

The logo for the National Oceanography Centre, featuring a white square with a black border. The text "National Oceanography Centre" is written in black, sans-serif font inside the square.

National
Oceanography
Centre

Global ocean observations for equitable knowledge-based
decision making

OCEAN-BASED CARBON DIOXIDE REMOVAL

PROFESSOR ED HILL CBE

WHAT IS CARBON DIOXIDE REMOVAL (CDR)?

“Deliberate human activities – using technologies, practices and approaches - that **remove** and **durably store** carbon dioxide **from the atmosphere**”

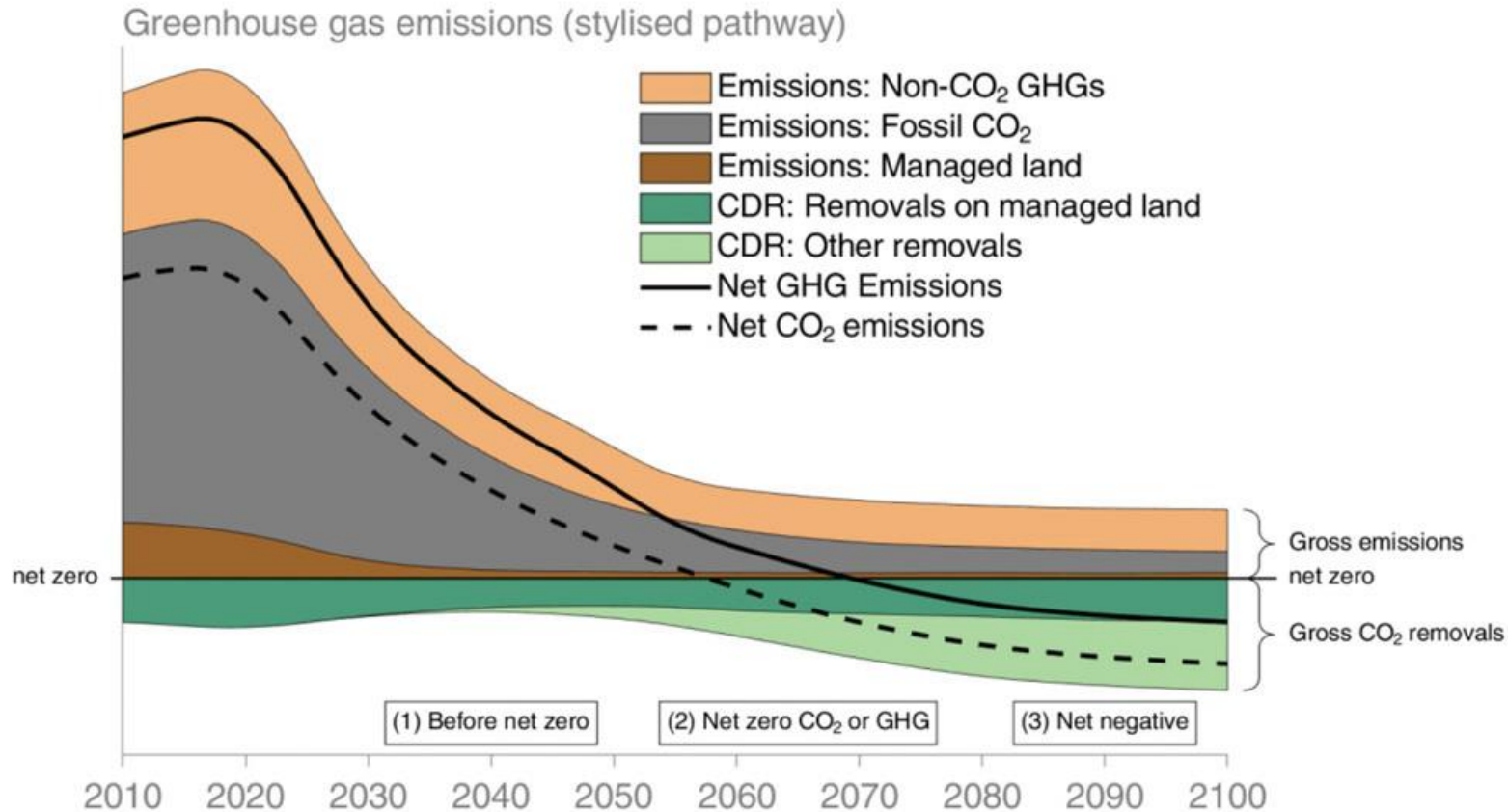
“Storage can be vegetation on land, soils, geological formations, manufactured products or in the **ocean and coastal marine environments**”

IPCC 6th Assessment Working Group III Report

Marine-based CDR (mCDR) when

CO₂ removal takes place in a marine environment (not just storage in marine environment)

SOME BIG NUMBERS



For Net Zero: Remove 5-10 billion tonnes CO₂ per year?

For Clean up: Remove 950 Gt over 100 years, say = 10Gt/year

How much feasible by enhancing ocean uptake?

BIG NUMBERS (continued)



Carbon Price: \$100/t CO₂

Remove: 10Gt/year

**Annual value:
\$1,000,000,000,000**

What first attracted you to the trillion-dollar CDR industry?

WHY THE OCEAN ?

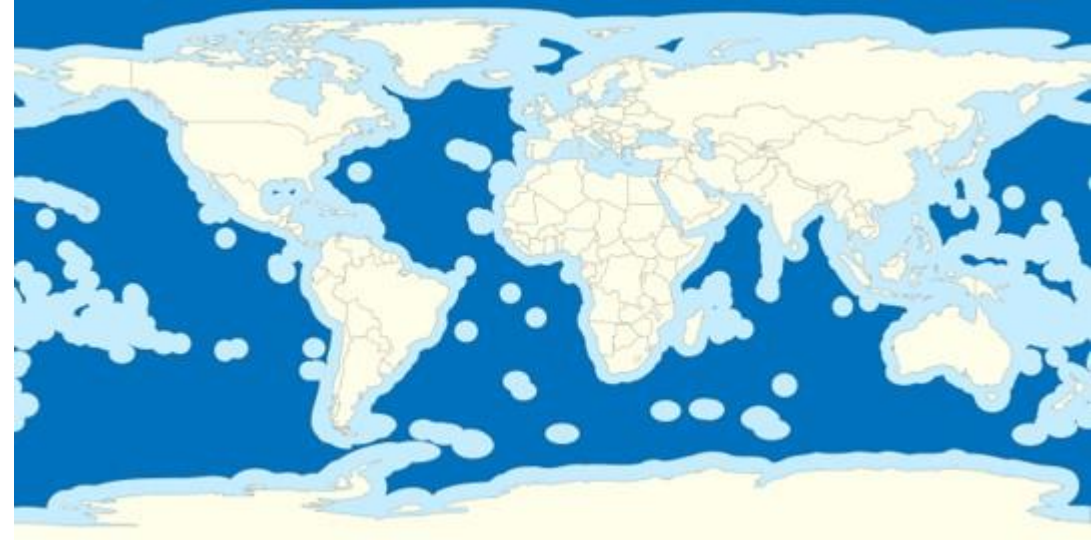
70% EARTH'S SURFACE IN CONTACT WITH ATMOSPHERE



UK land area
242,495 km²
0.05%



UK EEZ
773,676 km²
0.15% [x3]



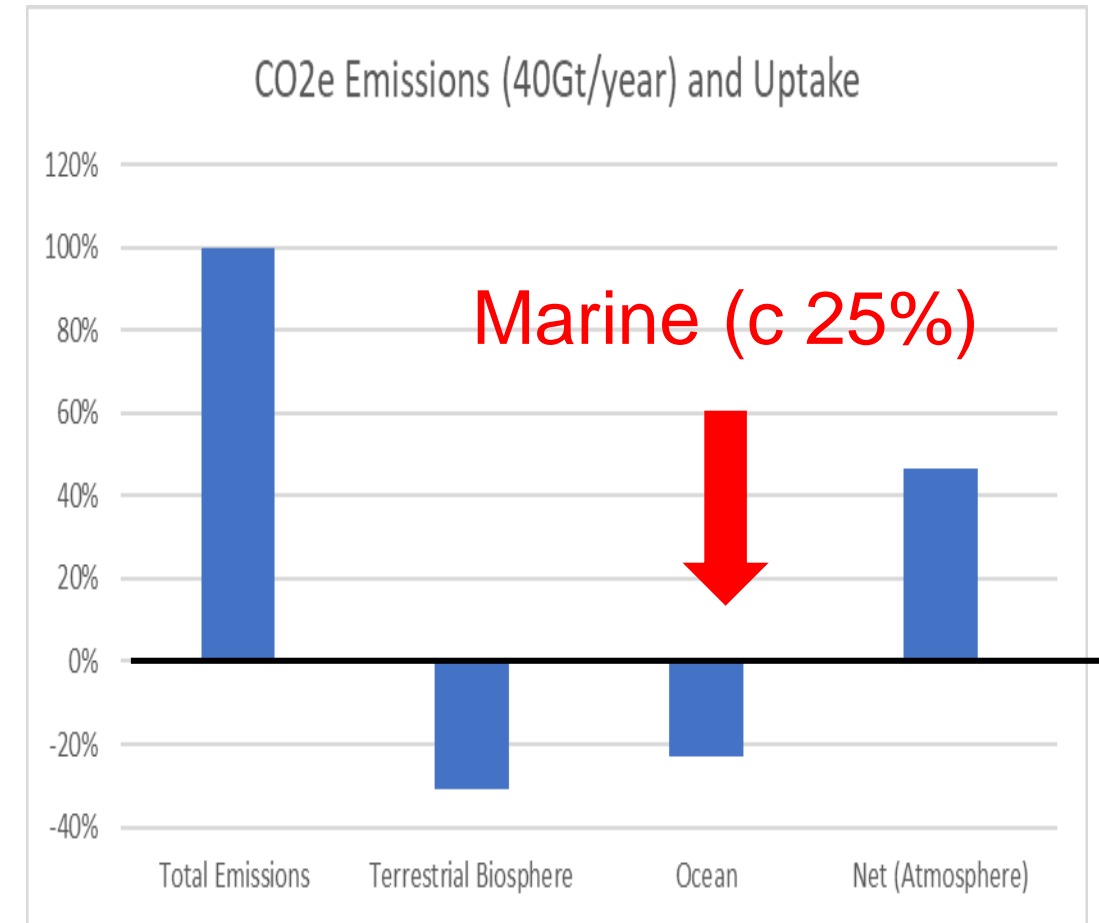
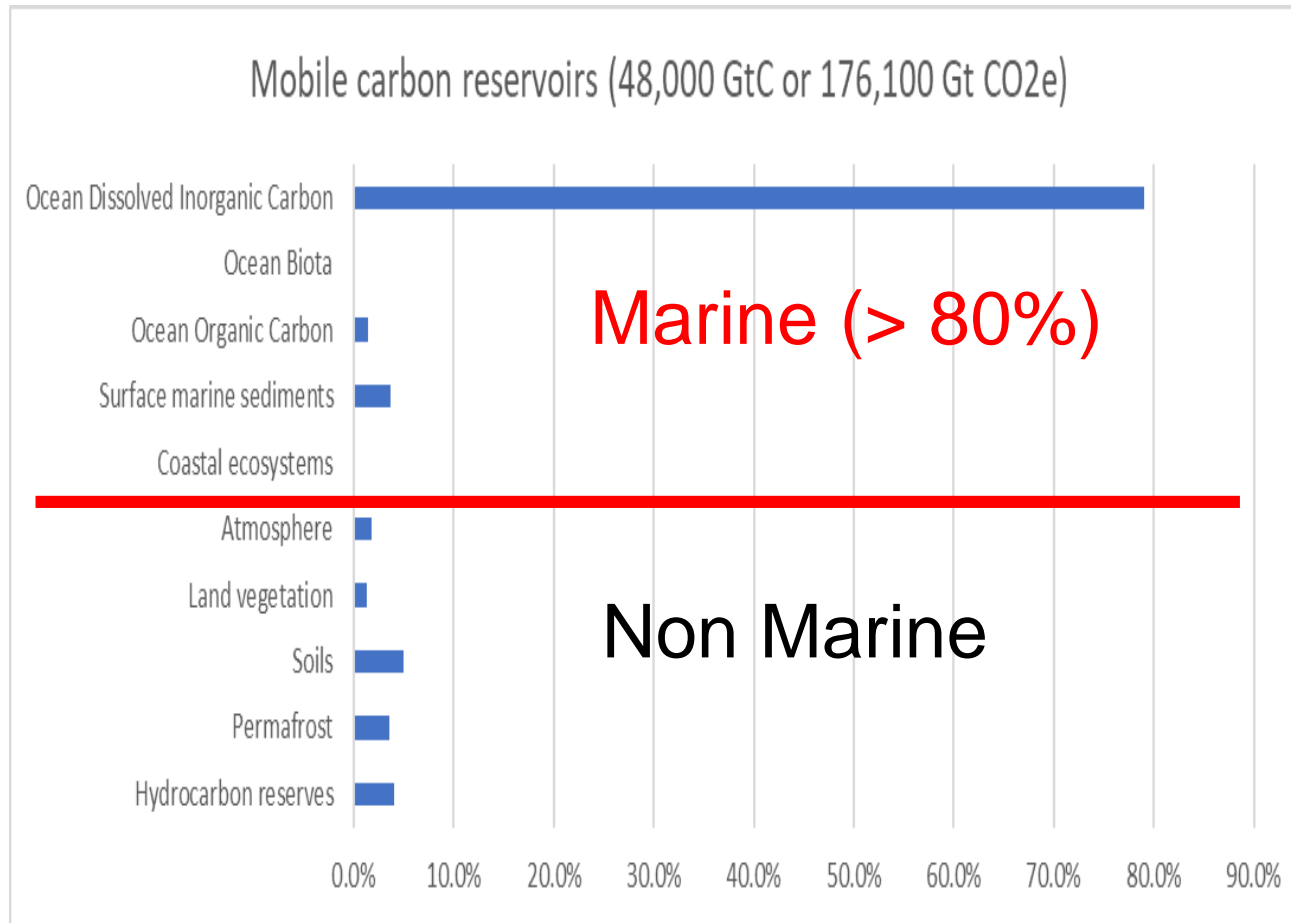
International waters
255,050,250 km²
50% [x1050]

% indicates relative proportion of Earth's surface. [x] shows increase relative to UK land area.

What parts of the ocean are most suitable for different techniques?

WHY THE OCEAN?

80% OF EARTH'S MOBILE CARBON – LONG DURATION 100'S-1000'S YEARS



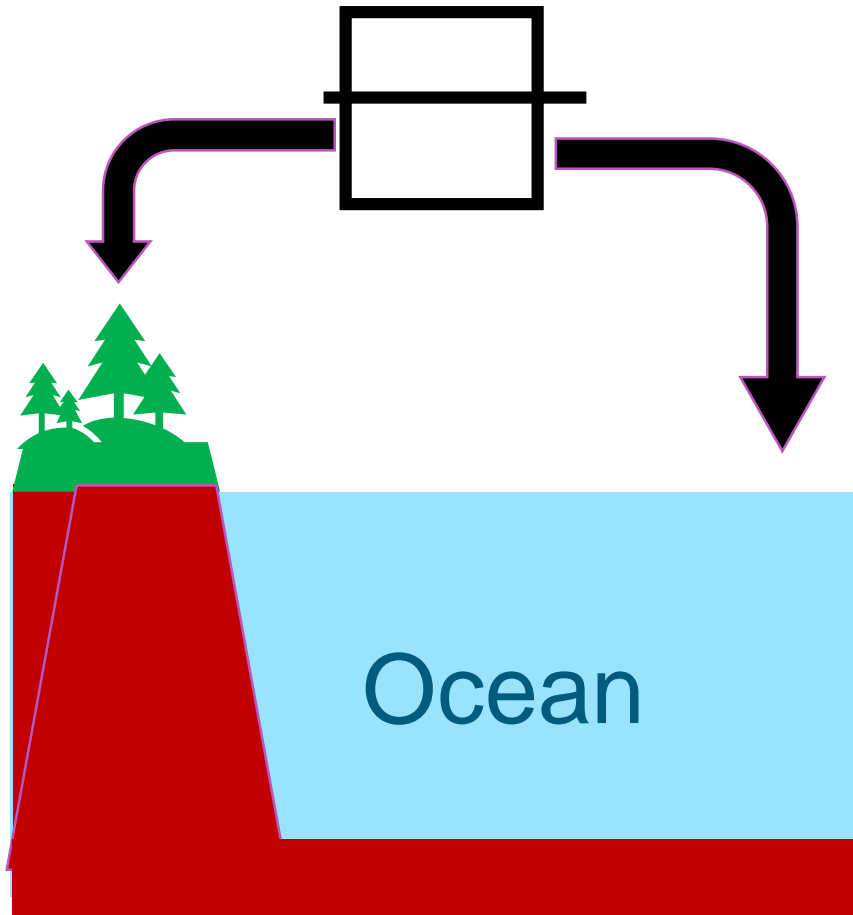
What is the ultimate aim for mCDR?

Ocean takes up 10Gt/y – enhance it by 1Gt/y (10%), 10Gt/y (100%), more?

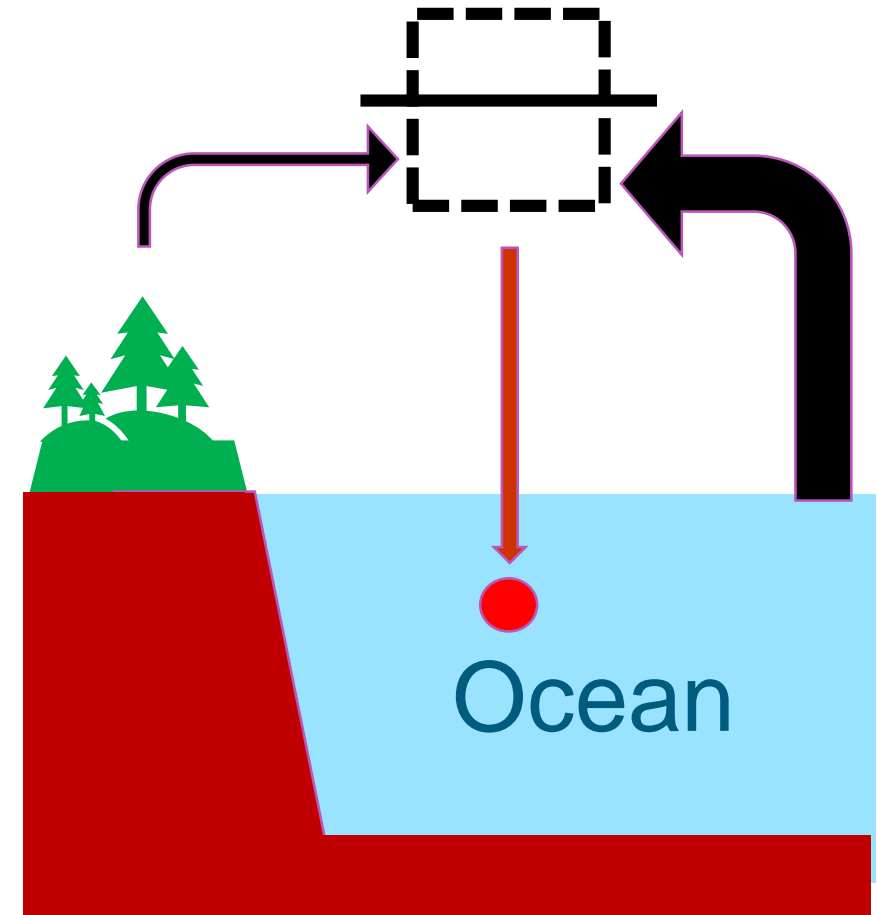
COMPLEX OCEAN-ATMOSPHERE INTERACTIONS AT GLOBAL SCALE

MEASUREMENT OF LOCAL CO₂ REMOVAL DOES NOT TELL WHOLE STORY

Add CO₂

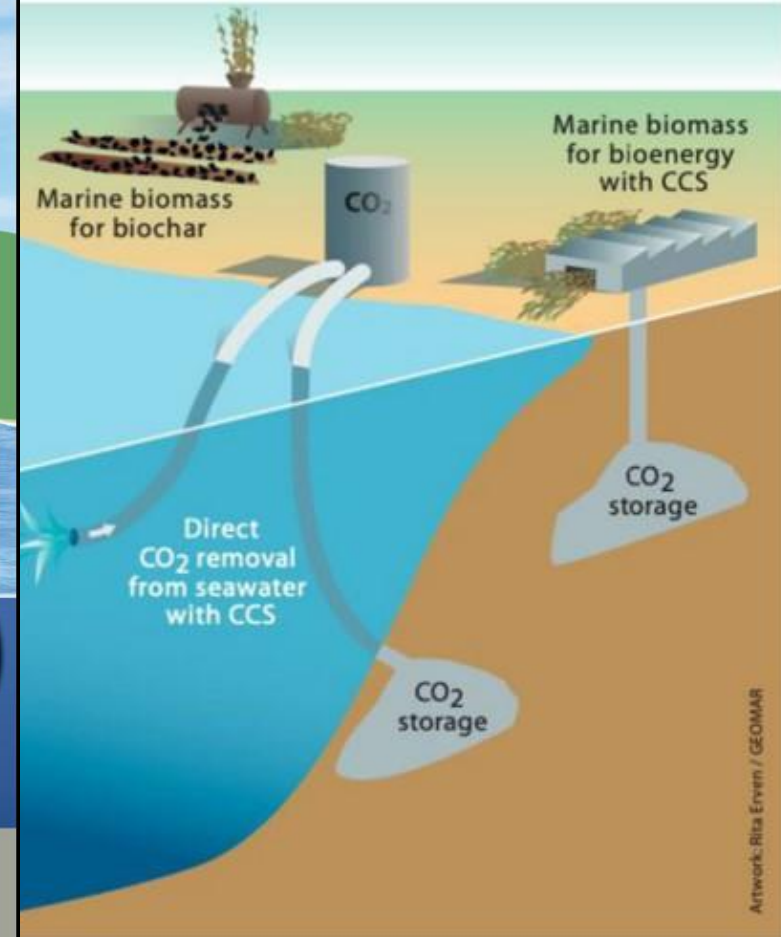
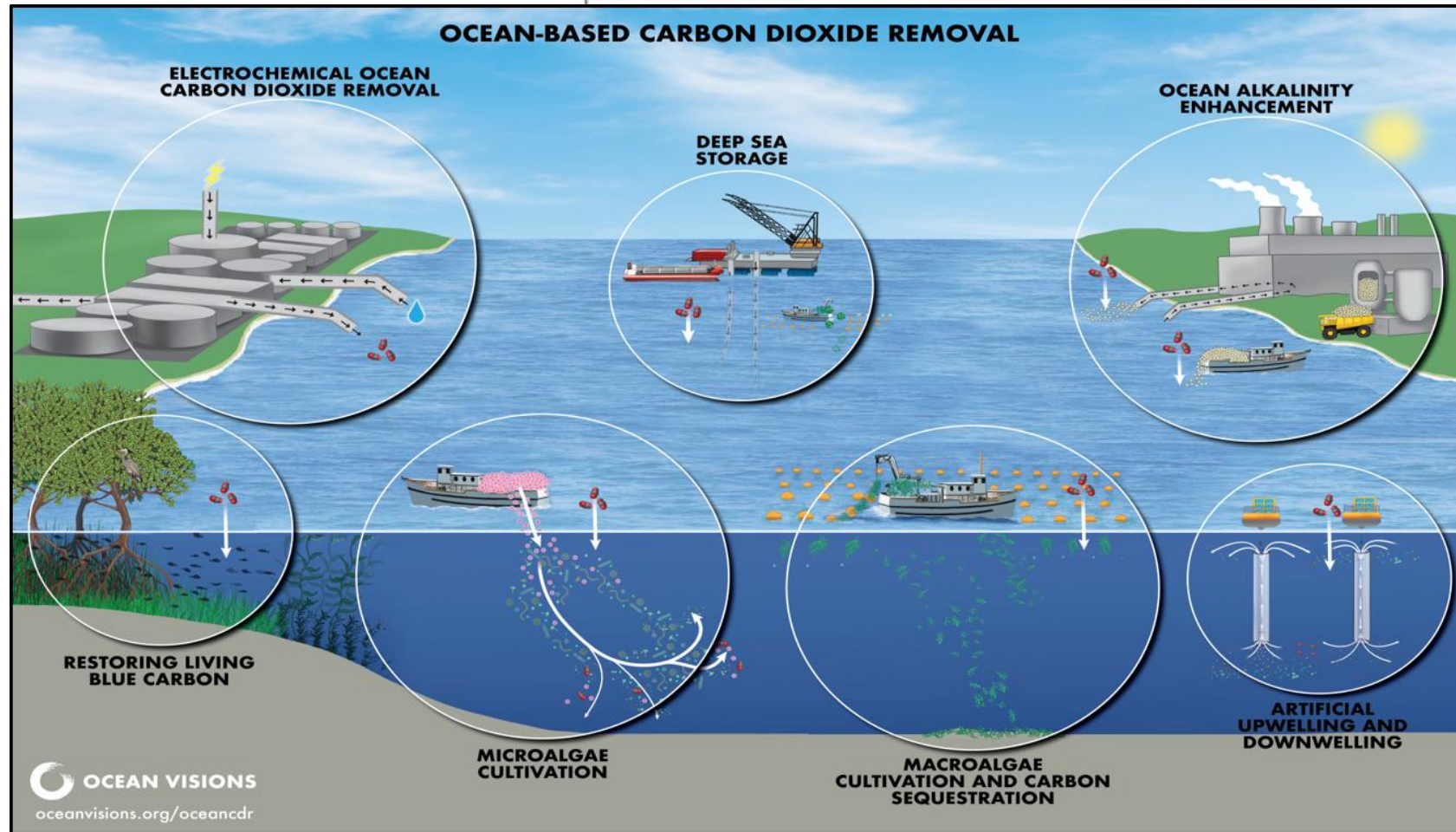


Remove CO₂



And are we competing with natural ocean CO₂ uptake reducing?

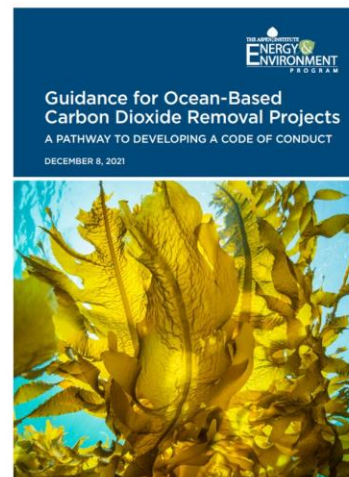
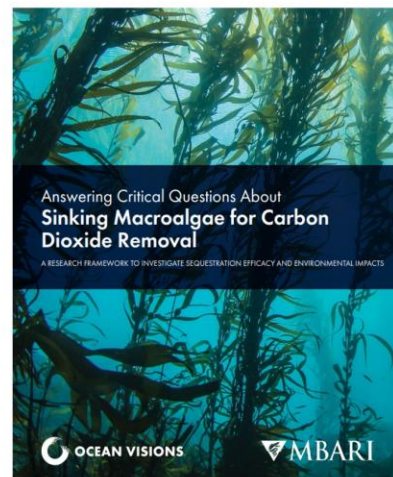
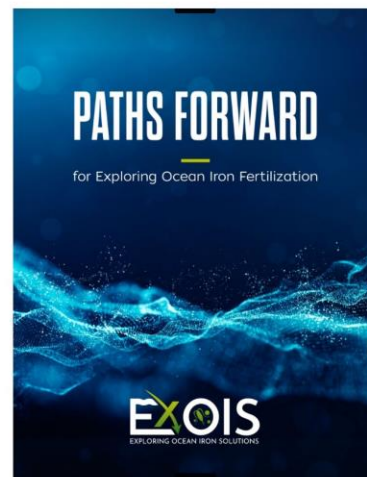
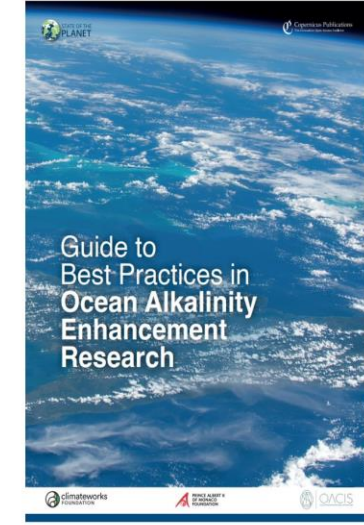
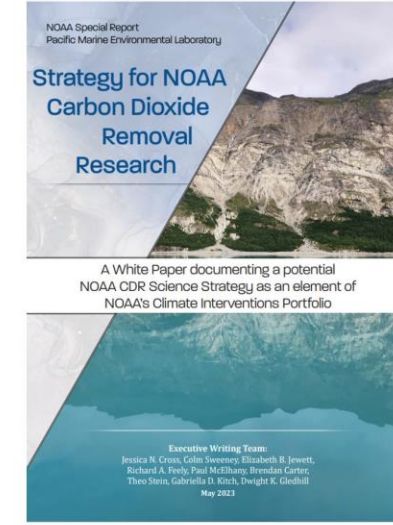
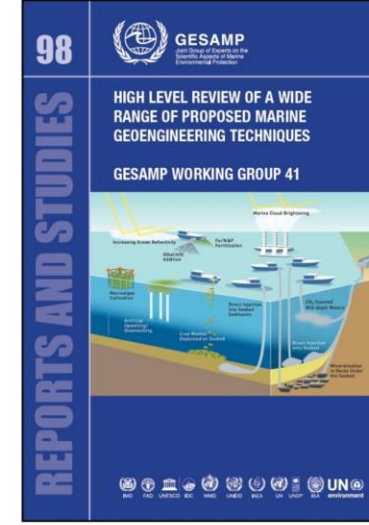
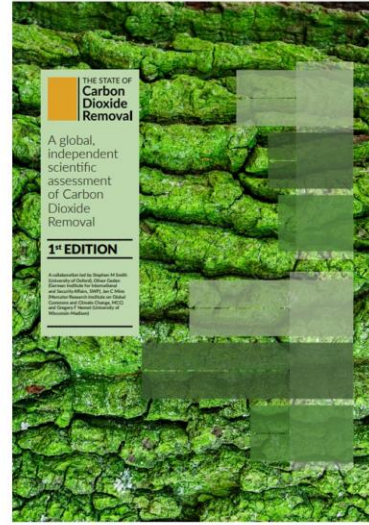
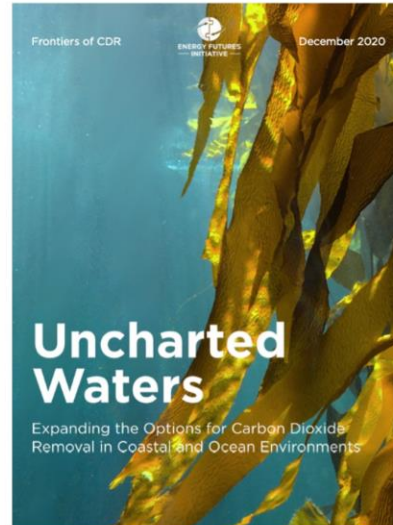
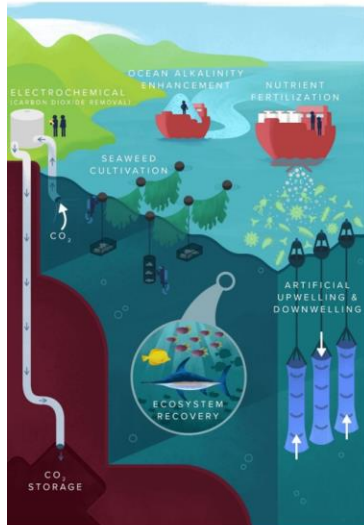
SOME MARINE BASED CDR TECHNIQUES



Boettcher et al. (2021)

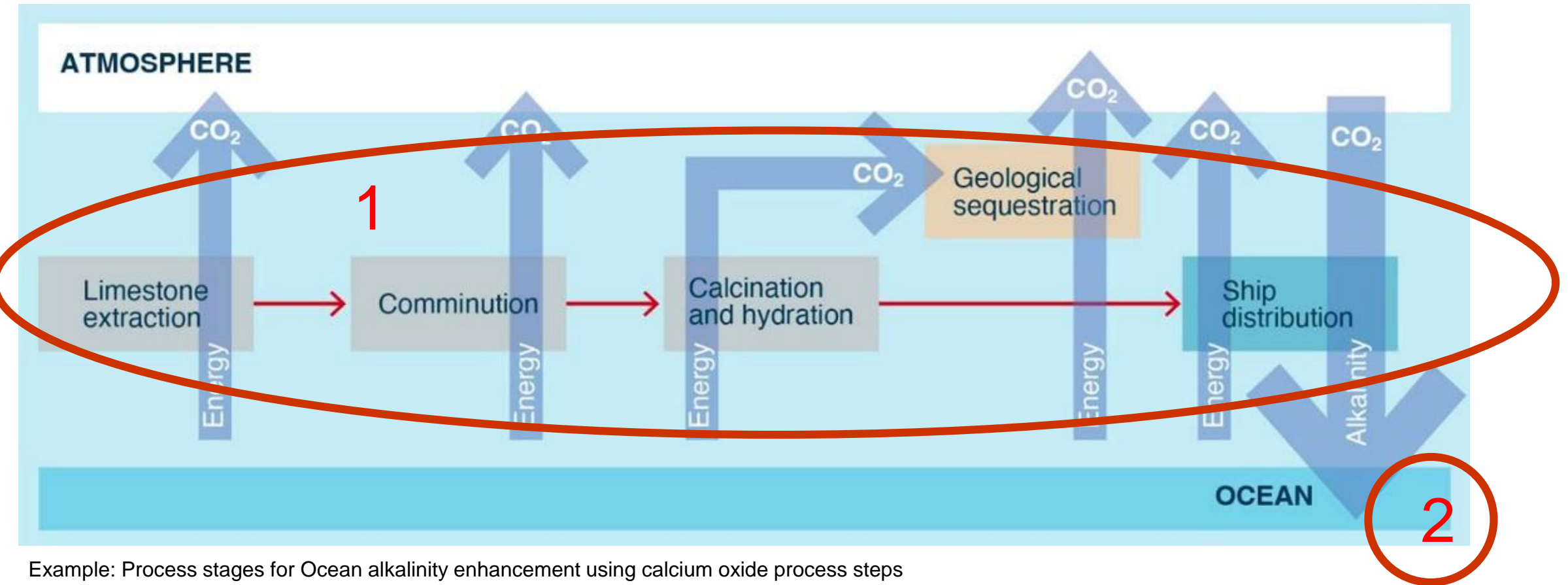
What is their efficacy, impact, permanence, scalability?

OCEAN CDR: GROWING INTEREST IN THE OPTIONS



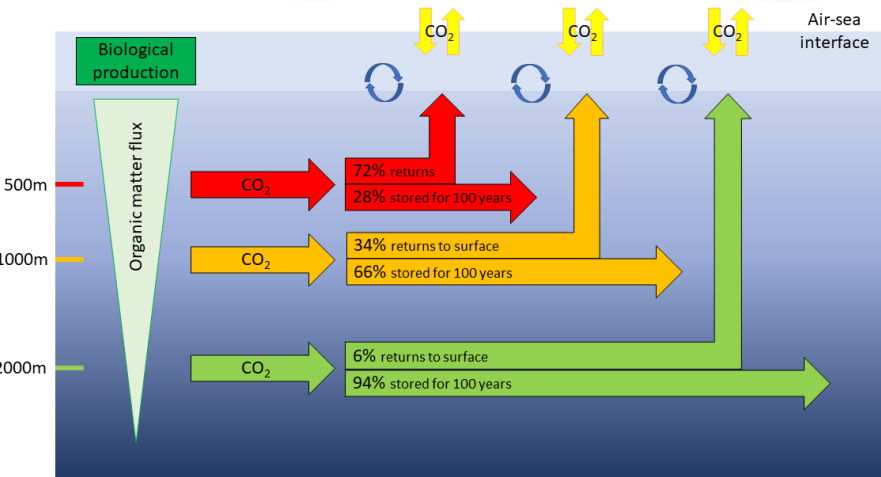
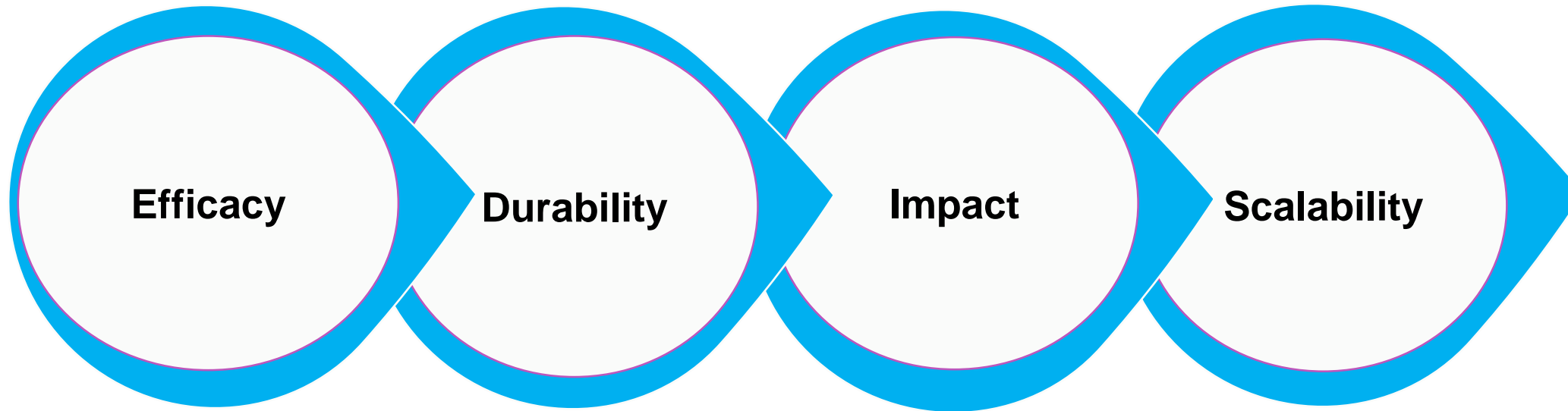
Who is interested and how to focus effort?

RESEARCH: LIFE CYCLE ANALYSIS AND TECHNO-ECONOMIC ASSESSMENTS



(1) Do total volumes of mineral materials used, energy consumption, CO₂ production and costs of processes stack up - before the ocean?

RESEARCH: EVALUATING CDR APPROACHES (IN THE OCEAN)



IN THE OCEAN

- ✓ Small-scale controlled field trials
- ✓ Diverse ocean settings
- ✓ Operational requirements
- ✓ Design/test Monitoring Reporting Verification (MRV)

Durability dependent on depth and location

(2) How much CO₂ can be removed, for how long, what are impacts?

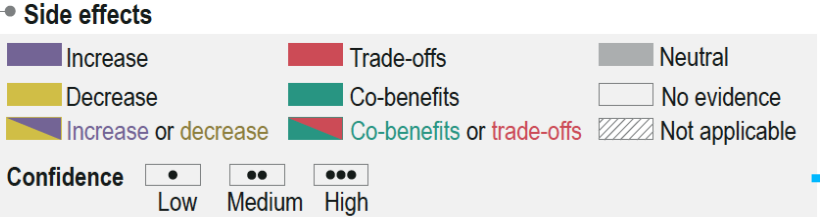
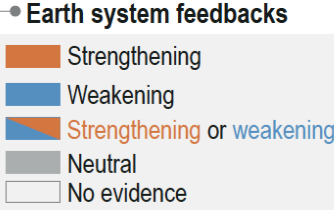
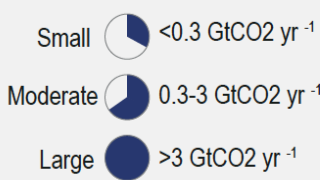
HEADLINE EVALUATION



Timescale of carbon storage

CDR methods

Biogeophysical or technical sequestration potential



Biogeochemical effects

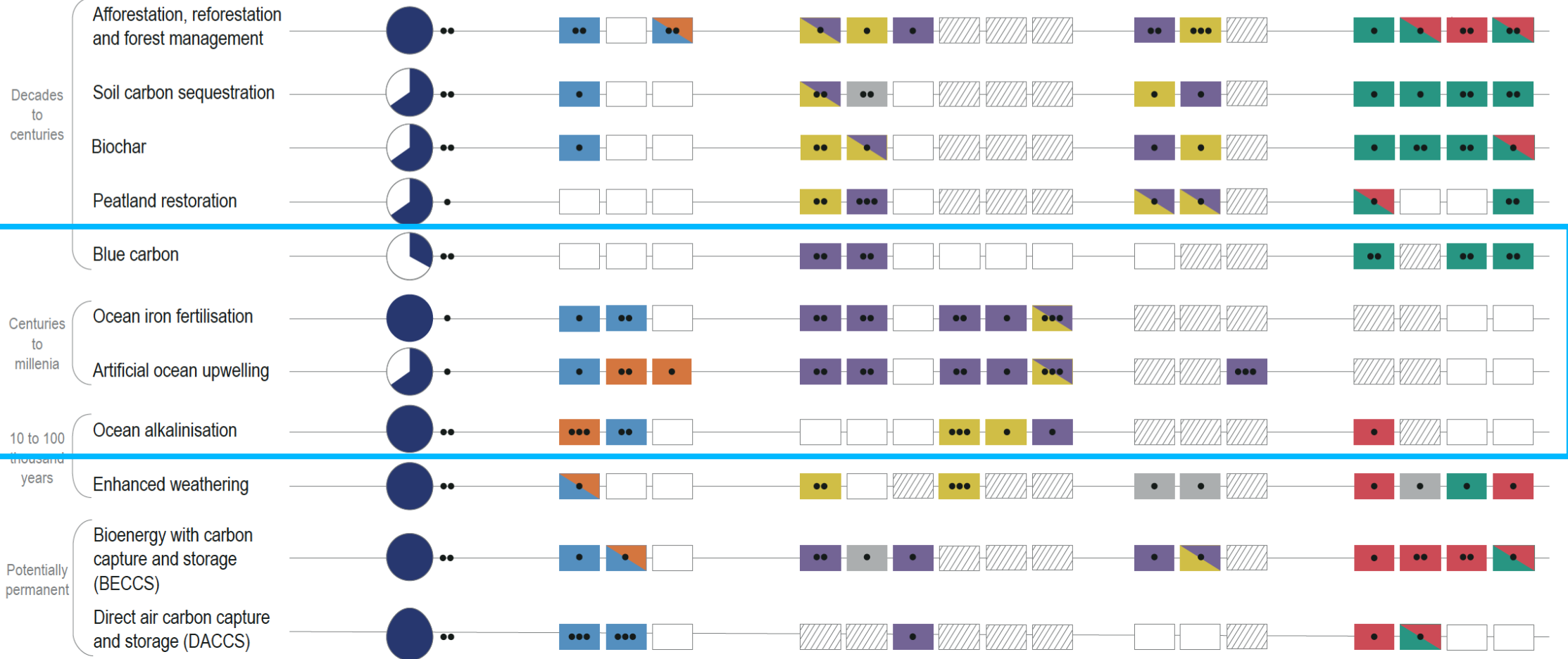
N₂O emissions
CH₄ emissions
VOC emissions
Ocean acidification
Ocean deoxygenation
Marine NPP

Biophysical effects

Evapotranspiration
Albedo
Cold water upwelling

Co-benefits / Trade-offs

Water quality
Water quantity
Food supply
Biodiversity



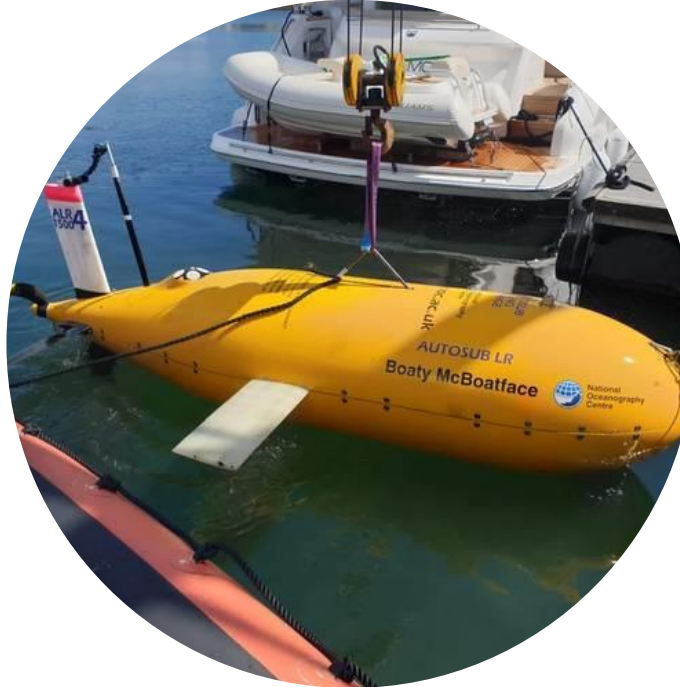
RESEARCH: METHODS FOR TESTING AND MRV



Field Observations

Deployment site

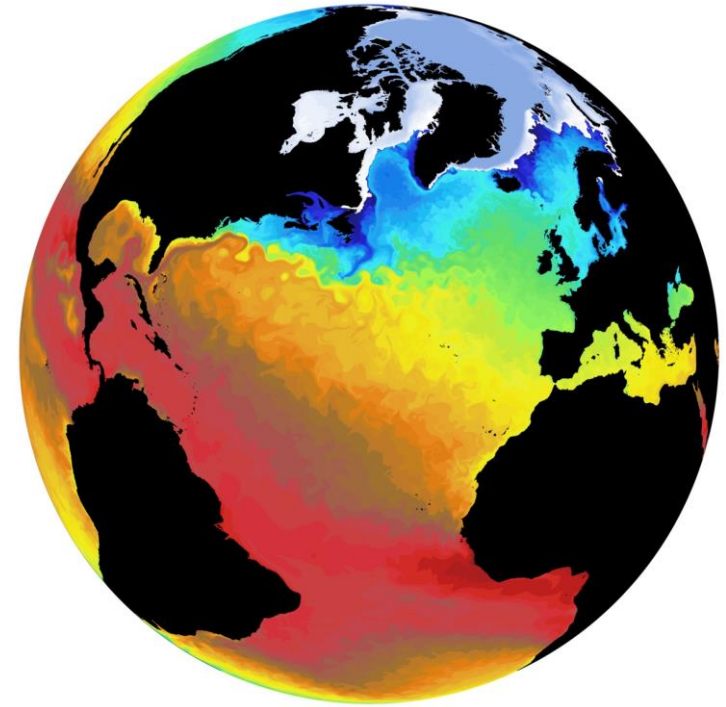
Immediate



Autonomy/ drifters/ satellites

Tracking perturbation

Month(s)



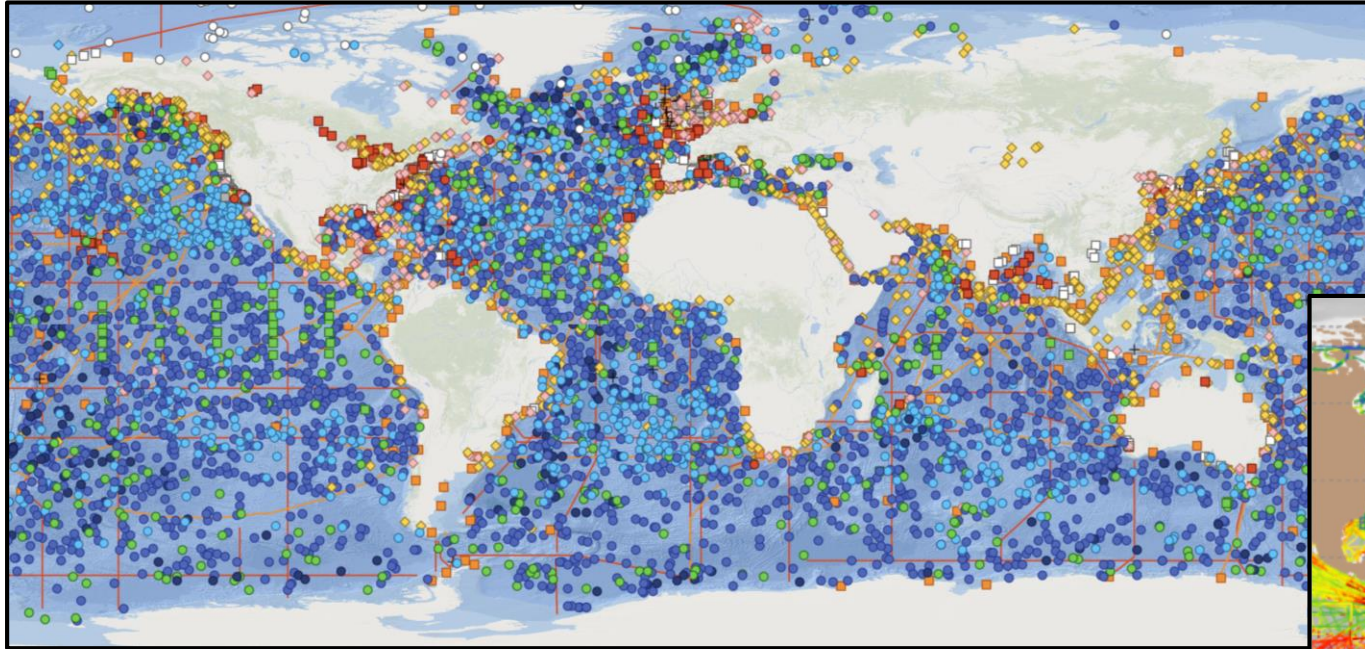
Modelling

Deployment to global

Days to 100s years

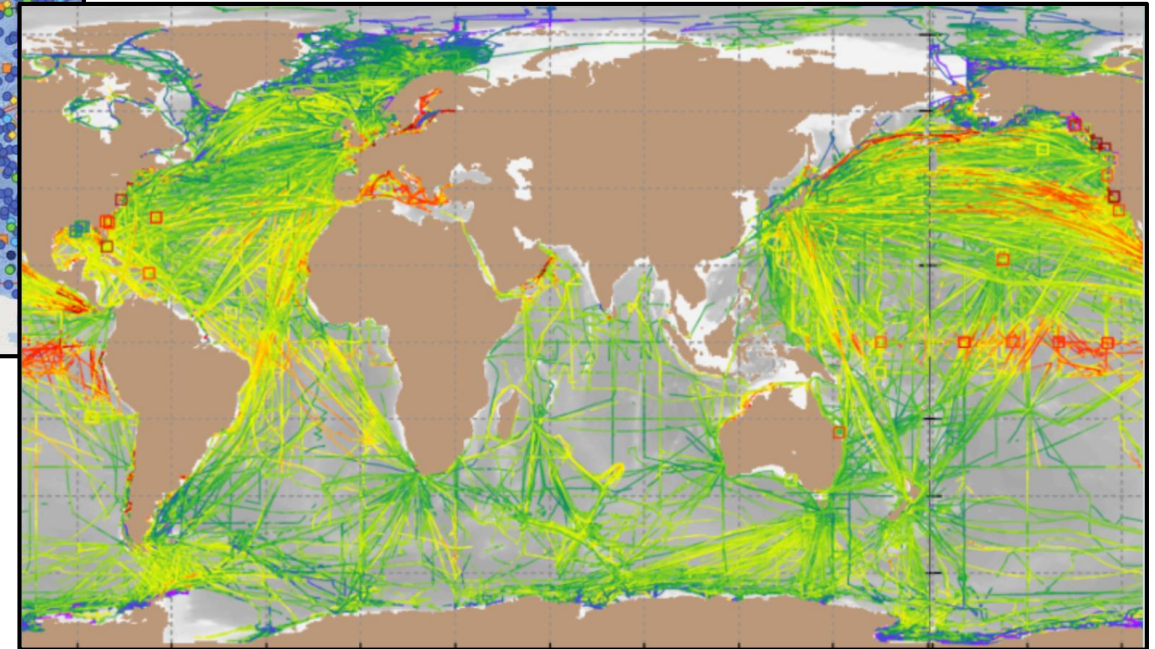
What methods enable CDR evaluation at relevant space-time-scales?

GLOBAL INFRASTRUCTURE FOR CONTINUOUS OCEAN OBSERVATIONS (PRESENTLY AN INCOMPLETE, FINANCIALLY FRAGILE SYSTEM OF SYSTEMS)



7920 Platforms; GOOS OceanOPS (2023)

FAIR, CARE DATA PRINCIPLES

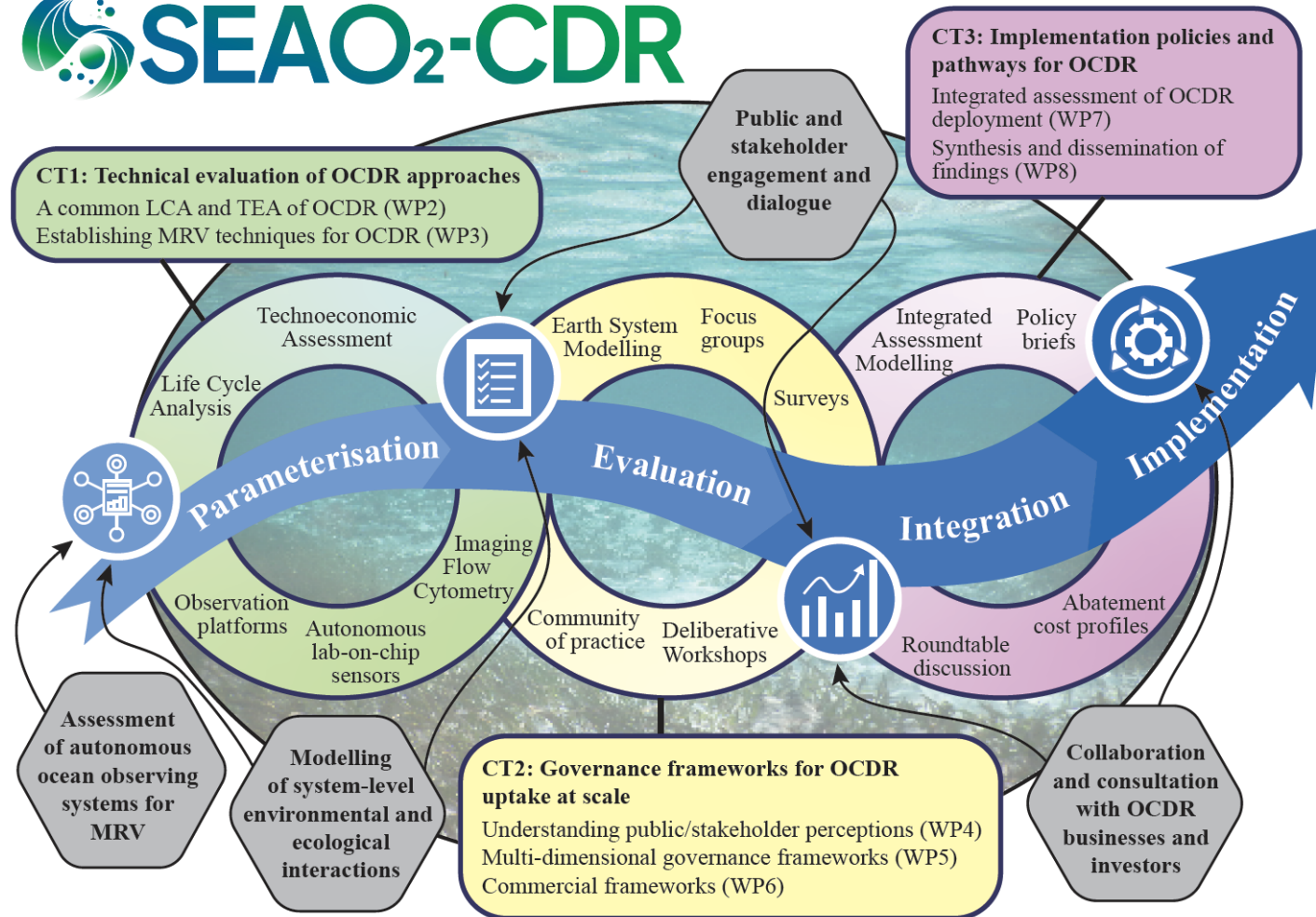


SOCAT (2023)

What is needed to enable global observations to support MRV?

RESEARCH: BRINGING THE COMMUNITIES TOGETHER

NATURAL SCIENCE, ENGINEERING, GOVERNANCE, ECONOMICS, SOCIAL



To evaluate and establish the mechanisms and processes required to facilitate the environmentally safe, socially acceptable, and economically viable implementation of appropriate ocean-based CDR approaches to support the realisation of global climate policies

€7M Horizon Europe funded project |
14 partner institutions |
Runs from June 2023 to May 2027

What is the totality of considerations to assess and facilitate mCDR?

SUMMARY

GLOBAL CLIMATE TARGETS

Implementation and upscaling of
CDR approaches

THE OCEAN

Carbon sink, scale, durability

SCIENTIFIC AND SOCIO- ECONOMIC RESEARCH

- Efficacy
- Durability
- Scalability
- Environmentally safe,
- Socially acceptable
- Economically viable
- MRV local, global

GOVERNANCE

- Regulation
- London Convention
- UNCLOS - High Seas BBNJ
- UNFCCC – NDC vs High Seas

OPEN COMMUNICATION & COLLABORATION

Essential between all parties

An aerial photograph of the ocean with white-capped waves breaking against a deep blue background. The perspective is from directly above, showing the intricate patterns of the water's surface.

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THANK YOU

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