MACS - Marine Anoxic Carbon Storage

Bucharest Workshop Summary

On February 4-5, 2025, over 30 scientists convened in Bucharest to discuss Marine Anoxic Carbon Storage (MACS). MACS is a promising method for Carbon Dioxide Removal (CDR) focused on storing terrestrial organic carbon (plant biomass) in anoxic marine environments. MACS utilizes naturally anoxic marine environments, such as the Black Sea, marine sediments, and deep hypersaline basins, where decomposition rates are minimal, providing permanent (>1,000 years), large-scale, and environmentally safe carbon sequestration. Preliminary research indicates that these sites could collectively store hundreds of gigatons of CO_2, making MACS a viable option for meaningful climate impact. This understanding brought together world leading marine scientists to discuss a research roadmap enabling MACS to reach megaton scale.

With funding from the Grantham Foundation and the H2020 DOORS Project, the Workshop identified 4 critical scientific gaps essential for scaling MACS as an ecosystem service:

1. Environmental Impacts & Capacity: What risks do nutrient leakages (during sinking) pose in causing eutrophication, and how much methane and sulfide can be released from biomass decomposition over time and with respect to storage site capacity?
2. Measurement Technology: What is the optimal combination of monitoring technologies (sensors, AUVs, gliders, remote sensing, etc.) that will provide sufficient spatial and temporal data resolution for verification and environmental safety?
3. Storage Permanence: how can decomposition rate and extent be measured and forecasted for different types of biomass in different kinds of environments?
4. Social and Political Acceptance: how can existing knowledge and research be communicated effectively to secure regulatory approval & public support for pilot studies?

To address these gaps, there is consensus among the Workshop participants on the urgent need to advance beyond laboratory studies to in-situ trials. Workshop participants suggest conducting well-monitored pilot studies at scales up to 1,000 tons of biomass. This scale is necessary to provide meaningful results, overcoming the "signal-to-noise" barrier set by the magnitude of the ocean. While ensuring thorough monitoring of environmental impacts, the risk of such experiments is far lower than the risk we impose on the oceans due to climate inaction. Such experiments will significantly advance scientific understanding and build regulatory confidence, facilitating future larger-scale implementations.

Coming out of the Workshop is a consortium of scientists from 25 institutions and 14 countries, including Bulgaria, France, Germany, Romania, Turkiye, USA, and other EU member states, ready to advance MACS research. This consortium has already prepared several collaborative proposals ready for immediate initiation, enabling geographically coordinated research around potential storage sites. These synchronized research projects will provide essential data for the development and validation of MACS as a nature based, permanent, & scalable CDR approach.

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Workshop Participants	Country	Organization
Aaron Martinez	USA	UCSB
Allison Matzelle	USA	Carboniferous
Andreas Neumann	Germany	HEREON
Andrew Sweetman	Scotland	SAMS
Antoine Cremiere	France	CNRS
Bilge Tutak	Turkiye	ITU
Christopher Pearce	UK	NOC
Chris Vivian	UK	GESAMP
David Lordkipanidze	Georgia	Georgian National Museum
Dror Angel	Israel	University of Haifa & Rewind
Elena Stoica	Romania	NIMRD Grigore Antipa
Florence Schubotz	Germany	MARUM Bremen
Jan-Hendrik Hehemann	Germany	MARUM
Jean-Daniel Paris	France	CEA/LSCE
Jim Barry	USA	MBARI
Laura Boicenco	Romania	NIMRD Grigore Antipa
Leonardo Valenzuela Pérez	USA	Ocean Visions
Marian Paiu	Romania	Mare Nostrum
Mehmet Ilicak	Turkiye	ITU
Mihaela Muresan	Romania	GeoEcoMar
Morgan Reed Raven	USA	UCSB & Carboniferous
Nick Reynard	UK	Cambridge
Nikolaos Zarokanellos	Spain	SOCIB
Nitai Amiel	Israel	Rewind
Nora Gallarotti	Switzerland	ETH Zurich
Peter Krost	Germany	Coastal Research & Management & Rewind
Ram Amar	Israel	Rewind
Selma Menabit	Romania	GeoEcoMar
Sukru Besiktepe	Turkiye	DEU
Tiia Luostarinen	Finland	Puro.earth
Vangelis Papathanassiou	Greece	HCMR
Violeta Slabakova	Bulgaria	IO-BAS
Yoana Voynova	Germany	HEREON

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