: 11 August 2016 / Revised and accepted: 20 November 2016

Abstract Seaweed aquaculture beds (SABs) that support the production of seaweed and their diverse products, cover extensive coastal areas, especially in the Asian-Pacific region, and provide many ecosystem services such as nutrient removal and CO_2 assimilation. The use of SABs in potential carbon dioxide (CO_2) mitigation efforts has been proposed with commercial seaweed production in China, India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Thailand, and Vietnam, and is at a nascent stage in Australia and New Zealand. We attempted to consider the total annual potential of SABs to drawdown and fix anthropogenic CO_2. In the last decade, seaweed production has increased tremendously in the Asian-Pacific region. In 2014, the total annual production of Asian-Pacific SABs surpassed 2.61×10^6 t dw. Total carbon accumulated annually was more than 0.78×10^6 t y^{-1}, equivalent to over 2.87×10^6 t CO_2 y^{-1}. By increasing the area available for SABs, biomass production, carbon accumulation, and CO_2 drawdown can be enhanced. The conversion of biomass to biofuel can reduce the use of fossil fuels and provide additional mitigation of CO_2 emissions. Contributions

Paris agreement (COP21, 2015)

"건강海요, 깨끗海요 대한민국 청정바다"

Korea Algae Industry Development Association

International Conference on Sustainable Seaweed Industry for Blue Carbon

Sustainable Seaweed Industry for Blue Carbon

4. 14 –17, 2017

4.14 (FRI) - 17 (MON), 2017

Wando oneness resort, Wando, Korea

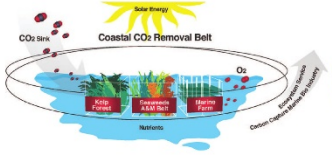
Venue

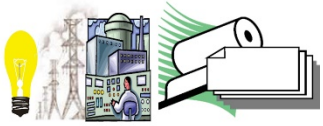
Wando oneness resort, Wando, Korea

Seaweed Solution

Seaweed Solution

Seaweed Source | **Ecological Roles** | **Economic Roles**





Seaweed aquaculture beds (SABs)

Integrated Multi-Trophic Aquaculture (IMTA)

Natural beds

Structure/Habitat

Primary producer: CO_2 & nutrient uptake, pH, O_2

CO_2: C sink (incl sink to deep sea);
Bioremediation: pollutants, nutrient,
OA: pH
O_2: Hypoxia

Human Food
Animal Feeds
Fertilizers
Bioactive and Extractive cpds

Substitute for other C sources:
Biofuel
Battery
Paper
Construction
Others

Summarized by Prof. Ang (2017)

Carbon Zero Seaweed Town

Global Project

Name
Affiliation

Wando CØST

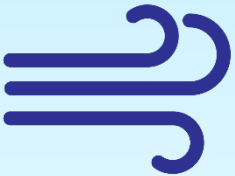
- It is the time to go beyond sustainable development to achieve low carbon green growth. We propose to build a **net zero carbon emission community** with **seaweed-based mitigation and adaptation measures**. Here we declared the initiation of the **Wando Carbon Zero Seaweed Town Project** (hereafter **CØST**) during the Second Wando Seaweed Expo on April 14, 2017 at the Wando Province, Home of Seaweed in Korea.

Principle Action Plans:

- **Preserve Natural Seaweed Community**
  - establish a Visitor Centre for community education
  - exhibits of seaweed species, products, etc.
  - In the future can establish a Seaweed Research center, where visiting scientists can carry out short-term research, etc; for scientist-industry linkages.
- **Establish Seaweed Aquaculture Beds (SABs)**
  - integrate with aquaculture of fish & shellfish? - **IMTA** system for multi-products and environmental management)
  - **Seaweed Carbon Capture and Sink (Seaweed CCS)**
- **Develop Seaweed biofuel technology: BE CCS**

Subsidiary Action plans

Solar energy



Ocean Energy

- wind mill,
- wave energy, etc.

Algae Fuel Cells

frontiers in Marine Science

PERSPECTIVE
published: 12 April 2017
doi: 10.3389/fmars.2017.00100

Can Seaweed Farming Play a Role in Climate Change Mitigation and Adaptation?

Carlos M. Duarte[1,2,3]*, *Jiaping Wu*[4], *Xi Xiao*[4], *Annette Bruhn*[2] *and Dorte Krause-Jensen*[2,3]

[1] *Red Sea Research Center, King Abdullah University of Science and Technology, Thuwal, Saudi Arabia,* [2] *Department of Bioscience, Aarhus University, Silkeborg, Denmark,* [3] *Arctic Research Centre, Aarhus University, Silkeborg, Denmark,* [4] *Ocean College, Zhejiang University, Zhoushan, China*

Seaweed aquaculture, the fastest-growing component of global food production, offers a slate of opportunities to mitigate, and adapt to climate change. Seaweed farms release carbon that maybe buried in sediments or exported to the deep sea, therefore acting as a CO_2 sink. The crop can also be used, in total or in part, for biofuel production, with a potential CO_2 mitigation capacity, in terms of avoided emissions from fossil fuels, of about 1,500 tons CO_2 km^{-2} $year^{-1}$. Seaweed aquaculture can also help reduce the emissions from agriculture, by improving soil quality, substituting synthetic fertilizer

SEAWEED FARMING AND CLIMATE CHANGE

MITIGATION VIA:

Ongoing processes:

C-sequestration
via export of "unseen" production

Food production
with reduced CO_2 foot print

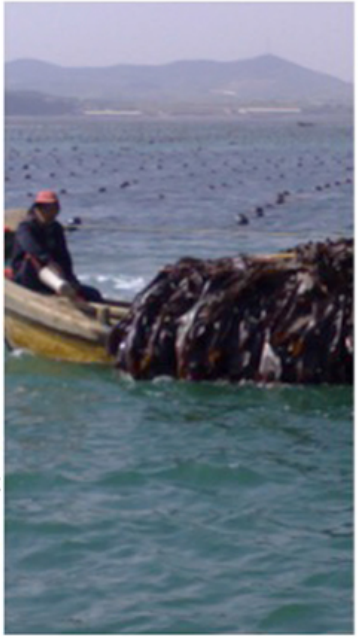
Future potentials:

Bioenergy production
substituting fossil fuels

Reduction of methane emission
via seaweed feed additive to ruminants

Stimulation of land-based production
via seaweed biochar soil amelioration & seaweed prebiotic health benefits to livestock

Climate benefit of circular nutrient management
Via avoidance of CO_2 emissions for synthetic fertiliser production



ADAPTATION TO:

Increased storminess and sea level rise
Shoreline protection via dissipation of wave energy

Ocean Acidification
High daytime pH in seaweed to the benefit of calcifiers

Oxygen inputs to coastal waters
Avoiding ocean deoxygenation with warming

Duarte *et al*. (2017)

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 & P**
- **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

United Nations
Framework Convention on
Climate Change

The Carbon Zero Seaweed Town (**CØST**) Project from PNU/MRI builds **carbon-neutral** communities based on **seaweed solutions** and other **renewable ocean energy options**. It provides **sustainable mitigation and adaptation measures** within the context of climate change and creates **new jobs** and **revenue**.

SBSTA Virtual Platform for Exchange with Observers
UNFCCC Calendar
Rio Conventions Calendar
Webcast & Videos
Documents & Decisions
Bodies

PROCESS

Essential Background
Kyoto Protocol
Cooperation & Support

Click to create a side event or mini side event application

Exhibit(s)

Preferred duration	Scheduled	Theme	Thematic categories	Status	Attachments	Action
Monday, 06 November, 2017 - Saturday, 11 November, 2017	Pending	The Carbon Zero Seaweed Town (CØST) Project from PNU/MRI builds carbon-neutral communities based on seaweed solutions and other renewable ocean energy options. It provides sustainable mitigation and adaptation measures within the context of climate change and creates new jobs and revenue.	**Adaptation** Sinks, forests, oceans	Waiting for authorization		[Communicate with the secretariat]

Click to create an exhibit application

http://www.troposplatform.eu/

Ocean of Tomorrow

floating modular multi-use platform system

Project cofinanced by the European Commission under the Seventh Framework Programme

The Tropos project

TROPOS is a European collaborative project funded by the European Commission under the 7th Framework Programme for Research and Development, more specifically under the "Ocean of Tomorrow" call OCEAN 2011.1 – Multi-use offshore platforms. The TROPOS Project aims at developing a floating modular multi-use platform system for use in deep waters, with an initial geographic focus on the Mediterranean, Tropical and Sub-Tropical regions, but designed to be flexible enough so as to not be limited in geographic scope.
TROPOS gathers 20 partners from 9 countries (Spain, the United Kingdom, Germany, Portugal, France, Norway, Denmark, Greece and Taiwan), under the coordination of PLOCAN (Spain - http://www.plocan.eu/es/).

TRANSPORT

ENERGY

AQUACULTURE

LEISURE


thank YOU