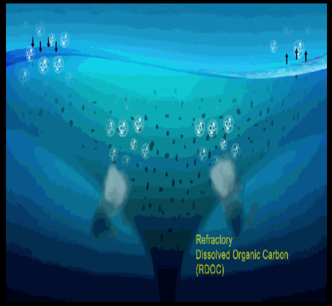
Ocean Negative Carbon Emissions

O N C E

# Ocean Negative Carbon Emissions (ONCE)

2021 2030 United Nations Decade of Ocean Science for Sustainable Development





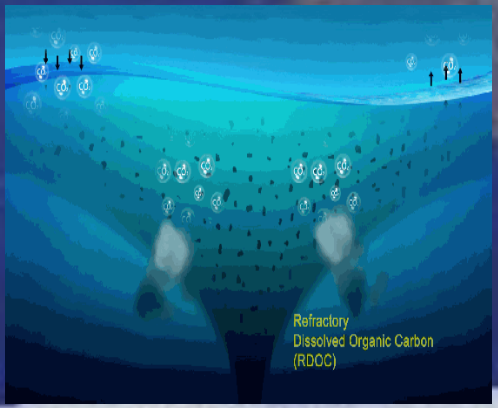
**Nianzhi JIAO**

**On behalf of the team**


**78 teams from 35 countries**

# Ocean Negative Carbon Emissions

"Negative Emission" = Emission → "Carbon Neutral"




Microbial Carbon pump (MCP)

Targets and Missions

# UN SDGs

Sustainable Development Goals

Goal 13:Take urgent action to combat climate change and its impacts

13 CLIMATE ACTION

Goal 14: Conserve and sustainably use the oceans, seas and marine resources

14 LIFE BELOW WATER

Goal 17: Revitalize the global partnership for sustainable development

17 PARTNERSHIPS FOR THE GOALS

Missions

Ocean Negative Carbon Emissions

O N C E

- Innovative Research
- Infrastructure facility
- On Site Demo
- International Exchange
- Education & Sci Popularization

Ocean Negative Carbon Emissions

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# Theory
# Carbon sequestraiotn
# Mechanisms

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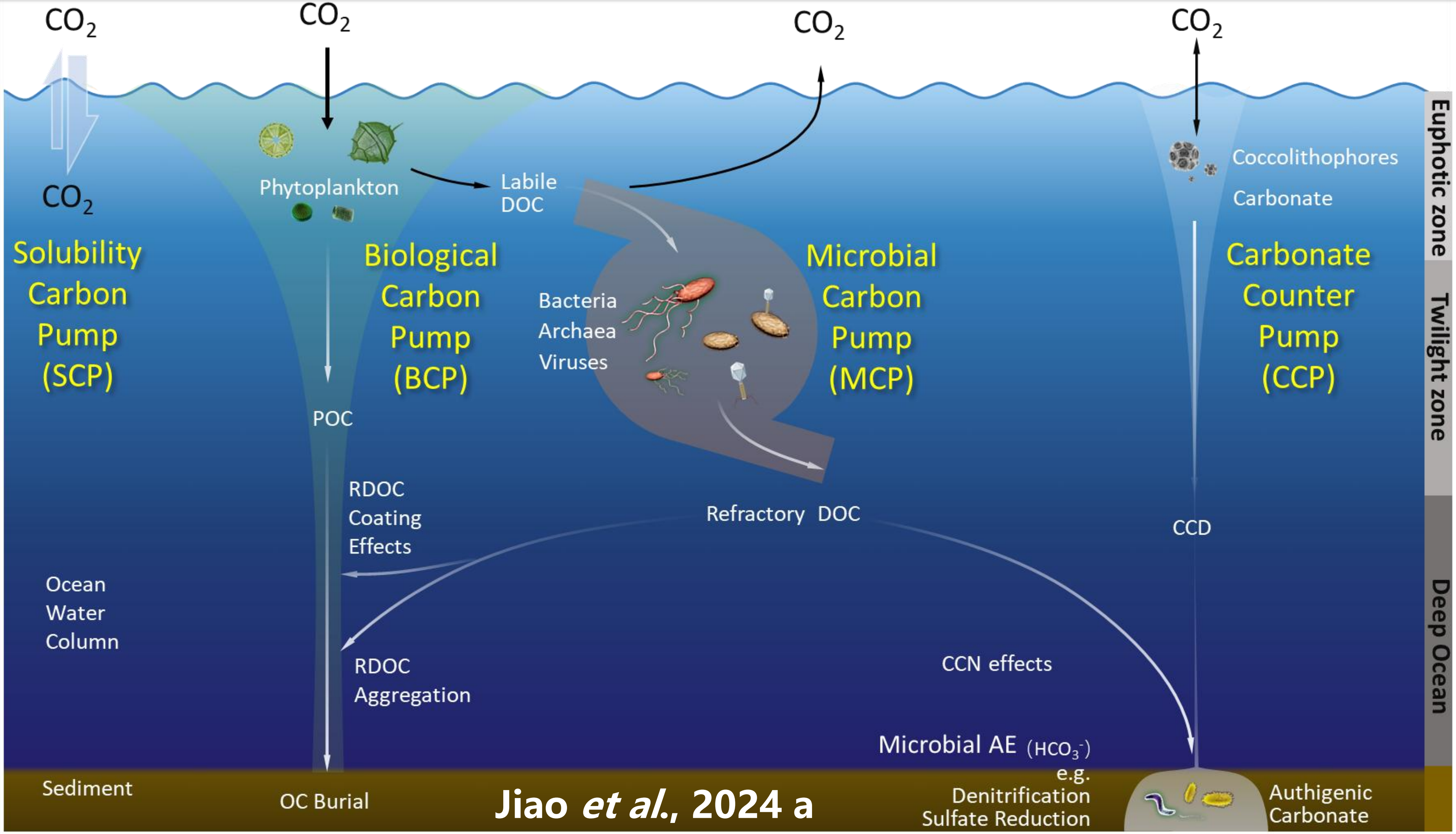
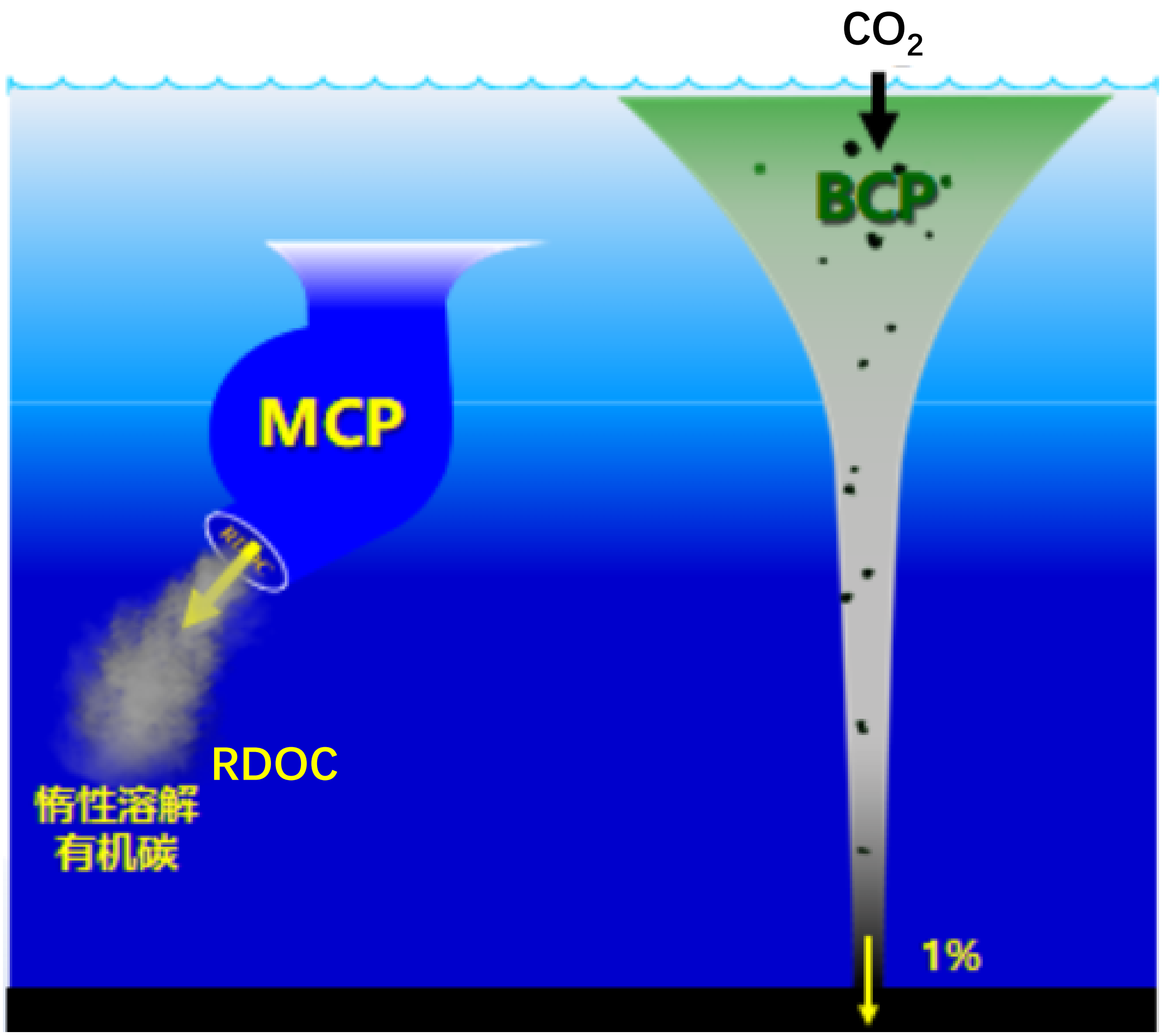
# ONCE approaches are based on Combined the Ocean Carbon Pumps BCMS (BCP-CCP-MCP-SCP)



# Fundmetal Differences Between
## Microbial Carbon Pump (MCP) and Biological Carbon Pump (BCP)




1.**Carbon Sequestration Mechanism**

1. MCP: Transformation of organic carbon at the molecular level.
2. BCP: Requiring a certain particle size.

2.**Carbon Storage Process**

1. MCP: Can occur in any layer of the ocean
2. BCP: Must be vertical from the surface to the deep seafloor.

3.**Dominant Organisms**

1. MCP: Microbial molecular transformation and release of organic carbon.
2. BCP: Phytoplankton production, zooplankton packaging, and physical aggregation of organic carbon.

4.**Climate Effects**

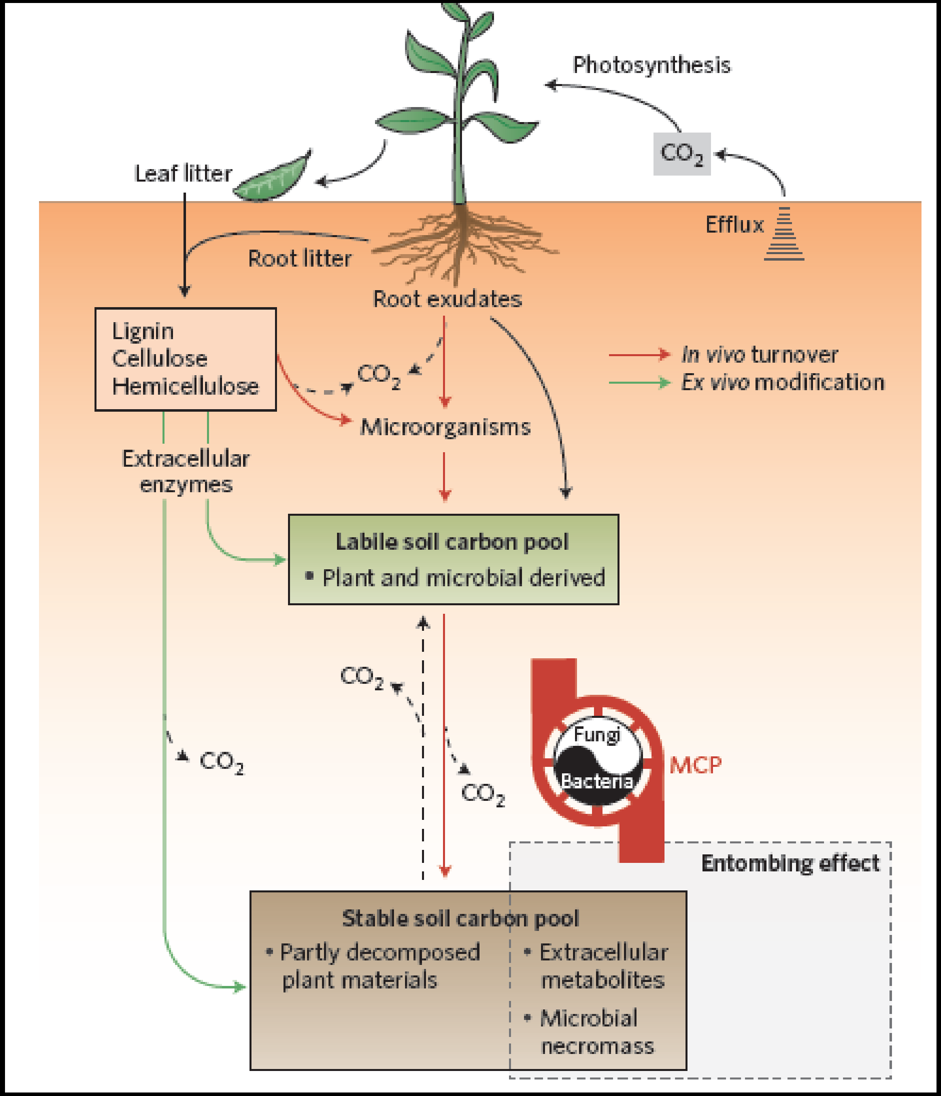
1. MCP: A bidirectional pump, dual regulatory effect on climate change.
2. BCP: A unidirectional pump, one-way effect on climate change.

5.**Historical Contribution**

1. MCP: Since the formation of oceans and carbon storage in water bodies.
2. BCP: Later than MCP by 5–10 billion years.

# Soil MCP

Liang , Schimel and Jastrow ; 2011





nature microbiology

PERSPECTIVE

PUBLISHED: 25 JULY 2017 | VOLUME: 2 | ARTICLE NUMBER: 17105

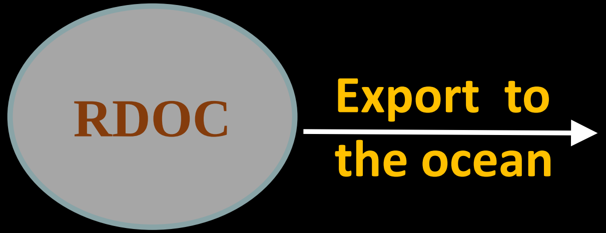
The importance of anabolism in microbial control over soil carbon storage

Chao Liang[1*], Joshua P. Schimel[2] and Julie D. Jastrow[3]

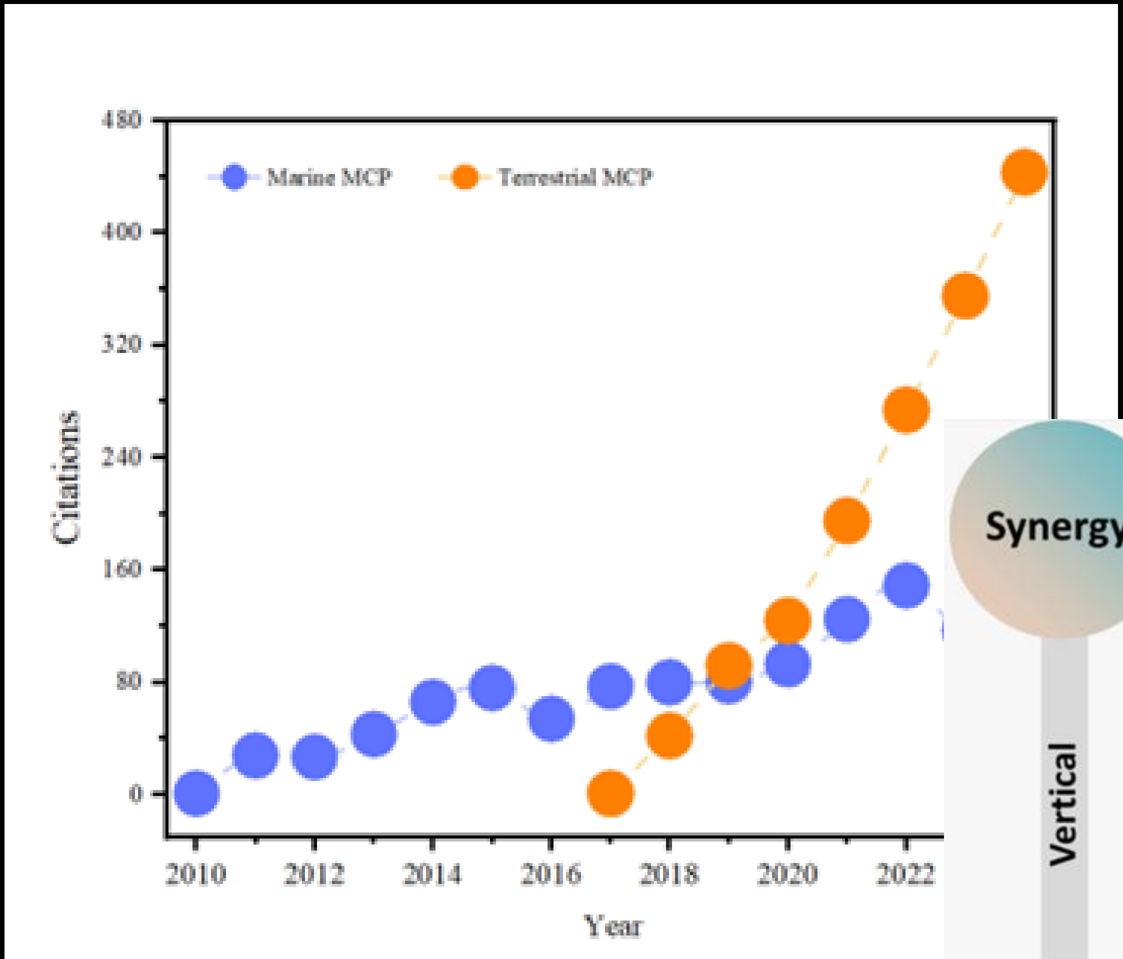
Liang , Schimel and Jastrow ; 2017

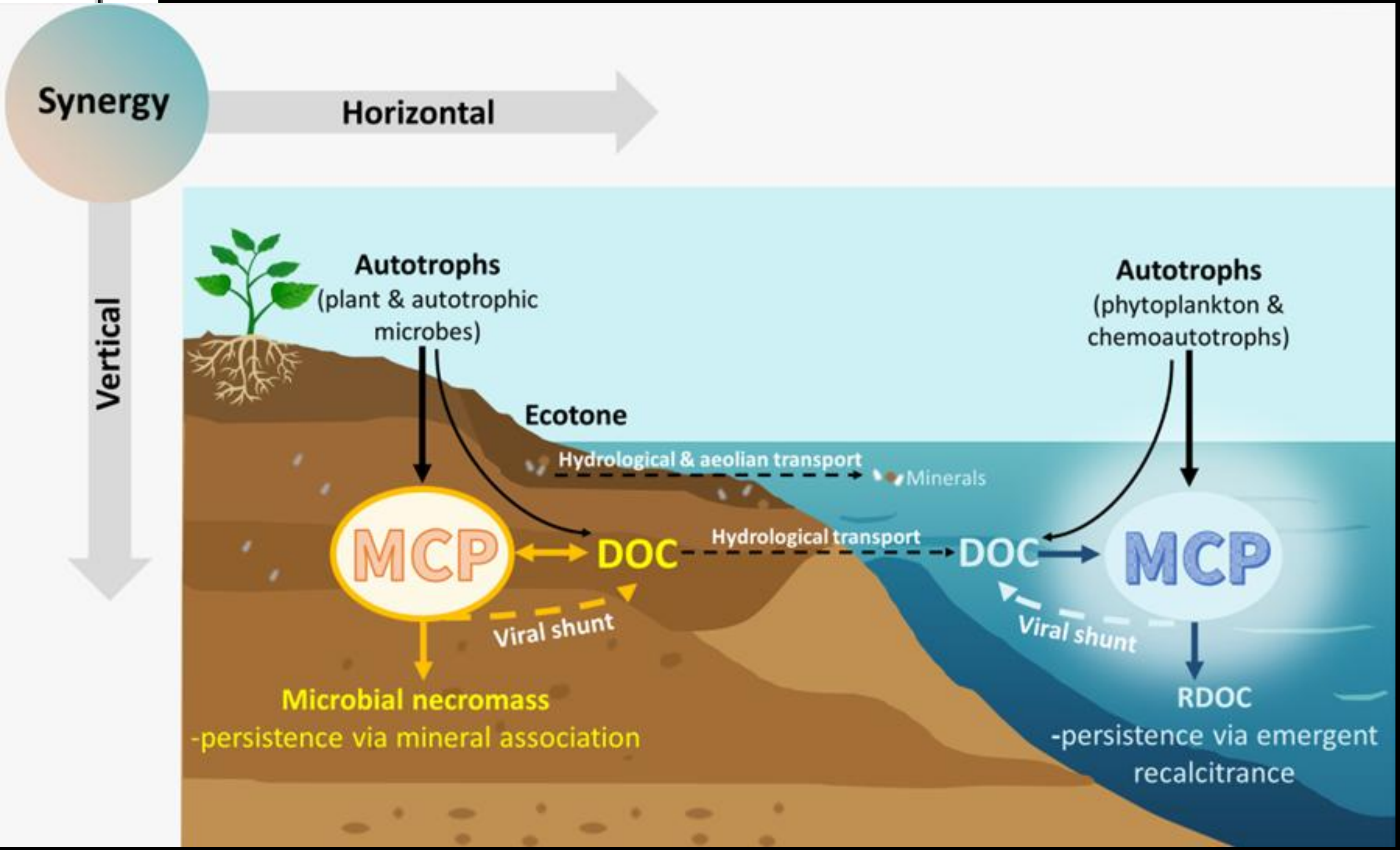
**Linking MCP with Coastal BC**

**MCP expands coastal blue carbon**



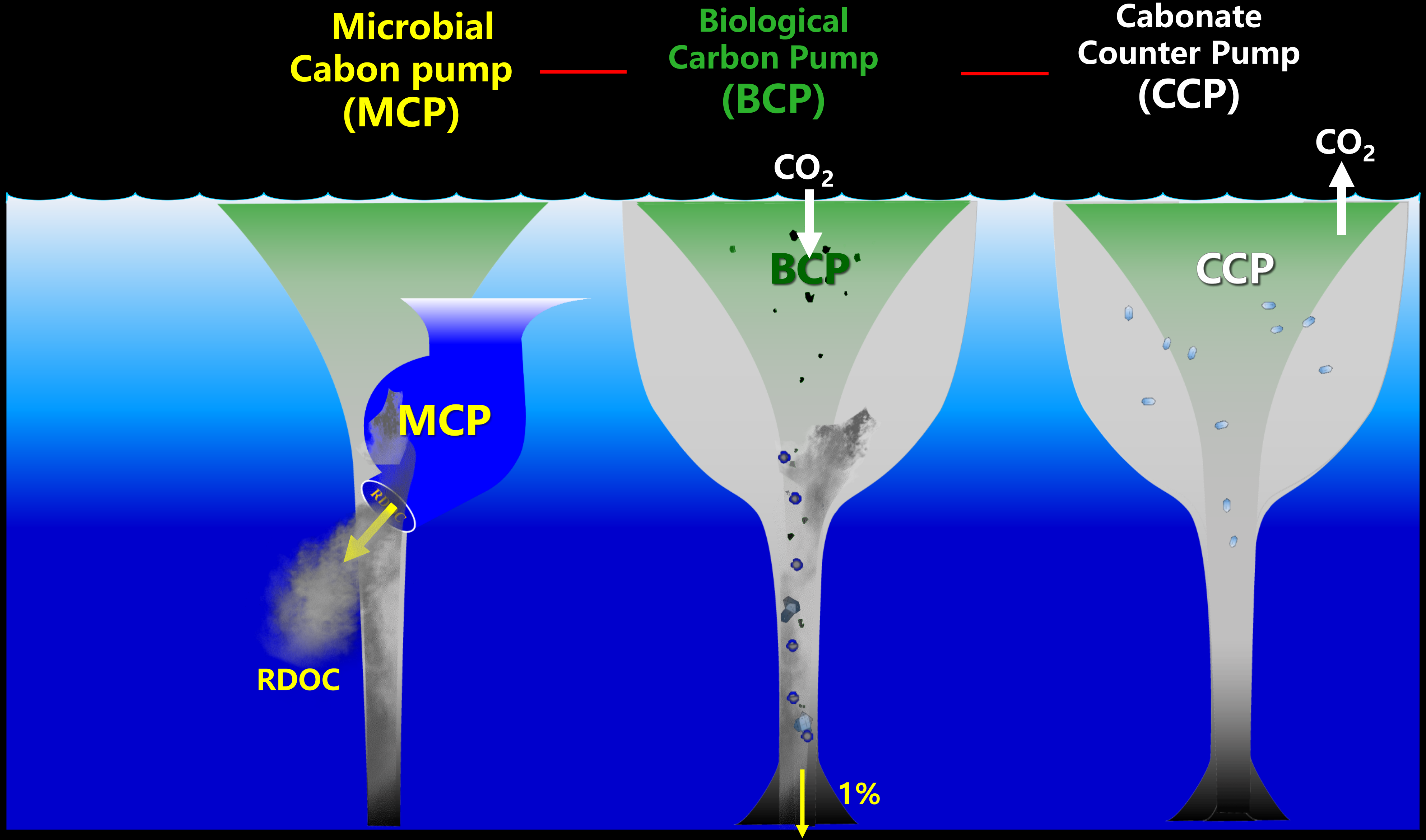
# MCP in marine and terriestrial environments




Lianget al

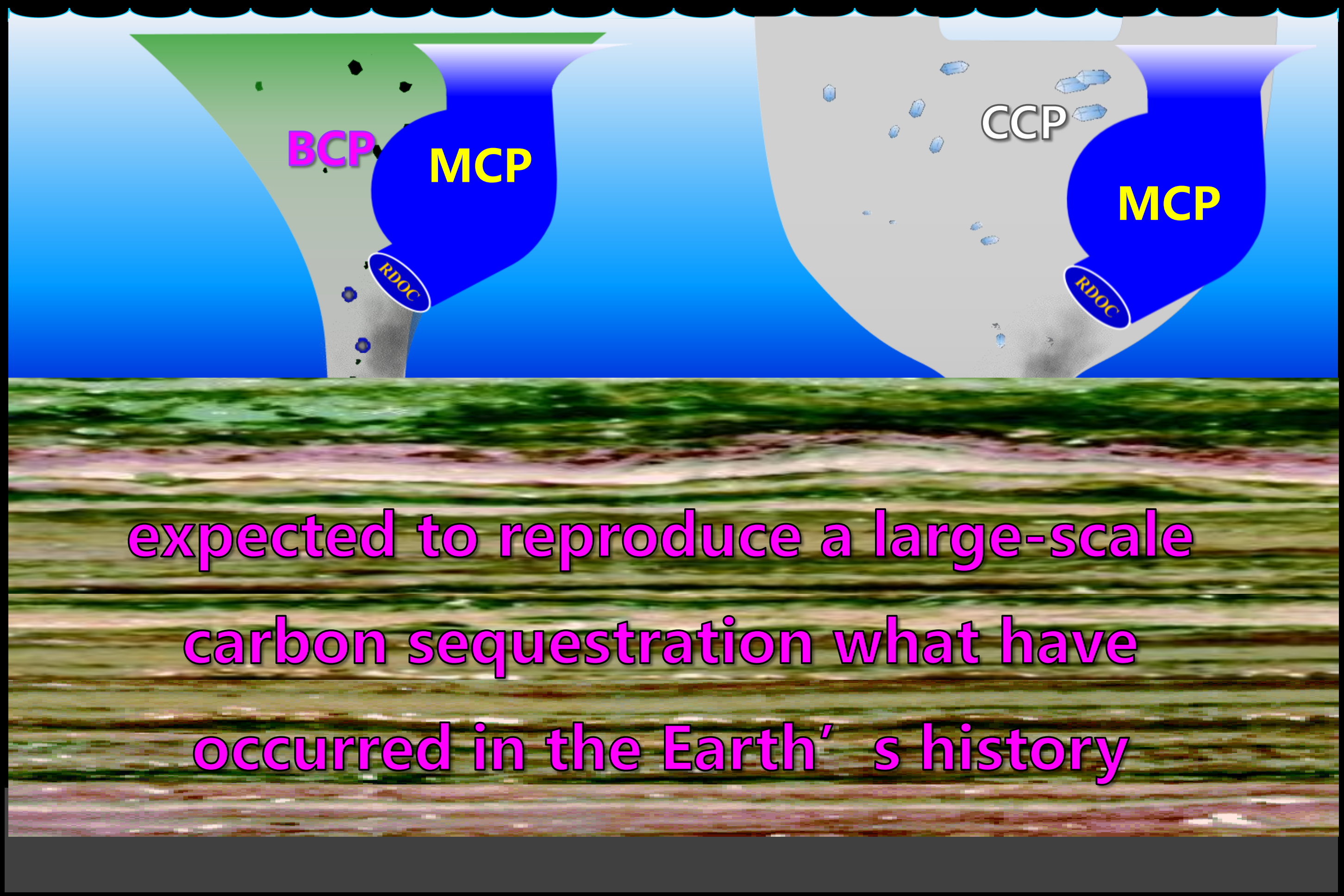
# Interactions & Synergistic effects of MCP-BCP-CCP on carbon storage



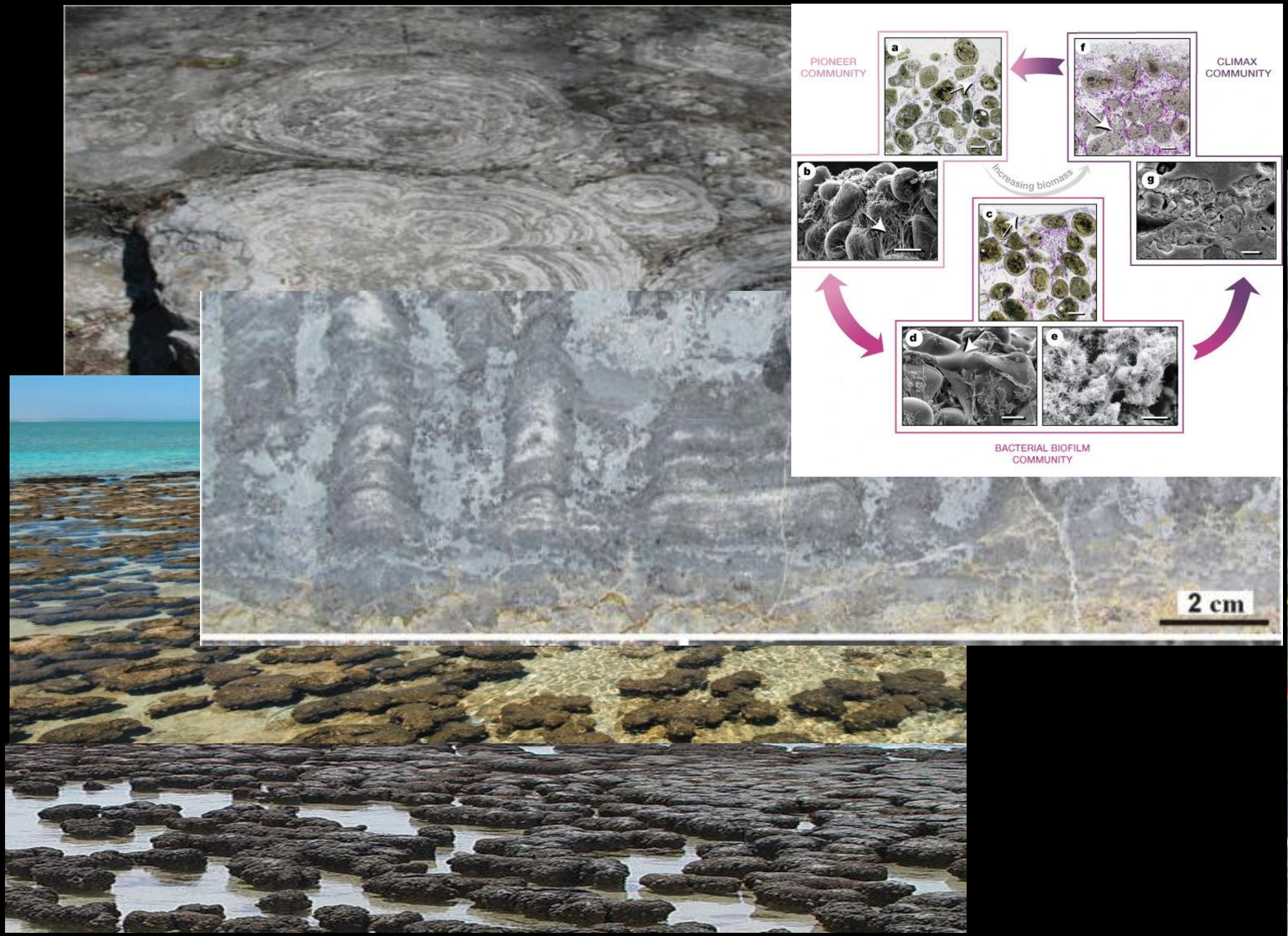
# Goal

Synergistic Carbon storage are expected to be achieved by regulating boundary conditions of the environemnt

BCP + MCP + CCP



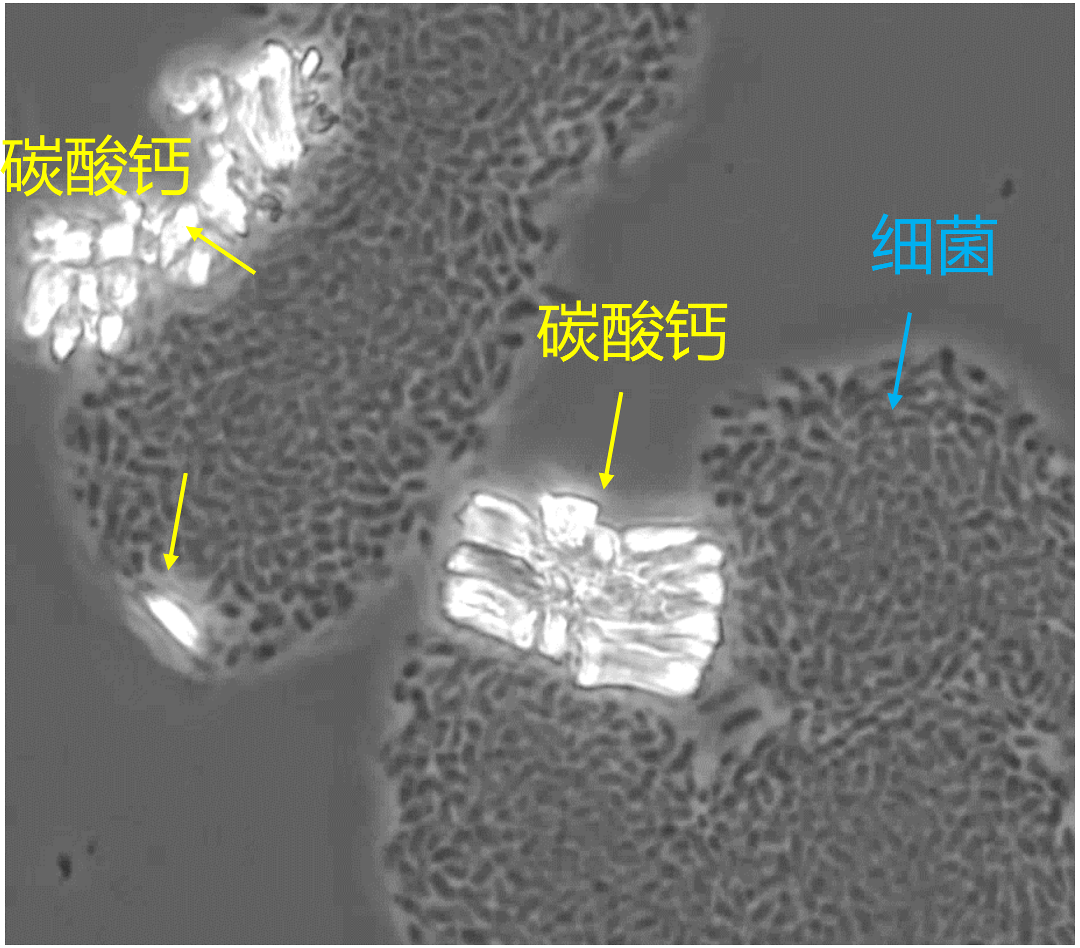
# Geological record of microbially induced carbonates sediments and rocks




(Reid et al., 2000, Nature)

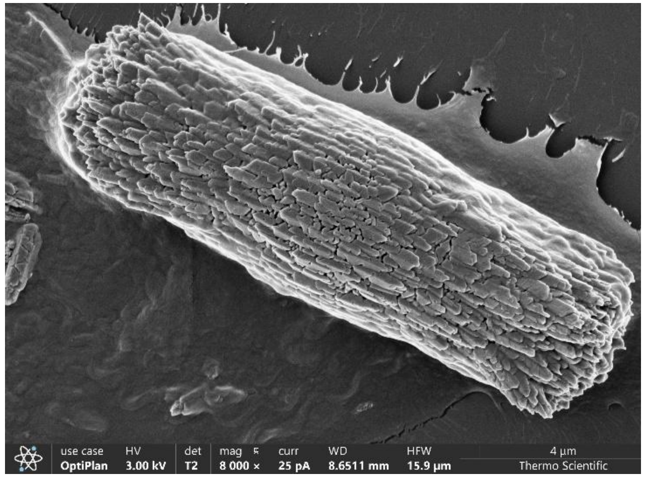
(Wang et al., 2018, Palaeogeography)

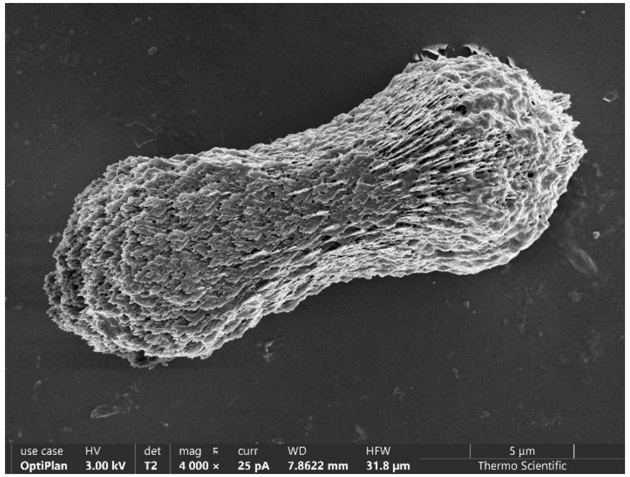
# Test out: Electronic microscopic observation of Microbial induced carbonates precipitation




晶体主要成分均为$CaCO_3$，长约10微米

以$Ca^{2+}$估算，沉降晶体比分占10-30%




纯化晶体后进行显微镜观察及能谱分析 Wang et al.

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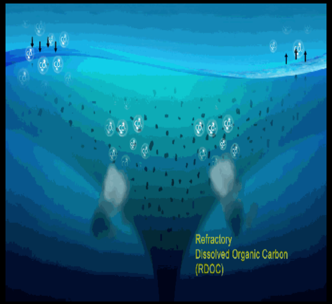


# Integrated ONCE approach

## for potential best practice

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# Approach -#1

**Jiao et al., 2011**

nature REVIEWS MICROBIOLOGY

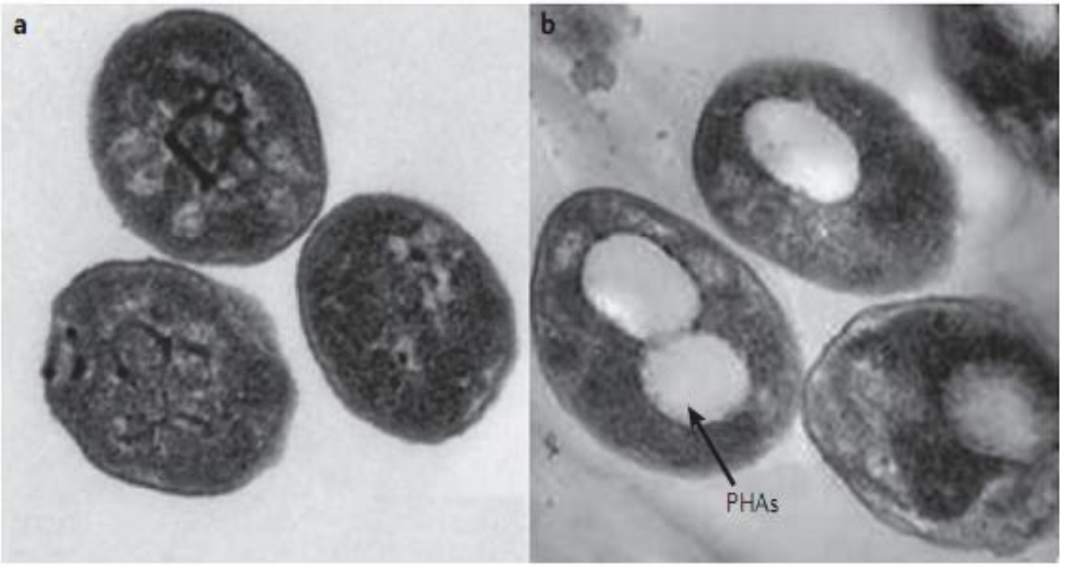
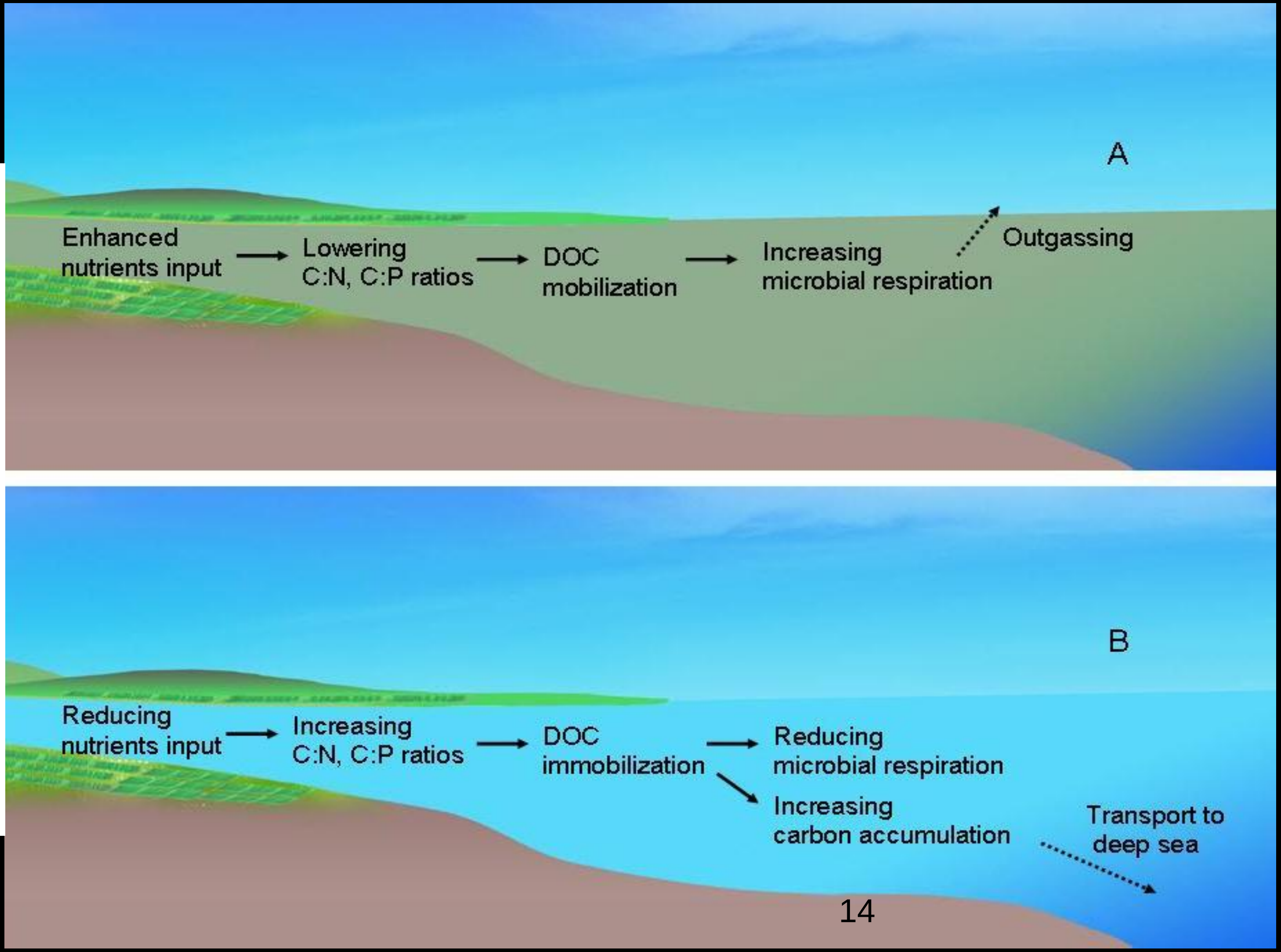



Figure 2 | **Increased carbon/nitrogen ratios induce the formation of polyhydroxyalkanoates (PHAs) as carbon-storage compounds.** Ultrathin-section transmission electron micrographs of *Dinoroseobacter* sp. JL1447 cultured with rich organic media. **a** | Glucose was added to the medium at a carbon/nitrogen ratio of ~3. **b** | Glucose was added to the medium at a carbon/nitrogen ratio of ~6.



Demo # 2

# Seaweeds - farming

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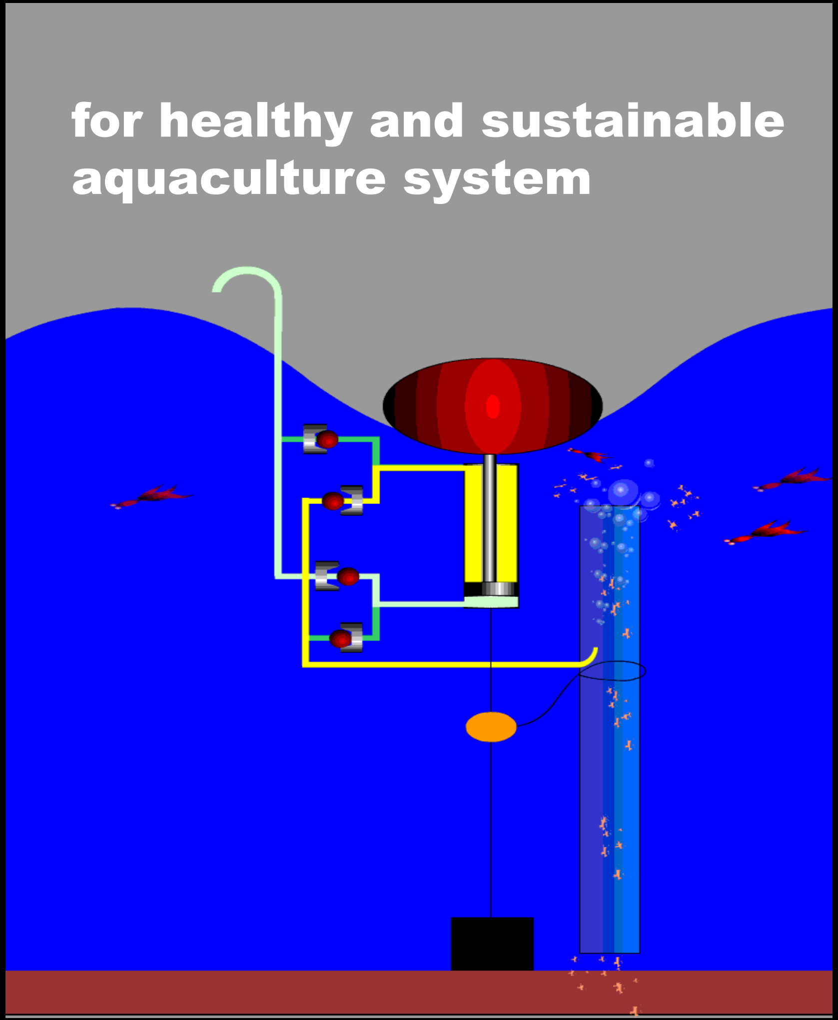
Sea farming in China

On site Demonstration

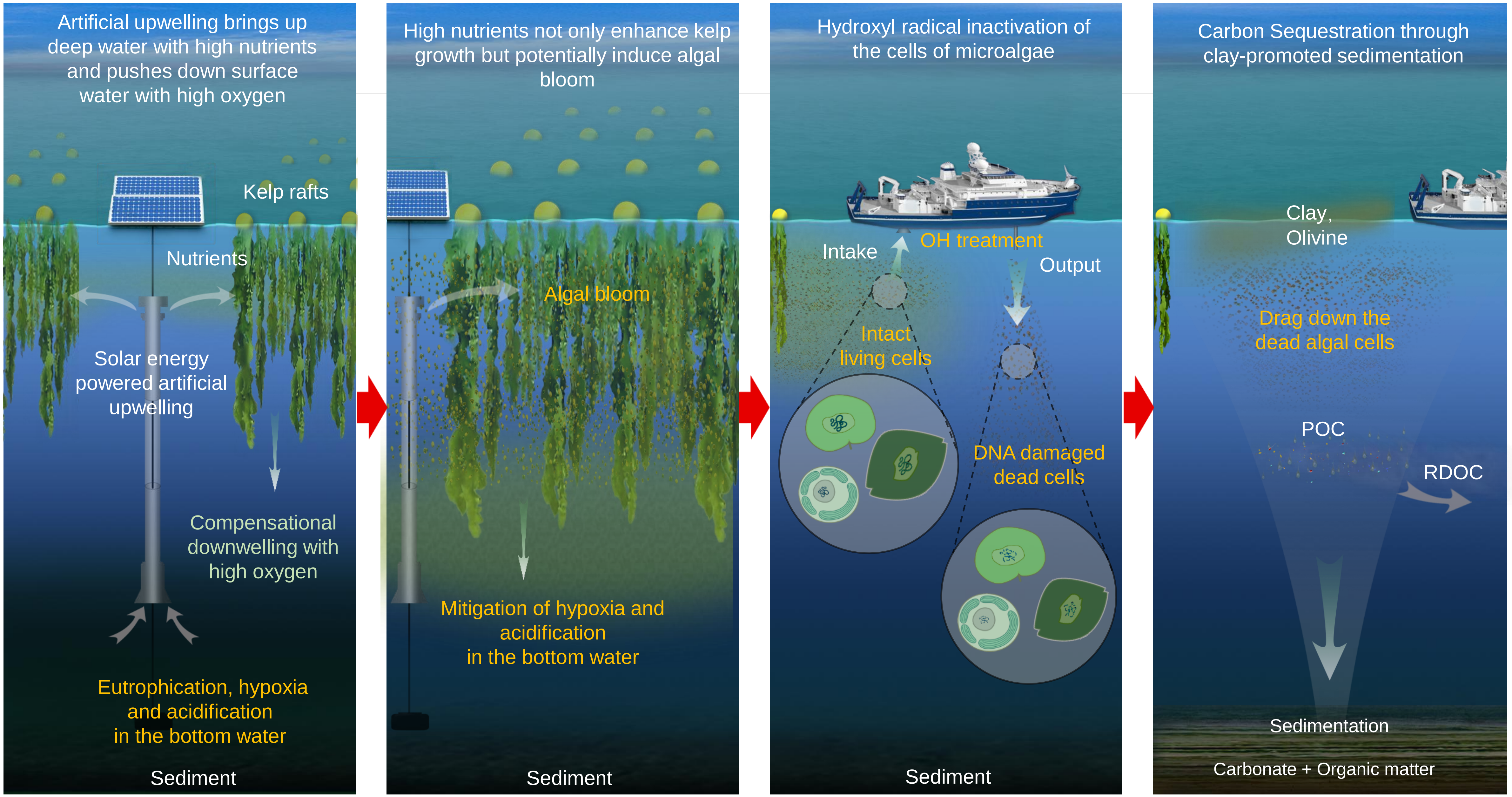
Demo # 3

# Artificial upwelling in seaweeds farming Environment

Grean energy driven Artificial upwelling system




XMU, ZJU, SDU



Artificial upwelling brings up deep water with high nutrients and pushes down surface water with high oxygen
Kelp rafts
Nutrients
Solar energy powered artificial upwelling
Compensational downwelling with high oxygen
Eutrophication, hypoxia and acidification in the bottom water
Sediment
High nutrients not only enhance kelp growth but potentially induce algal bloom
Algal bloom
Mitigation of hypoxia and acidification in the bottom water
Sediment
Hydroxyl radical inactivation of the cells of microalgae
Intake
OH treatment
Output
Intact living cells
DNA damaged dead cells
Sediment
Carbon Sequestration through clay-promoted sedimentation
Clay, Olivine
Drag down the dead algal cells
POC
RDOC
Sedimentation
Carbonate + Organic matter

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**Demo # 4**

# BCMS implementation in sea-farming fields

ONCE Application

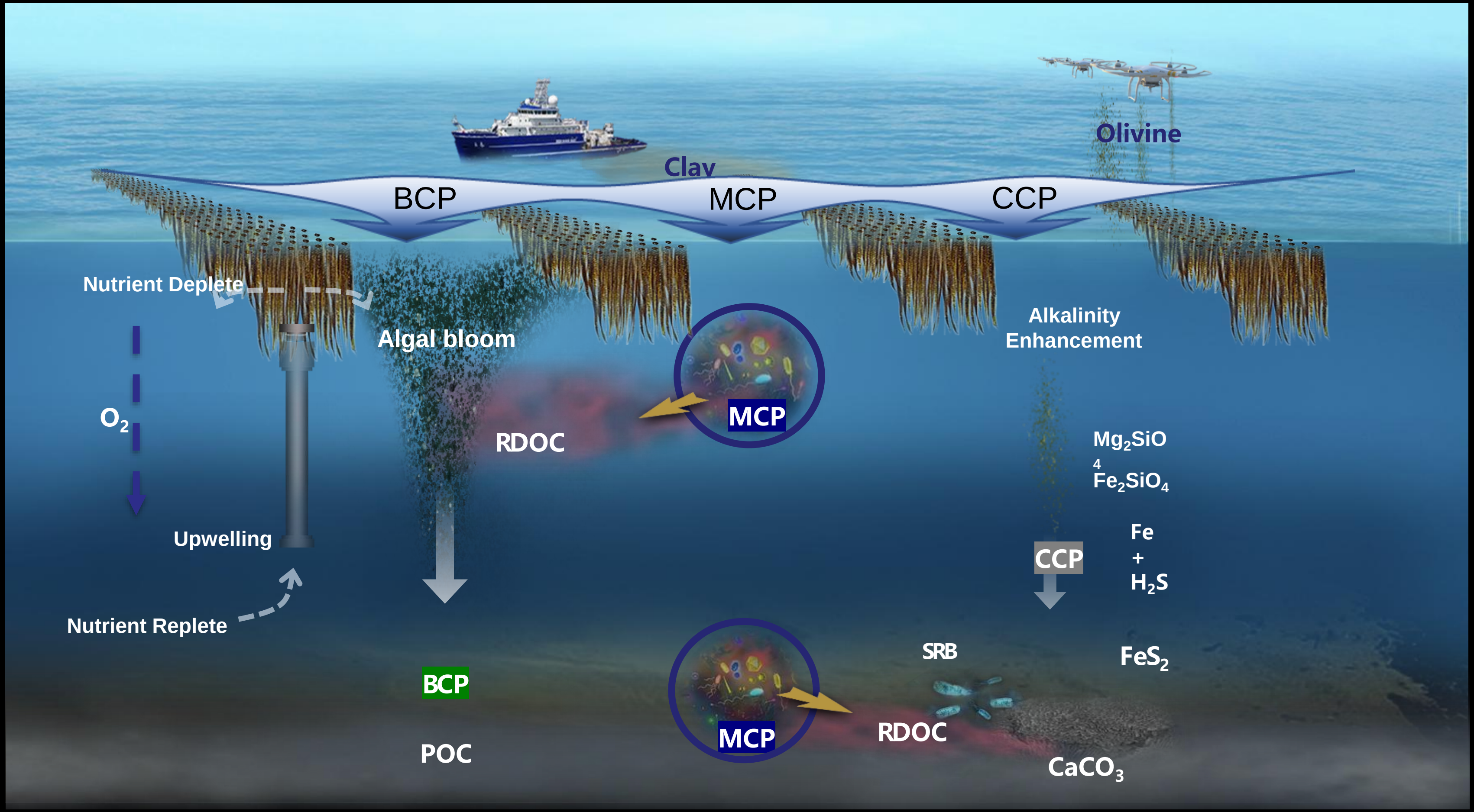
## BCMS Synergistic Effects

Biological carbon pump
Carbonate carbon pump
Microbial carbon pump
Solubility carbon pump

- Twin goals:
- enhancement of carbon sink
- remediation of the ecosystem;

Jiao et al., 2023; 20024

**B**usiness
**C**ontinuity
**M**anagement
**S**ystem




## SMART approach

**S**pecific
**M**anageable
**A**chievable
**R**ealistic
**T**ransparent

**A Potential Best Practice**

Demo # 5

# ONCE via Wastewater Treatment Plants (WWTP)

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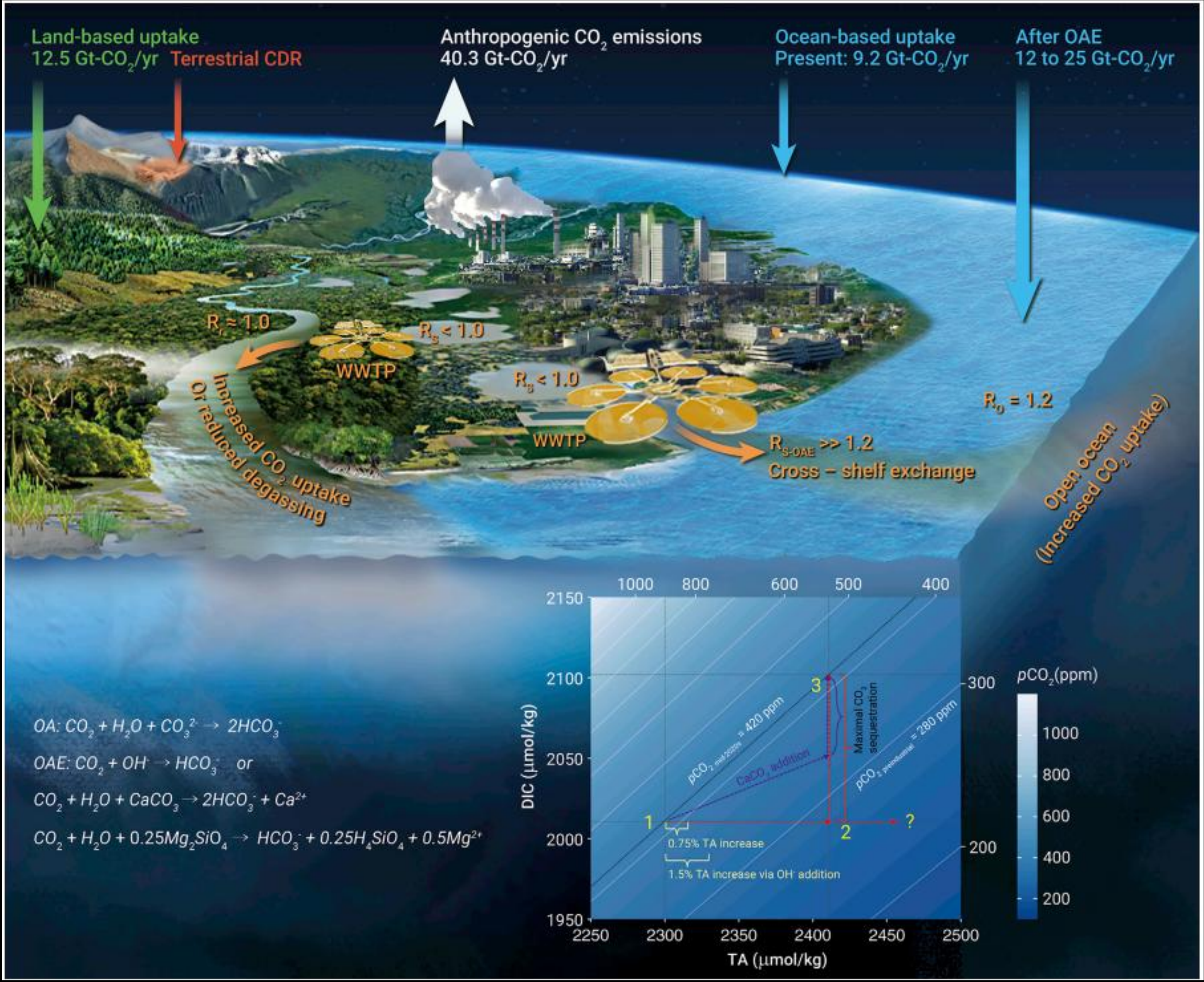


## Approaches

- Harness Microbial processes
- Enhance alkalinity

## Turning WWTPs

- From sources to sinks
- From Invested to Profits

Cai& Jiao 2022,

*The Innovation*

Policy Proposal

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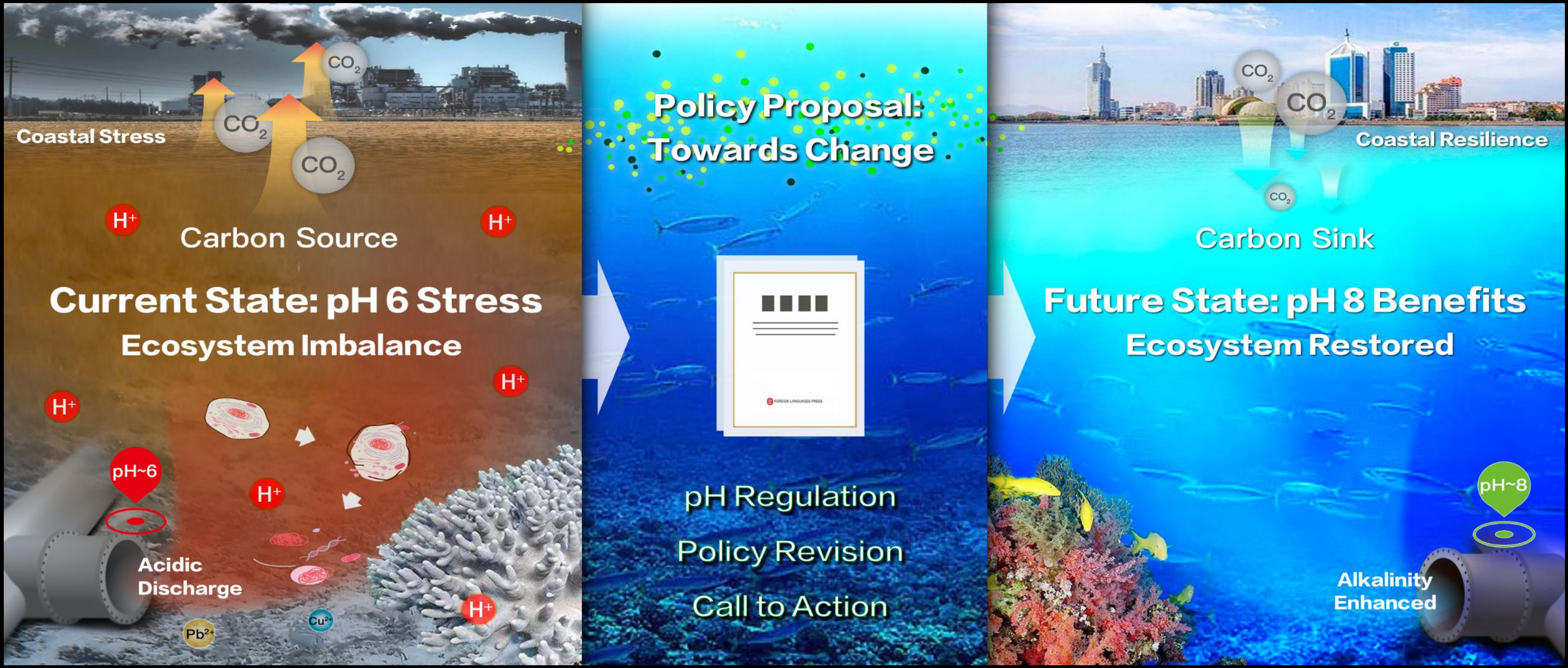
# Wastewater Treatment Plants effluent pH lower limit: < 6.0 → > 8.0




Increasing the lower limit of effluent pH from <6.0 to >8.0 for mitigation of coastal water acidification and toxicity of heavy metals, and enhancement of carbon sequestration and sustainable development.

Meng & Jiao 2025

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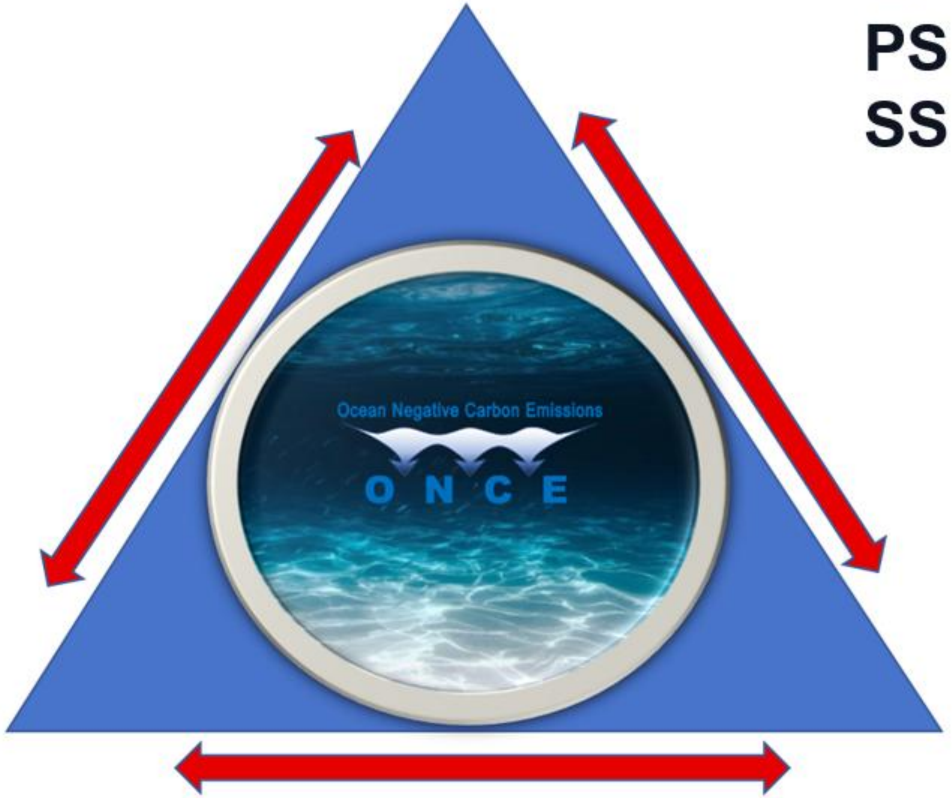
# Science – Policy – Society (SPS)

**Policy**




**Science**

**Society**

**SP** —— link **Science** to **Policy**

**PS** —— Make **Policy** work for **Science**

**SS** —— Promote **Science** serve the **Society**

**Thanks for your attention !**

ISO Standards

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# ISO TC8- WG15 for ONCE and Carbon Neutralization

ISO/NP25283-1

2023。10

# Global ONCE Triple REAL Visions

## Triple R for ONCE approaches

- **R**ealistic, **R**eliable – ISO-certified, **R**eproducible
  *(Ensuring technically sound and verifiable action)*

## Triple E for ONCE implementation

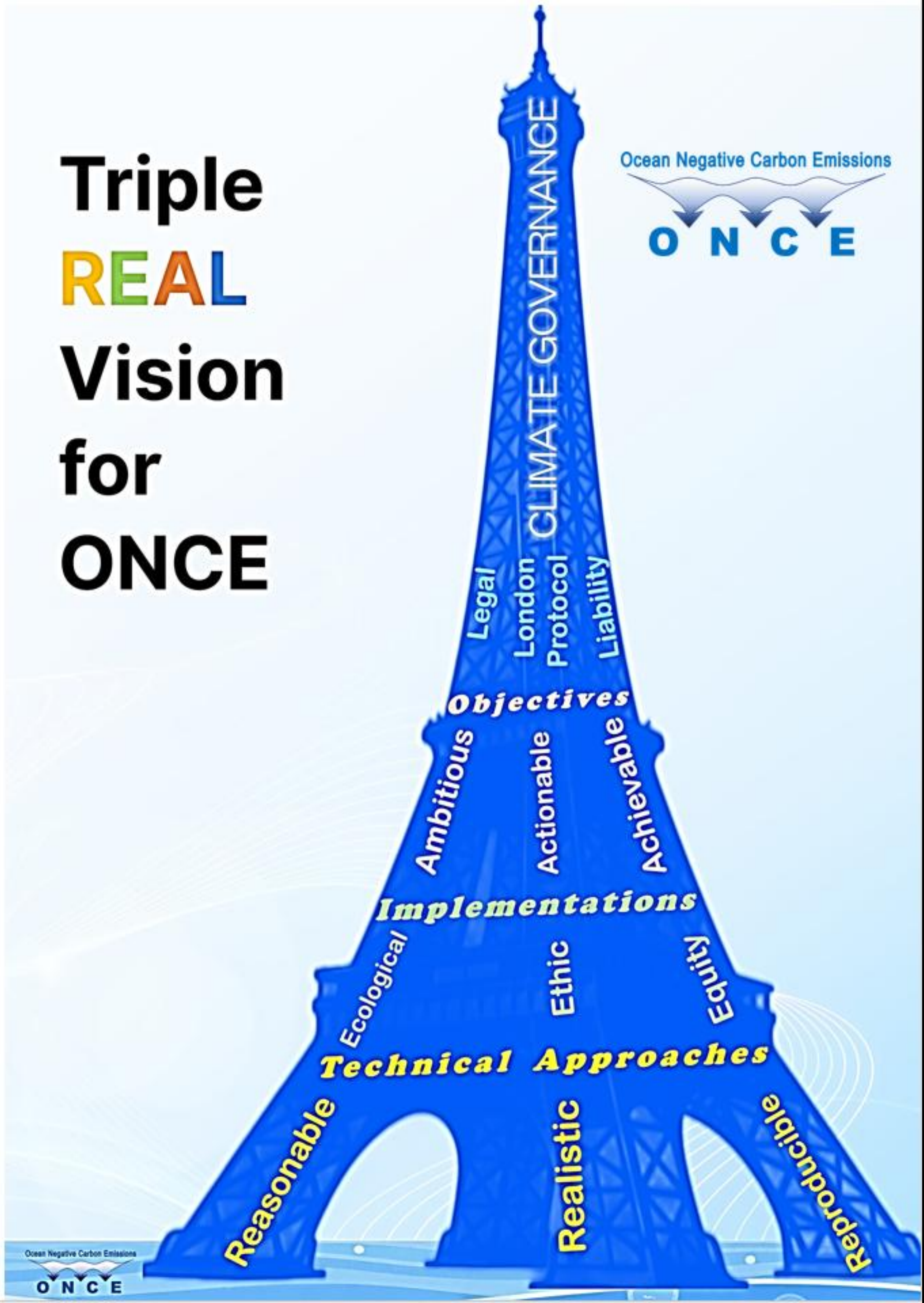
- **E**cological , **E**thic , with **E**quity
  *(Balancing environment and social justice)*

## Triple A for ONCE objectives

- **A**mbitious, **A**ctionable, **A**chievable
  *(Bridging ambition with execution and feasibility)*

## Triple L for ONCE Governance

- **L**egal, by **L**ondon Protocol, with **L**iability
  *(Strengthening compliance, treaties, and enforcement)*



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# Ocean Negative Carbon Emissions (ONCE)

**Thanks for your attention !**