Project: **1258**

Project title: **RETAKE—Carbon Dioxide Removal by Alkalinity Enhancement: Potential, Benefits and Risks**

Principal investigator: **Ute Daewel**

Report period: **2025-11-01 to 2026-10-31**

(Maximum of 2 pages including figures. 9 pt minimum font size.)

Project overview

Project 1258, RETAKE – Carbon Dioxide Removal by Alkalinity Enhancement: Potential, Benefits and Risks, investigates ocean alkalinity enhancement (OAE) as a marine carbon dioxide removal strategy in the North Sea within the CDRmare research mission. Numerical simulations conducted on the Levante HPC system aim to quantify the potential, efficiency, and environmental impacts of different OAE applications. These include alkalinity additions via wastewater treatment plants using dedicated reactors, the release of different alkaline minerals and solutions, and applications across coastal and estuarine regions, and ship-based release in offshore regions. Future experiments will also address secondary effects such as impacts of pH changes and on marine food webs, pollution of trace metals, alkalinity loss through secondary mineral precipitation, reduced natural alkalinity generation.

Model system and numerical experiments

All numerical experiments are performed using the SCHISM-ECOSMO-CO_2 modeling system, which couples the Semi-implicit Cross-scale Hydroscience Integrated System Model (SCHISM), based on unstructured triangular grids, with the lower-trophic-level ecosystem model ECOSMO II and a carbonate system module. During the current reporting period (2025-11-01 to 2026-10-31), reference simulations and several OAE scenarios were conducted, focusing on alkalinity additions via wastewater treatment plants and dedicated reactors, as well as olivine release under different sediment transport pathways.

Resource allocation, usage, and justification

During the allocation period 2025-11-01 to 2026-10-31, project 1258 utilized 5,420 of the 26,458 allocated CPU node hours, while 15,736 expired or were reallocated, leaving 5,302 CPU node hours available for the final quarter (Table 1). GPU usage amounted to 24 of 33 allocated GPU node hours, with 9 remaining. Of the 58 TiB of allocated Levante storage, 47 TiB are currently in use, leaving 11 TiB available. The additional allocations of 17 TiB of Archive Project storage, 500 GiB of Levante Shared storage, and 10,240 GiB of Swift Object Storage have not yet been utilized. No storage on long term Archive was allocated.

Table 1: *Resource allocation and usage of project 1258 for 2025-11-01 to 2026-10-31.*

Resource Type	Allocated for 2026	Consumed (until 29.10.2026)	Expired or reallocated (until 29.10.2026)	Remaining (until 31.12.2026)	Projection of consumption to end of 2026
Computing time CPU [Node hours]	26,458	21,156	15,736	5,302	26,458
Computing time GPU [Node hours]	33	24	-	9	24
Levante storage [TiB]	58	47	-	11	58
Archive project [TiB]	17	0	-	17	17
Archive long term	0	0	-	0	0

[TiB]					
Levante shared [GiB]	500	0	-	500	0
Swift Object Storage [GiB]	10,240	0	-	10,240	0

Due to the sudden and unexpected passing of our colleague Dr. Feifei Liu in early March of this year, much of the planned work could not be completed, leaving a substantial fraction of the allocated resources unused. Dr. Liu was conducting the research within this project, including the numerical experiments and analyses on Levante. As a result, computational work was largely paused between March and July.

At the beginning of August, we were able to fill the position and resume the work within the project. Since then, a substantial fraction of the allocated resources has been used during the third quarter, and further resources are expected to be utilized in the final quarter. Data from previous experiments will also be archived, likely requiring much of the allocated Archive Project storage.

Scientific results

Initial numerical experiments have been conducted for two OAE approaches: alkalinity enhancement through olivine release under different sediment transport pathways and alkalinity addition via chemical reactors at wastewater treatment plants. Although the results remain preliminary, they provide first insights into the spatial variability and efficiency of both approaches (Fig. 1 and 2).

For olivine release, the bedload scenario produces a greater net increase in alkalinity than the permeable sediment scenario (Fig. 1). For reactor-based alkalinity enhancement, both the half-capacity and full-capacity scenarios show increased oceanic CO_2 uptake compared with the reference wastewater discharge without alkalinity enhancement. The increase in CO_2 uptake is approximately proportional to the amount of alkalinity added (Fig. 2).

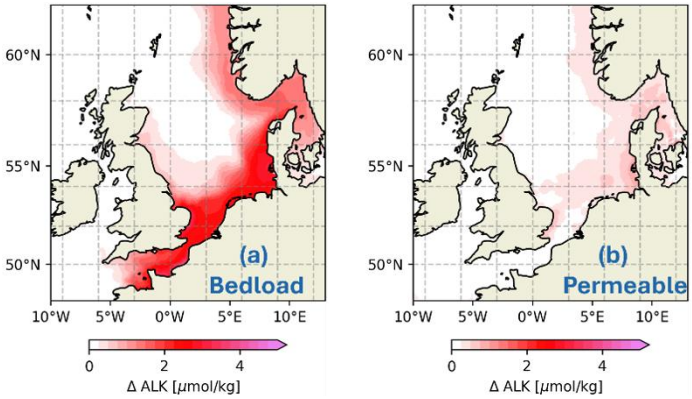


Figure 1: Increase in alkalinity compared to a reference simulation for (a) a bedload olivine application and (b) a permeable sediment application.

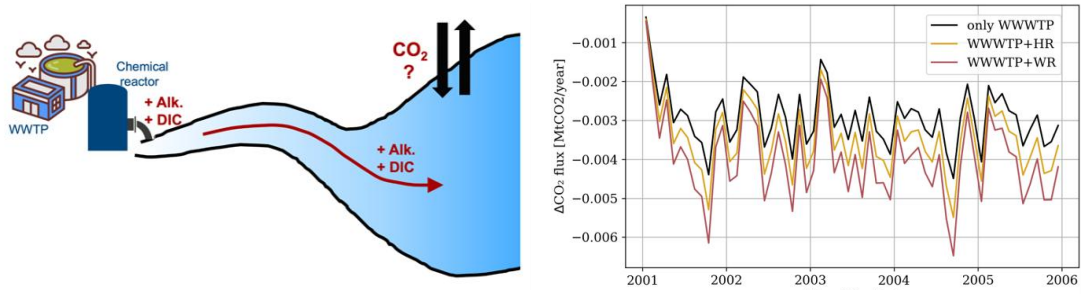


Figure 2: Left: conceptual schematic of ocean alkalinity enhancement by addition in a chemical reactor via wastewater treatment plants (WWTP). Right: Changes in air–sea CO_2 exchange for half and full capacity of alkalinity enhancement via the chemical reactor.