

A call for internationally coordinated scientific research for marine Carbon Dioxide Removal (mCDR) activities

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Various mCDR activities have been proposed to reduce the atmospheric CO2 concentration to curtail global warming and mitigate surface ocean acidification, such as coastal blue carbon, sinking crop residue, sinking macroalgae, sediment trapping, ocean fertilization, and ocean alkalinity enhancement in recent decades. More than one hunderd coastal states can technically carry out one or more such CDR activities. The efficacy and environmental impacts of significant-scale of mCDR activities are not understood fully due to the absence of field scientific experiments. mCDR activities are more transphere are coupled. The international community, therefore, has waited for a globall utranspherony mechanism, such as the 2013 amendments of the London Protocol, to be universally accepted. Introducing substances or energy into the marine environment to mtigate elimate change is much less costly than the efforts to assess the efficacy and environmental impact arising from such an introduction, commonly, known as more all verification (MRV). Developing economies may introduce the material or energy into the marine environment to mitigate elimate the goals of the 2015 print agreement. A more robust international governance regime will emerge through learning scientific frestarch. Authors call for an international governance regime will emerge through learning scientific frestarch and point international joint scientific research.

1) Everyone emits CO₂ into the atmosphere regardless of economic status.



2) Climate litigation in domestic and international courts increases over time

CLIMATE IN COURT

cases filed. Un n with 139, Austr Trovent 8% of 1 es has 1,745, fol rith 82, Low- an



* International Court of Justice (ICJ), the United Nations' principal judicial organ in The (co.7), no Ometarlands, was requested by the General Assembly of the United Nations to provide an advisory opinion on the obligations of States in respect of climate change on 19 April 2023.

1) First, what are countries' obligations in international law t First, what are countries' obligations in international law to protect the climate system from anthropogenic greenhouse gas emissions, and Second, what should the legal consequences be for states when their actions — or failure to act — cause harm?

Second, what should the legal consequences be for states their actions — or failure to act — cause harm?
 The Court will deliver its advisory opinion in due course (<u>https://www.ici-cii.org/case/187/press-releases</u>)

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>States generally prefer to comply with international agreements with a margin of appreciation in determining water measures to take to avoid climate change (i.e., due diligence standard).

3) Technical options to draw down atmospheric CO₂ (including industrial emissions), transform it into non-climatologically active carbon species, and store them in the marine environment



4) The material or space required to compensate 1 Gt C yr⁻¹ (to be refined)

Coastal blue carbon	1 x 10 ⁶ km ² area, 50 x 1000 times wider than that of 102.30 km ² Dongtan
	wetland in Shanghai
Subsea bed geological formation	Sufficient reservoir (~ 0.37 GtCO2 yr ⁻¹) by 2030
Sinking crop residue	1 x 103 km ² of sea area once spread on the seafloor for 4 m thickness,
	oxygen-depleted zones offshore (oxygen minimum zones, OMZs)
Sinking macroalgae	13 km3 of kelp, 3,380 km ² of the seafloor by stacking 4 m thick each year
Ocean fertilization (Fe)	3000 kg of Fe
Ocean alkalinity enhancement	5 x 109 t of CaO or olivine powder

5) MGE potential project areas and their pertinent jurisdiction. The area impacted could be much greater than those of project sites.



6) Naturally occurring marine hypoxia on continental margins – ideal place for storing organic matter for longer time scale without much environmental disturbance



Region, W/E/S/N		Quartile OMZ boundaries (0.5 ml L ⁻¹) (depth in meters)		Estimated benthic area (km ²) (computed value
		Upper (25%)	Lower (75%)	 in parentneses)
	-150/-120/37/60	-659	-1088	30,000 (29,880)
	-140 - 110 / 28 / 37	-513	-686	14,000 (14,013)
	-125/-98/23/28	-225	-714	42,000 (41,984)
	-120/-70/6/23	-90	-965	147,000 (146,555)
	-92/-76(0)6	-264	-600	8000 (8,169)
	-92/-76/-60	-198	-508	17,000 (16,799)
	-90/-70/-20/-6	-57	-368	77,000 (77,440)
	-90 - 70 - 40 - 20	-113	-378	26,000 (26,434)
	Subtotal			361,000
Arabian Sea	45/73/0/30	-122	-1100	285,000 (284,990)
Bay of Bengal	73/100/0/30	-91	-582	389,000 (389,120)
Southeastern Atlantic	0/30/-15/0	-293	-416	7,000 (6,870)
	0/30/-30/-15	-100	-277	106,000 (105,860)
	Subtotal			113,000
Total	1,148,000			

>All coastal states are required and can also carry out MGEs. Monitoring, reporting and verification (MRV) can be assisted by developed countries.

7) International governance on MGEs



Administrative procedures for marine geoengineering activities (a). "Consultation" in (a) refers to consultation with adjacent states and relevant international organizations. An overlap between the continental shelf and the high seas for the extended continental shelf can exist. "The Area" goes up the EEZ/High Seas boundary (b).

8) A moderate path stewarding emerging MGEs: London Protocol and BBNJJ 2023 approaches

- Full scientific knowledge is required for the implementation of ocean-based CDRs CDRs are at the scientific proposal state and a few small-scale field experiments has
- carried out very recently.
- Scientific knowledge is non-rival
- Climate mitigation is non-rival



9) A paradigm shifts from the victim-offender model to the common but differential responsibility model

- > The free-of-charge usage of Earth observation data from providers, open-access technical and scientific research publications, open-source software, and high-speed internet service has revolutionized scientific research in recent decades, including developing economies.
- purpose of all MGEs is to mitigate climate change, i.e., the global atmosphere. The effect of the execution of MGEs will be widespread (transboundary) and long-lasting (at least 100 years), therefore, all MGEs should be subject to the auspice of the international community.
- More than 150 coastal states can participate in a joint international project by pairing scientific research asset-deficient laboratories in developing economies with advanced laboratories from developing local research proposals to publishing the research outcomes in international journals.

10) A call for internationally coordinated scientific research for marine mCDR activities

- ✓ to collect essential information required for screening CDRs tailored l for each site,
 - ✓ to develop tools for environmental impact analysis, ✓ to build scientific and technical capacity for potentially all coastal states,

✓ to conduct field scientific research involving CDRs