Effects of Acute Simulated Ocean Alkalinity Enhancement (OAE) on Natural Phytoplankton Assemblages in the North Atlantic Ocean

MAPEL MicroAlgal Process Evaluation Lab

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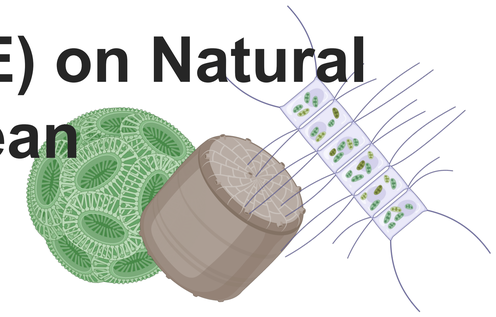
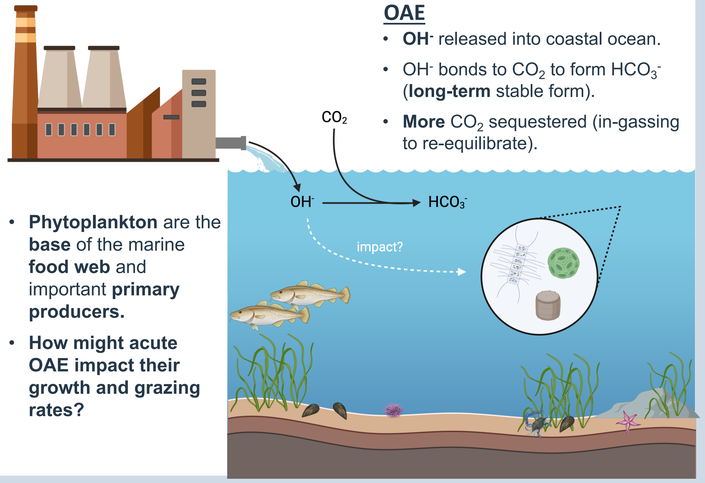


Introduction

To achieve our targets in the fight against climate change, both CO_2 emission reduction and removal (CDR) are required – OAE is one of these CDR strategies.



OAE

- **OH^-** released into coastal ocean.
- OH^- bonds to CO_2 to form HCO_3^- (**long-term** stable form).
- **More** CO_2 sequestered (in-gassing to re-equilibrate).

- **Phytoplankton** are the **base** of the marine **food web** and important **primary producers.**
- **How might acute OAE impact their growth and grazing rates?**

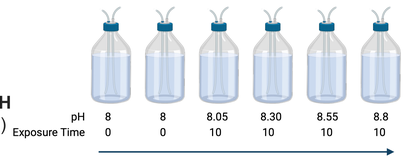
Methods

Setup

- Used raw seawater from Ketch Harbor, NS to **test the effects of acute simulated OAE** on phytoplankton composition, growth and grazing rates.
- 24-hrs long, 12:12 L:D, constant temperature and mixing, experimental duplicates.
- Treatments **alkalized** with **NaOH** (followed by **neutralization** with **HCl** for benchtop experiments only).

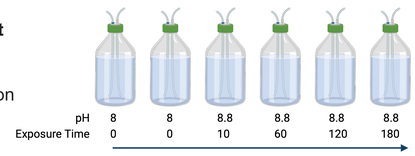
Experiment 1: pH Effect

- 2L glass photobioreactors (PBRs)
- Test the effect of **different pH exposures** (10-min duration) on growth and composition.



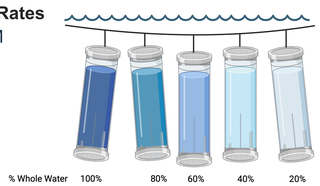
Experiment 2: Time Effect

- 2L glass PBRs
- Test the effect of **different exposure times** (pH 8.8) on growth and composition.



Experiment 3: Growth and Grazing Rates

- 1-L plankton cages capped with 1- μM Nitex screen, suspended in 1000-L tanks bubbled with air.
- **Landry & Hassett (1982) serial dilution method.**
- Ctrl **vs** NaOH dosed to pH 8.8.



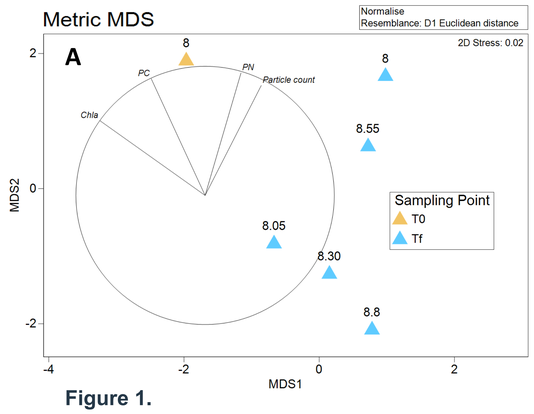
Sampling

- At **T0** (experiment start) & **Tf** (harvest after 24h).
- **Biomass** (chlorophyll, particulate C and N, biovolume, particle counts).
- **Environmental** (dissolved inorganic C, total alkalinity, pH).

Analyses

- **Univariate** (ANOVA, paired t-tests, linear regression).
- **Multivariate** (mMDS, ANOSIM).

Results



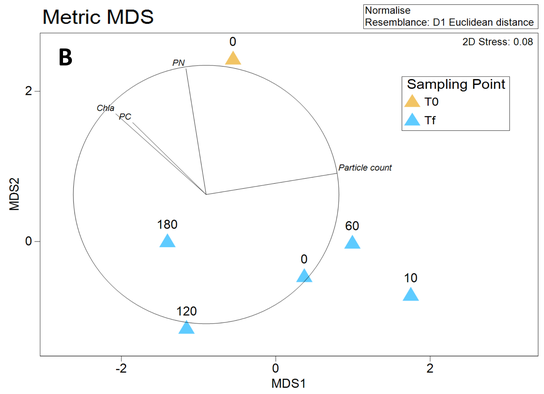


Figure 1.

- Dimensional reduction of phytoplankton **biomass indicators** – chlorophyll-a (**Chla**), particulate carbon (**PC**), particulate nitrogen (**PN**) and particle counts – for the **(A) pH effect** and **(B) time effect** benchtop experiments (**Figure 1**).
- **Separation of T0 and Tf** samples in both experiments.
- For **pH effect**, treatments are **not** ordinated by order pH.
- For **time effect**, treatments are **not** ordinated by duration of exposure.

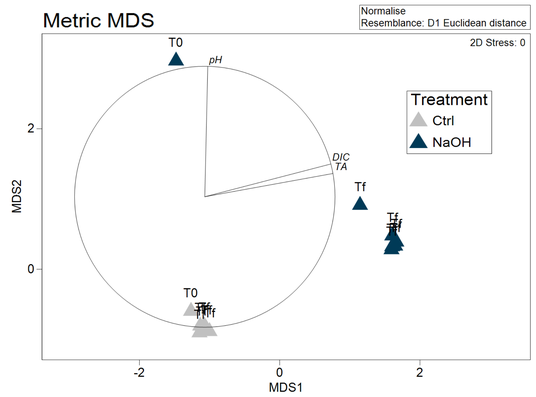
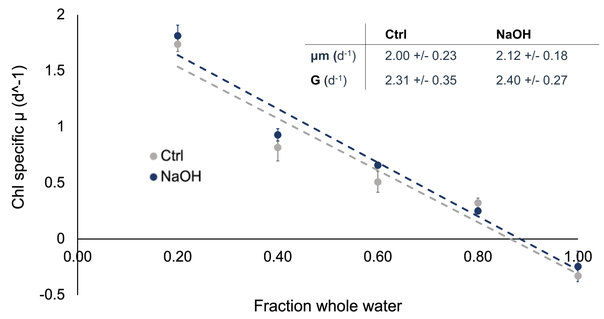


Figure 2.

- Dimensional reduction of **environmental carbon indicators** – dissolved inorganic C (**DIC**), total alkalinity (**TA**), and pH – for **Experiment 3 (growth and grazing rate) (Figure 2)**.
- Clear **separation** of T0 NaOH tank **due to high pH treatment**.
- Clear **separation** of Tf NaOH tank **due to high DIC and TA**, while pH returned to near initial pre-alkalization measurement.

Figure 3.

- Chl-specific growth rates +/- SD for phytoplankton populations during the **serial dilution experiments (Figure 3)**.
- Linear regression gives the **intrinsic specific growth rate**, **μm** (intercept, d^{-1}) and the **specific grazing rate**, **G** (-slope, d^{-1}).
- **No significant differences** between control and alkalized sample in specific growth and grazing rates.



Results

- All experiments were repeated (not shown) and the results were consistent.
- For the **pH effect (Experiment 1)**, dissimilarities seen in biomass indicators across treatments were **not significantly related** to the pH treatment (p = 0.73; ANOSIM).
- For the **exposure duration (Experiment 2)**, dissimilarities in biomass indicators across treatments were **not significantly related** to the length of exposure (p = 0.87; replicate experiment p = 0.80; ANOSIM).
- Exposure to NaOH had **no significant effect** on intrinsic growth rates nor grazing rates (p = 0.14; p = 0.94; paired t-tests on replicate experiments).
- Simulated OAE resulted in **significant increases** in DIC (17%, p < 0.001; replicate experiment 16%, p < 0.001; ANOVA).

Conclusion

∴ In these experiments, **no significant impact** of simulated OAE was detected in phytoplankton biomass composition, growth rates, or trophic transfer by grazing, however, there was evidence of **CO_2 capture.**

- These findings are **congruent** with the available literature.
  - Notable pH-related impacts tend to be species and group-specific and often fall **outside** the ideal range of OAE (Hinga, 2002; Oberlander, 2023).
- Field trials **were** conducted in Bedford Basin, NS, in Fall, 2023.
- **Future testing** should consider different assemblages and more diverse metabolic pathways (e.g., nutrient cycling).

Acknowledgements

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