Supplement information for manuscript "Evaluating ocean alkalinity enhancement as a carbon dioxide removal strategy in the North Sea"

Supplement S1: Passive tracer experiment

We conduct two passive tracer experiments regarding the different locations of tracer added. The two locations are illustrated in the following figure.

The tracer is added as continuous surface fluxes to the surface ocean of the selected regions. The flux is prescribed as 1mmol/m2/s. The tracer in the interior ocean is only subject to hydrodynamic processes.

Before the tracer is added, the initial field is set to zero over the whole model domain. The addition of tracer flux starts from 01.01.2005 and the model runs for one year.

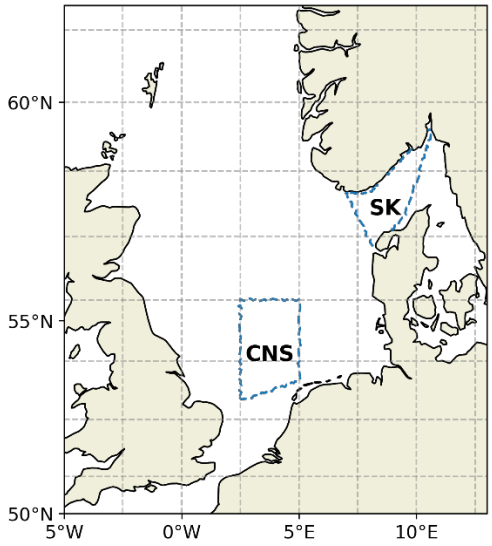

Figure S1: Locations of passive tracer added.

Supplement S2: One-time alkalinity addition experiment

To test our hypothesis, we conduct three single-instance alkalinity addition experiments, where a fixed amount of alkalinity is added to the three selected locations only in the first month. Following the addition, we monitor the total excess CO_2 uptake relative to the CTL simulation. In all three scenarios, the ηCO_2 reaches a plateau of 0.57–0.76 mol CO_2 per mol of alkalinity after one year, with minimal further CO_2 uptake thereafter.

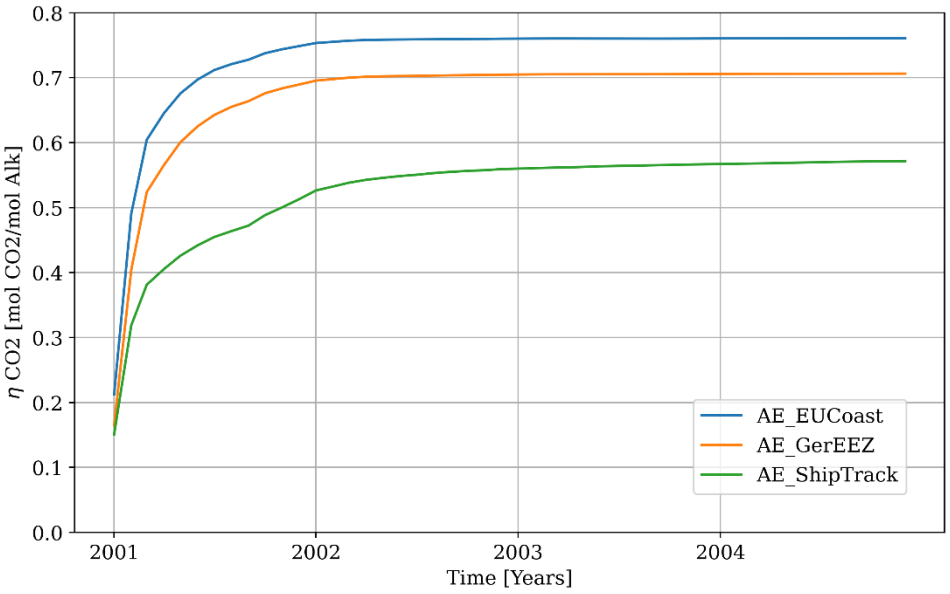

Figure.S2 Time series of ηCO_2 with one-time alkalinity implemented in the three locations.

Compared to our standard continuous alkalinity addition scenarios, the one-time addition method shows lower CO_2 uptake efficiency, even though in the latter case, the alkalinity is fully equilibrated with the atmosphere. One possible reason is that in the one-time addition scenarios, alkalinity is added during winter, when strong flushing leads to a shorter residence time and consequently poorer equilibration efficiency. Another possibility is that with continuous alkalinity supply, the added alkalinity disperses over a larger area, where the water has a lower buffer capacity.

Supplement S3:

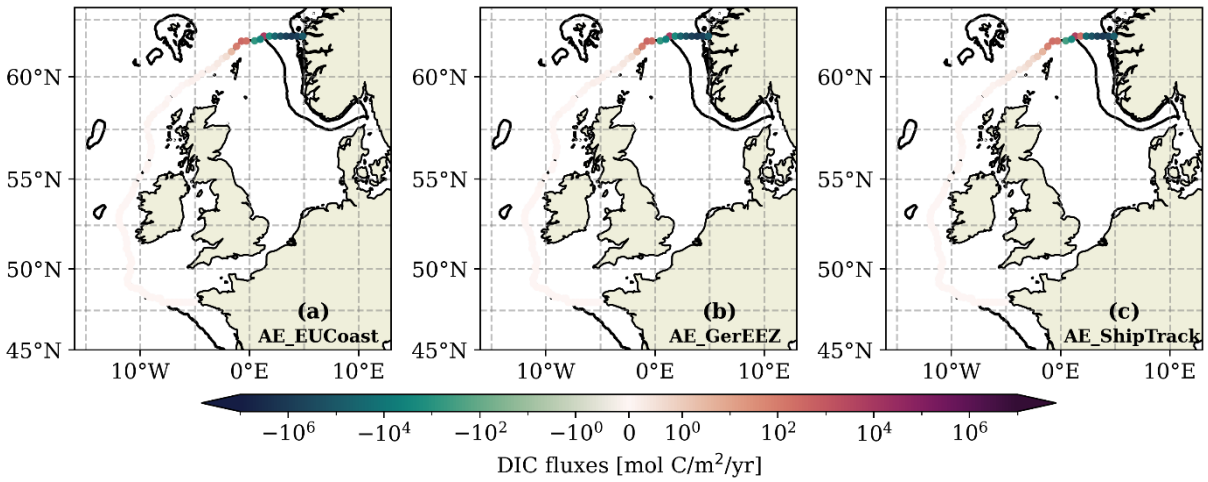

Figure S3: Difference of the vertically integrated DIC flux per unit horizontal distance across the shelf-break relative to the none-OAE condition for the three scenarios. Black contour shows the 200m isobath.

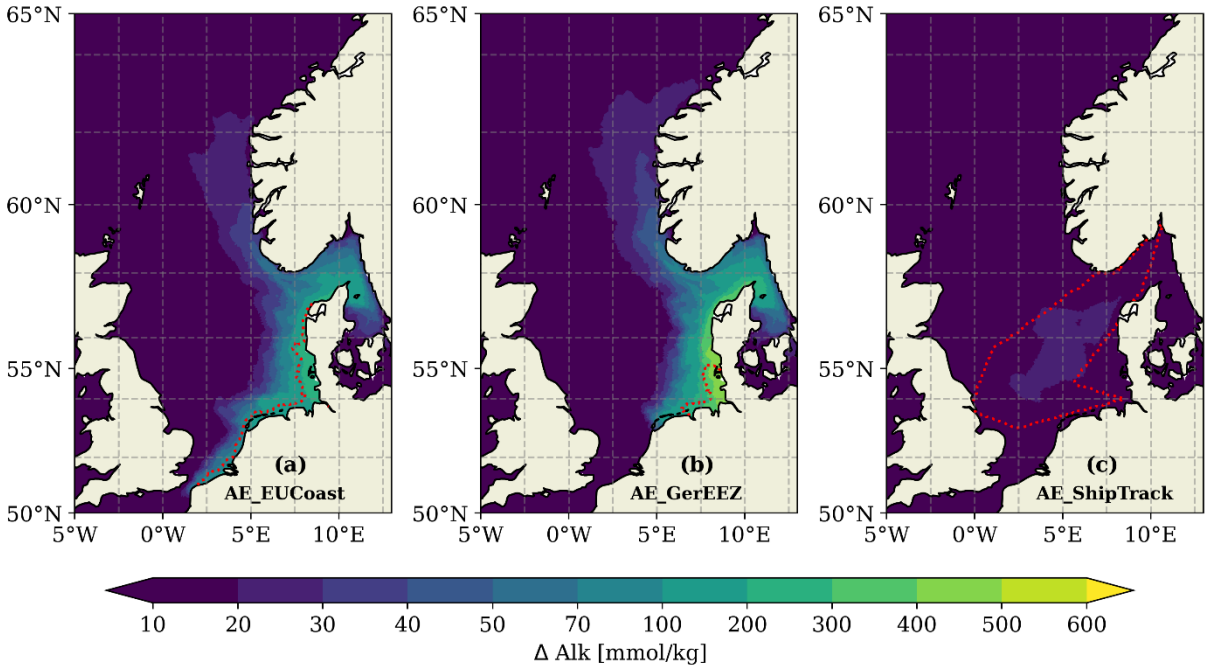

Figure S4: The maximum changes in surface alkalinity concentration during the OAE periods for each scenario. Overlaid dashed red contour lines indicate the alkalinity addition sites. Note the nonlinear color bar.

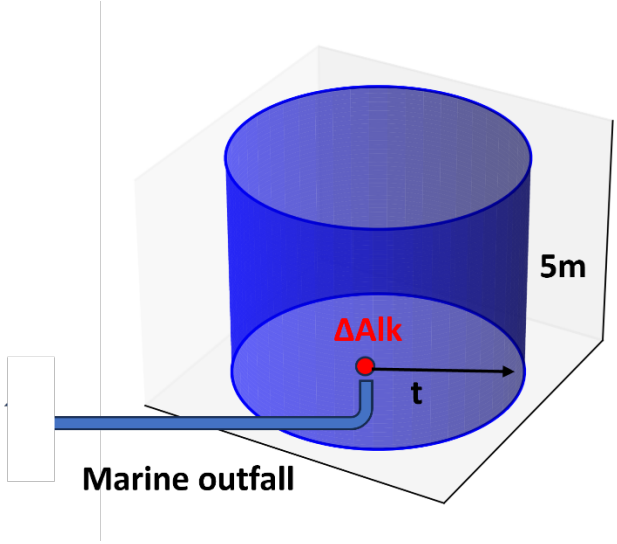

Figure S5: Schematic showing how the alkalinity is discharged through a marine outfall.