An analysis of implementing SEA MATE for carbon capture and ocean deacidification

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Project Proposal

Background

Ocean Acidification has many effects on every ecosystem present in the ocean. Carbon dioxide uptake has an effect on the marine-carbonate system by significantly reducing the concentration of carbonate ions, which is what shell building organisms use to build their shells. In California ecosystems, it was found that there is a 20% reduction in calcification by these organisms, as there has been a 35% reduction in carbonate ion concentrations [1]. Additionally, the ocean pH off the coast of California has declined by 0.21, which is (on average) two times higher than the rest of the world [1]. Ocean acidification also causes coral bleaching and can cause food insecurity, especially for those dependent on the ocean for food.

SEA MATE proposes to reverse ocean acidification while capturing atmospheric CO_2 and storing it safely for 10,000 to 100,000 years. SEA MATE uses carbon-free electricity to electrochemically pump acid out of the ocean and the restored seawater traps atmospheric CO_2 in a form that is safely and naturally stored in the ocean. The input can be seawater or any saltwater effluent, including discharge from water recycling or desalination facilities. The acid byproduct is prevented from returning to the ocean and is sold for beneficial use, providing a source of revenue. The less-acidic seawater returned to the ocean stores atmospheric CO_2 as oceanic bicarbonate, the ocean's most abundant form of natural carbon storage [2].

The SEA MATE process separates the NaCl in seawater or desalination effluent into HCl and NaOH. The NaOH is controllably returned to the ocean. This results in an increase in ocean alkalinity and thus total dissolved inorganic carbon (DIC) storage capacity, mitigating ocean acidification and absorbing additional atmospheric CO_2 which is safely stored as oceanic bicarbonate. The timescales of change in the natural ocean carbonate system are long, ensuring storage for 10,000 - 100,000 years. The process is performed in a way that: (1) ensures that the local maximum pH change very near the point of reintroduction never exceeds a pH increase of more than 0.4 units, (2) avoids precipitation of $CaCO_3$ (3) is within the bounds of natural ocean pH cycles and is likely to benefit marine life by restoring baseline ocean pH [2].

Objectives

The first objective is to determine where optimal areas are in Santa Barbara and in the rest of California to implement SEA MATE. These areas should have the following conditions (ideally):

- Coastal regions with water treatment effluent pipelines and the effluent have low Ca^{2+} and Mg^{2+} concentrations
- Coasts with locally lower pH
- Regions with more renewable energy resources to limit carbon footprint
- Regions with less coastal upwelling to allow the carbon to be deposited into the deep ocean

The impacts on the environment and the surrounding population would also be assessed. This would incorporate the environmental justice perspective.

The next objective would deal with determining what is the ideal energy source for SEA MATE and how effective it would be. Questions asked could be:

- What type of renewable Energy? i.e., solar, wind turbine, etc.
- What are the costs associated with using these technologies and what are the impacts?
- Is there additional permitting needed to use these technologies to power SEA MATE?
- Where can we limit electricity that comes from fossil fuels?
- How much carbon can SEA MATE capture, and by how much can it raise the surrounding ocean's pH level?

The third objective would be to conduct a thorough life cycle assessment (LCA) on SEA MATE once the region is chosen. The LCA could be done with differing types of electricity sources, could include the fate of the HCl product, and can determine the feasibility of SEA MATE in California for the long term to see if it is viable investment for the state.

The fourth objective would be a financial analysis on SEA MATE, including information like calculating the cost of operation, how much revenue with SEA MATE bring in, how much could be subsidized by the government, and what are other costs associated with implemented SEA MATE in this specific region.

Significance

This group project will provide the essential information for implementing this novel technology which as of now, has only been implemented in the laboratory setting. This project will allow for further modifications and/or updates to SEA MATE in order to make it a feasible and effective solution for combatting ocean acidification in California. Additionally, carbon capture is important as atmospheric carbon has negative effects on atmospheric processes, oceanic processes, and is the leading cause of climate change. Local carbon capture would also provide cleaner air for the surrounding area.

Equity

When deciding on where and how SEA MATE is going to be implemented in California, demographics of the surrounding area are going to be taken account of. The CALENVIRO SCREEN 4.0 provides detailed and important information on demographics, poverty, and other social aspects that are imperative to include in the decision-making process. The goal of this project is not just to provide a means of solving ocean acidification, but to also be implemented as to prevent environmental injustice to minority communities and emphasize the importance of incorporating environmental justice into major environmental projects. Air pollution has a significant effect on humans and is usually a strong indictor of poverty and environmental injustice. The implementation of SEA MATE would provide a local solution to this issue.

Available Data

- Ocean pH Data: http://www.ipacoa.org/Explorer
- Water Treatment Plant Locations: https://databasin.org/datasets/216db49227a24a8d8a3142524616657a/
- California Energy Data: https://cecgis-caenergy.opendata.arcgis.com/
- Solar Resource Data: https://www.nrel.gov/gis/solar-resource-maps.html
- California Offshore Wind Data: https://caoffshorewind.databasin.org/
- Potential WWTP Data (for effluent concentrations): https://www.waterboards.ca.gov/resources/data_databases/site_map.html
- Desalination Plants: https://www.waterboards.ca.gov/water_issues/programs/ocean/desalination/docs/170105_desal_map_existing.pdf
- CalEnviroScreen 4.0: https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-40

Possible Approaches

To determine the optimal area to implement SEA MATE, spatial mapping software like ArcGIS would be optimal to map ocean pH data and water treatment plant / desalination plant locations. Analysis of raw data would be done on programming languages such as R and Python. There is an abundance of data provided by the state of California on energy sources, treatment plant locations and other information, desalination plant locations and other information, financial data, as well as population data and environmental justice metrics like the Cal Enviro Screen 4.0. Data on ocean pH, coastal geography, and other information needed could be found by looking at research articles and other studies found on the internet.

Deliverables

A report would be provided to SEA MATE on (1) potential locations in California; (2) renewable energy options; (3) LCA findings; and (4) financial considerations. The report would be available to the public.

Internships

An internship for the summer is available with Ebb Carbon for $5,000. The letter with the clients intent will be available soon.

References

[1] E. B. Osborne, R. C. Thunell, N. Gruber, R. A. Feely, and C. R. Benitez-Nelson, "Decadal variability in twentieth-century ocean acidification in the California Current Ecosystem," *Nat. Geosci.*, vol. 13, no. 1, pp. 43–49, 2020, doi: 10.1038/s41561-019-0499-z.

[2] "SEA MATE Overview." [Online]. Available: https://www.ebbcarbon.com/.

ebb carbon

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1/21/2022

Dear Taylor Medina,

We have reviewed the proposal for a Group Project and we will enthusiastically support it by providing the necessary information for the students, as well as one summer internship of up to $5,000.

Sincerely,

Ben Tarbell, CEO