Reply to comments on EGUSPHERE-2026-982

Implemented Changes

Reviewer 1

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The manuscript assesses the impact of alkalinity addition via different methods (NaOH, CaO, and bicarbonate+calcium to simulate accelerated limestone weathering) on the organic and inorganic carbon partition. The study was conducted using bottle incubations in Los Angeles Harbor, with effects of additions at different concentrations being measured for about 4 days. In general, the study is well designed, and the figures reflect the results discussed.

I missed some discussion on the limitations of the study in addressing possible detrimental effects to the ecosystem throughout the manuscript, but this was added to the discussion in a clear way. There are a few points in the manuscript that require clarification of some rewriting, as pointed out in the specific comments below.

We agree that we could have added some more information on the limitations of assessing effects to the ecosystem with our measured parameters and experimental set-up. We have added more information about limitations in Section 2.3 Experimental Set-Up and addressed specific comments below.

Authors sometimes compare two different carbon variables assuming the reader will know why that comparison is being made, which might not be the case especially for an mCDR related publication that can attract readers outside of the ocean carbon scientific community.

We will keep this in mind and have clarified the significance of comparing multiple carbon variables (as suggested L304-307) throughout the manuscript.

Some general interpretation on what results mean throughout the results section and pointers on how it will be added to the discussion would be useful as well, for example pointing to potential impacts on biology in section 3.3.1.

We have referenced relevant discussion sections in the results to improve the ties between these sections.

In general, however, the manuscript is well written and adds useful information to the much needed and mounting literature assessing the impact of alkalinity additions on water chemistry and on biology. With some relatively minor reviews, it should be ready for publication.

We appreciate your recognition that this is an important topic and your feedback. We've addressed your line-by-line comments in the following sections.

L40: Needs reference

Added References - (Berner et al., 1983; Berner & Berner, 1997; Holland, 1978; Penman et al., 2020; Walker et al., 1981).

L42: Also worth discussing other impacts of dissolving all calcium carbonate

We are a bit confused by what the reviewer meant by "dissolving all calcium carbonate". To clarify, we state in the text that dissolution of oceanic carbonate sediments is a natural process that occurs on geological timescales. Archer (1996, 2009) and Sulpis et al. 2018 have investigated how anthropogenic CO_2 is driving sediment carbonate dissolution, consequently neutralizing the CO_2, yet it could take >10,000 years to neutralize all anthropogenic CO_2. However, the oceanic carbonate sediment stock is greater than the anthropogenic CO_2 stock, so not all oceanic carbonate sediments would dissolve completely. There is, fortunately, a surplus of $CaCO_3$ buffer in oceanic sediments.

L43: I would add a "potentially" here

Added.

Table 1: All salinities were exactly 35?

All salinities were measured with a refractometer with delineations of 1 unit; hence we rounded to the nearest whole number. We did not previously report the uncertainty of this scale which is ± 0.5 ‰ (parts per thousand), which we have now added to the manuscript. We have removed these values from table but still included the salinity measurement, and its uncertainty in the text.

L140: Consider adding equations here

We have added the following equation that clarifies the reactants and byproducts of accelerated weathering of limestone, and the chemicals we used to mimic this process.

$$\boldsymbol{CO_2} + H_2O + Ca\boldsymbol{CO_3} \leftrightarrow Ca^{2+} + \boldsymbol{2HCO_3^-} \qquad (2)$$

$$2Na\boldsymbol{HCO_3} + \boldsymbol{CaCl_2} \leftrightarrow \boldsymbol{Ca^{2+}} + \boldsymbol{2HCO_3^-} + 2Na^+ + 2Cl^- \qquad (3)$$

L165-167: I would rephrase or add more information here, as is it reads like a preemptive rebuttal of criticism without offering arguments. Adding some information on which aspects are desirable would be more helpful.

Thank you for this perspective, we will add more information on why there is debate over the usage of small volume bottle experiments, and the beneficial aspects that led us to our specific choice.

In perturbation experiments conducted with small volume microcosms (< 10L) it is recommended to limit the timescale of study to days-weeks if the goal is to understand the impact of the perturbation on microbial or plankton assemblages (Parsons, 1982; Riebesell et al., 2010). **The purpose is to limit unwanted effects such as biofouling on the walls of the enclosure, nutrient limitation, excess grazing or community changes due to lack of predators – these are commonly referred to as "bottle effects".** We intended to maintain a closed system experiment (with no headspace) to constrain the carbon budget by eliminating gas exchange as a potential variable for this study. This can be an analog for water that may temporarily lose contact with the atmosphere, e.g. when waters mix deeper into surface ocean or for times when gas exchange is minimal. **Additionally, our aim was to compare multiple alkalinity sources, thus we opted for a replication method that incorporated sacrificial bottle timepoints over the span of four days. Alternatively, some researchers may want to study the evolutionary response of a microbial community and thus a timeseries from larger volume enclosures with fewer replicates might be a more appropriate design (Iglesias-Rodríguez et al. 2023).**

L186-187: All bottles got the 13C tracer?

We added a 13C tracer to all control and treatment bottles in five experiments (07-15-24; 07-22-24; 11-04-24; 11-18-24; and 01-27-25). This data is used and discussed in 'Section 3.4.1 Carbon Isotopes to Track Respiration'. We collected an additional bottle of seawater during each of these experiments that received no alkalinity and no isotope tracer; to measure the natural isotopic signature of the seawater DIC (it was filtered on Day 0). This information was added to Section 2.2 Alkalinity Types. We elaborated on the tracer solution, the concentration of the stock, volumes added and the method of addition.

L304-307: This was a bit confusing to read. Would be less so to say both POC and DOC change, and explain why you are comparing these two variables

Rephrased these sentences to read as follows:

In the organic carbon pools, both particulate and dissolved organic carbon increase in the control and treatment bottles (Figure 3). There is no statistical difference between the controls and treatments with respect to both POC and DOC ($p > 0.05$, ANOVA and Linear Regression method). The $[Ca^{2+}] + [HCO_3^-]$ addition experiments intentionally resulted in the largest increase within DIC pool compared to all other alkalinity enhancements. In this experiment we found an increase in both particulate and dissolved organic pools, but it was not statistically dissimilar from the changes within the control condition.

L355: Consider adding the date to the subtitle here as well

Done.

L446-447: Where did you get these numbers from?

As mentioned in L444-445, the % carbon in each pool (DIC, DOC, PIC, and POC) mentioned in L446-447 was calculated by averaging the mean measured value of the controls (n=3) and treatments bottles (n=3). All these parameters yield moles of carbon and thus the calculation of partitioning total carbon among these species was our goal. The numbers in L446-447 reference the general distribution in each pool across all our experiments. This data is included in the carbon_budget_altasea.csv data sheet (which is publicly available in the associated dataset).

L448-450: Consider rephrasing. The first sentence says there was no change, and the following one starts with DIC decrease. In general good to be more clear about which experiments you are talking about throughout the manuscript.

Rephrased. We will refer to experiments in a more consistent manner with dates throughout the manuscript.

L463-464: as seen/assessed where/how?

More information was added on how this number was derived. This is a mass balance calculation assuming one mole of DIC loss could yield one mole of $CaCO_3$ formed

To account for DIC lost through other processes, we converted the $\mu gC\ L^{-1}$ ΔPIC in all experiments (Fig. 3 and Fig. 5) to ΔDIC (consumed/added) in $\mu mol\ kg^{-1}$ by assuming 1 mole of

PIC growth is equivalent to 1 mole of DIC consumed. We estimated the DIC lost to the precipitation of $CaCO_3$ is < 1 µmol kg^{-1} over the span of 4 days.

L509: how quickly?

This can happen on the scale of seconds to minutes depending on extent of intentional mixing (by stirring, aeration, circulation pumps, or shaking) or hours if the NaOH addition surpasses pH 10. In Bach et al. (2024) and Ferderer et al. (2022), intentional gentle mixing right after NaOH addition (up to 500 µmol kg^{-1}) redissolved brucite (or what could be amorphous magnesium hydroxide) within several minutes. Redissolution within minutes after intentional gentle mixing was also observed in Suitner et al. (2024). Ringham et al. (2024) reported the presence of brucite in XRD analysis from 0-3 h of the experiment, and a complete disappearance after 24 h of the experiment. These previously mentioned experiments do not report the presence of brucite at the end of their studies. In Hashim et al. (2024), the presence of brucite or amorphous magnesium hydroxide was only detected at $\Omega_{aragonite} = 30$ with thermogravimetric analysis and not X-ray diffraction analysis on samples taken 124 h after alkalinity addition. They theorize that the brucite or amorphous magnesium hydroxide did not dissolve even though the seawater was undersaturated with respect to brucite because either the 'brucite' served as nucleation sites for the aragonite the subsequently precipitated or due to slow dissolution kinetics. This discussion has been summarized in the text in Section 4.1 Secondary Precipitation of $CaCO_3$ and $Mg(OH)_2$

L514: Can you add another sentence or two on the ranges and setups of these experiments?

We have rephrased this section to provide more information on experimental conditions most similar to ours where $CaCO_3$ precipitation was not observed and the thresholds at which $CaCO_3$ precipitation began. The restructuring of this section was done by summarizing the following tables in the form of text.

NO PRECIPITATION OBSERVED

Study	**Feedstock**	**Media**	$\Omega_{aragonite}$	**Temperature (°C)**	**Time (days)**
Hartman et al. 2023	$NaHCO_3$ + Na_2CO_3	0.2 µm filtered SW	< 15	24	4
		55 µm filtered SW	~ 6	24	4
Suitner et al. 2024	$NaHCO_3$ + Na_2CO_3	0.2 µm filtered SW	< 15	12-16	20
		55 µm filtered SW	< 15	12-15	20
Moras et al. 2022	Na_2CO_3	0.2 µm filtered SW	~ 9	21	40

		0.2 µm filtered SW + Quartz crystals	~ 9	21	5
Hartman et al. 2023	NaOH	0.2 µm filtered SW	<20	24	4
		55 µm filtered SW	<20	24	4
Suitner et al. 2024	NaOH	0.2 µm filtered SW	< 15	11-13	25
		55 µm filtered SW	~19	10-11	25
Ringham et al. 2024	NaOH	Unfiltered SW	< 30	19-21	20-60
Moras et al. 2022	CaO	0.2 µm filtered SW; solid feedstock	5	21	40
	$Ca(OH)_2$		4	21	30

PRECIPITATION OBSERVED

Study	**Feedstock**	**Media**	$\Omega_{aragonite}$	**Temperature (°C)**	**Onset of Precipitation (days)**
Suitner et al. 2024	$NaHCO_3$ + Na_2CO_3	0.2 µm filtered SW	15-45	12-16	1-20
Moras et al. 2022	Na_2CO_3	0.2 µm filtered SW + Quartz crystals	~ 9	21	>5
Hartman et al. 2023	NaOH	0.2 µm filtered SW	~16-19	24	0-1
		55 µm filtered SW	~15-17	24	0-1
Suitner et al. 2024	NaOH	0.2 µm filtered SW	> 15-30	11-13	0-25
		55 µm filtered SW	> 19-30	10-11	1-15
Ringham et al. 2024	NaOH	Unfiltered SW	> 30	19-21	1
Moras et al. 2022	CaO	0.2 µm filtered SW; solid feedstock	~7	21	0.2
	$Ca(OH)_2$		~7	21	0.2

L541: How are you assessing negative impact? This is quite a broad term.

Negative impact is defined as an outcome that is statistically different than the control outcome.

Here we refer to negative impact in terms of ‘reduction in biomass (POC)’ or a ‘reduction in Chl a concentration’ due to the addition of alkalinity, although we agree with the reviewer that this is a broad was to refer to negative impact and should note that these are not individual species-specific metrics. We have rephrased this sentence to highlight that after NaOH addition and simulated AWL (limestone) addition, we see no difference to the evolution of POC or Chl-a between the controls and treatments which was also observed in other studies that measured POC (in addition to other parameters).

L568: Was not reproduced?

We have clarified this comment. CaO addition did not have the same impact on Chl a in all our experiments. Of the two experiments conducted around +500 µmol kg^{-1}, only one (01-27-25) shows that Chl a was statistically lower. This trend was not seen in the experiment conducted at +1000 µmol kg^{-1} (11-04-24).