2024 FECM/NETL Carbon Management
Research Project Review Meeting
August 5- 9, 2024

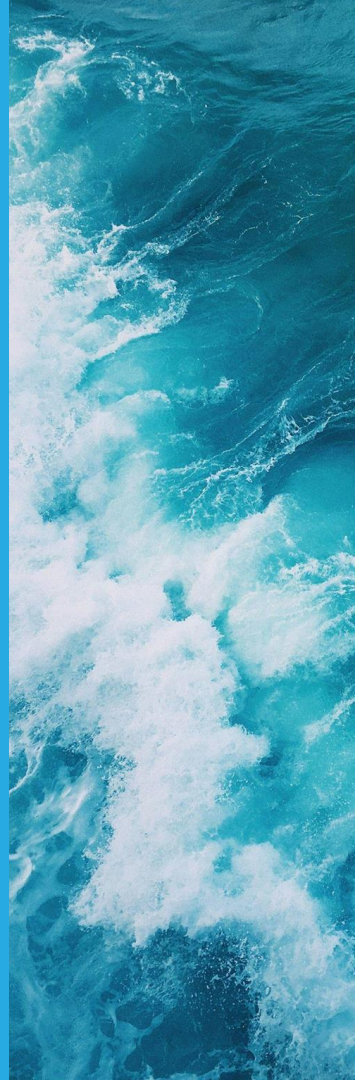
Optimizing the integration of aquaculture and ocean alkalinity enhancement for low-cost carbon removal and maximum ecosystem benefit

DE-FOA-0002614

Mallory Ringham
Ebb Carbon

Overview

- **Funding:** Budget: DOE: $200,000; Cost Share (Ebb): $50,000
- **Project Performance dates:** Dec. 20, 2023 to Sept. 19, 2025
  (operational performance period ends 12/19/2024)
- **Participants from four institutions:**
  - Ebb Carbon: Mallory Ringham, Todd Pelman, Kyla Westphal, Dana Zhu
  - PNNL: Chinmayee V. Subban, Lenaïg G. Hemery
  - UW: Emily Carrington
  - AU: Sara Nawaz

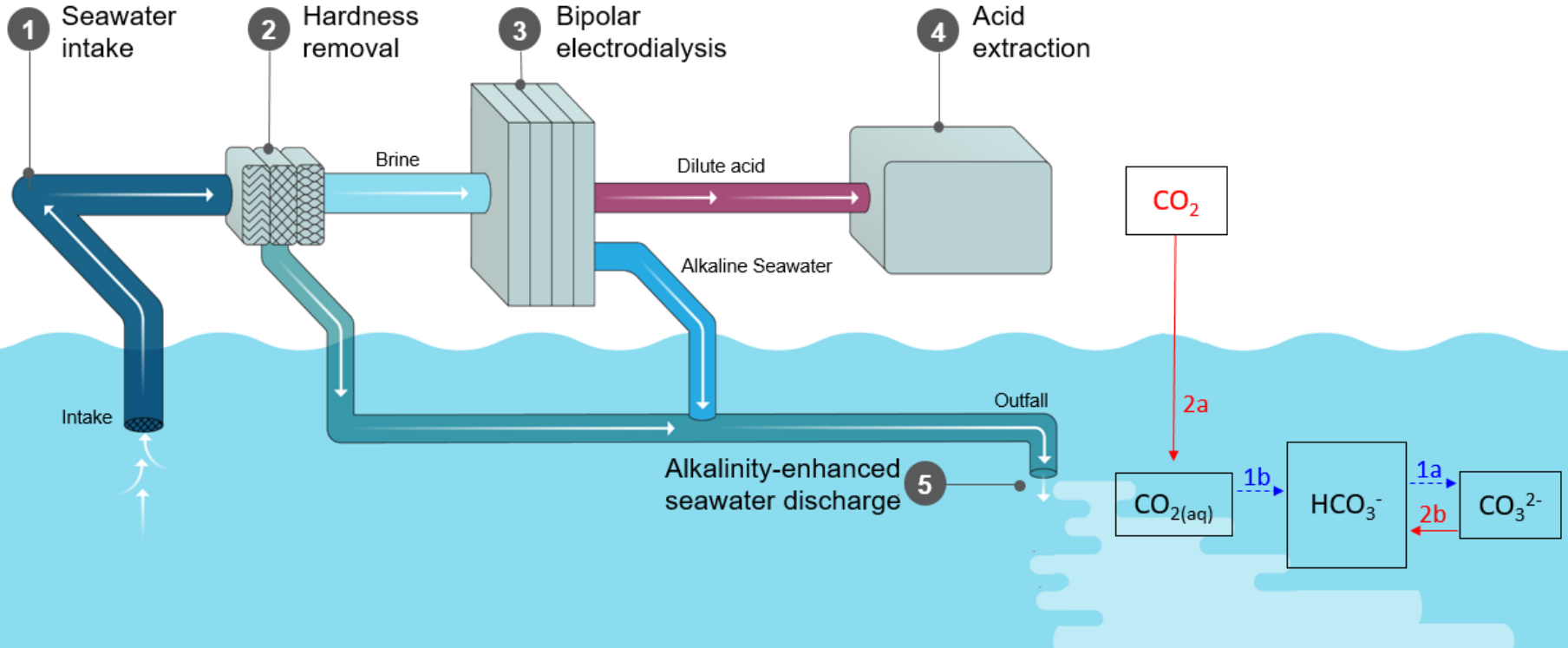


Project description

Ebb Carbon will investigate how ocean alkalinity enhancement (OAE) using electrochemically produced aqueous sodium hydroxide can be used to benefit ecosystems including shellfish and other species impacted by ocean acidification, in addition to Ebb's primary goals of marine carbon dioxide removal (mCDR).

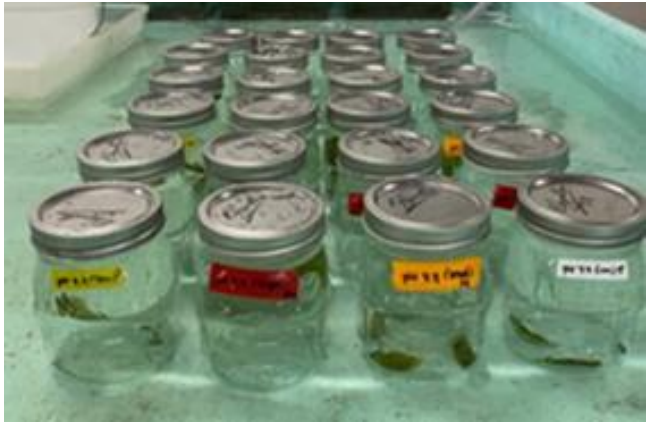
- Design experimental framework, models, and pilot studies to evaluate multitrophic impacts of alkalinity enhancement in coastal Pacific Northwest ecosystems
- Design and optimize alkalinity enhancement system to meet ecosystem needs
- Develop plan to conduct community engagement and to guide ecosystem studies and system design based on stakeholder input

Technology Background: Using the ocean to capture and store CO_2

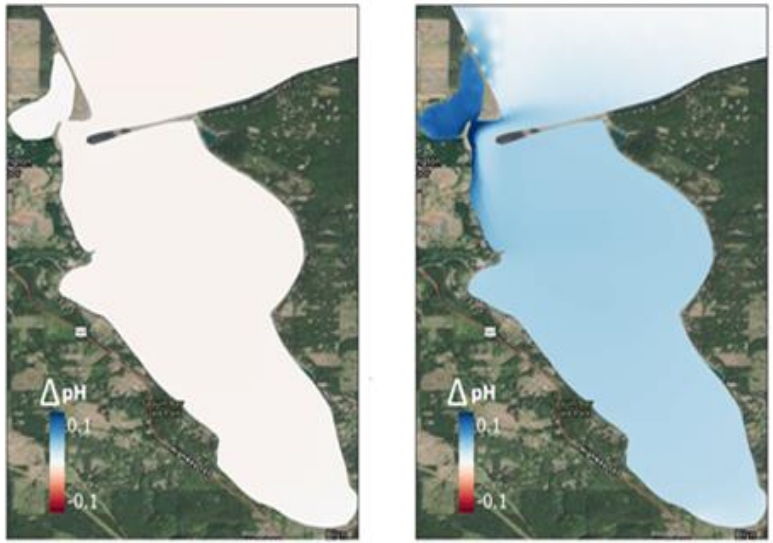


EASE-OA collaboration with UW, NOAA PMEL and PNNL-Sequim

Technological development



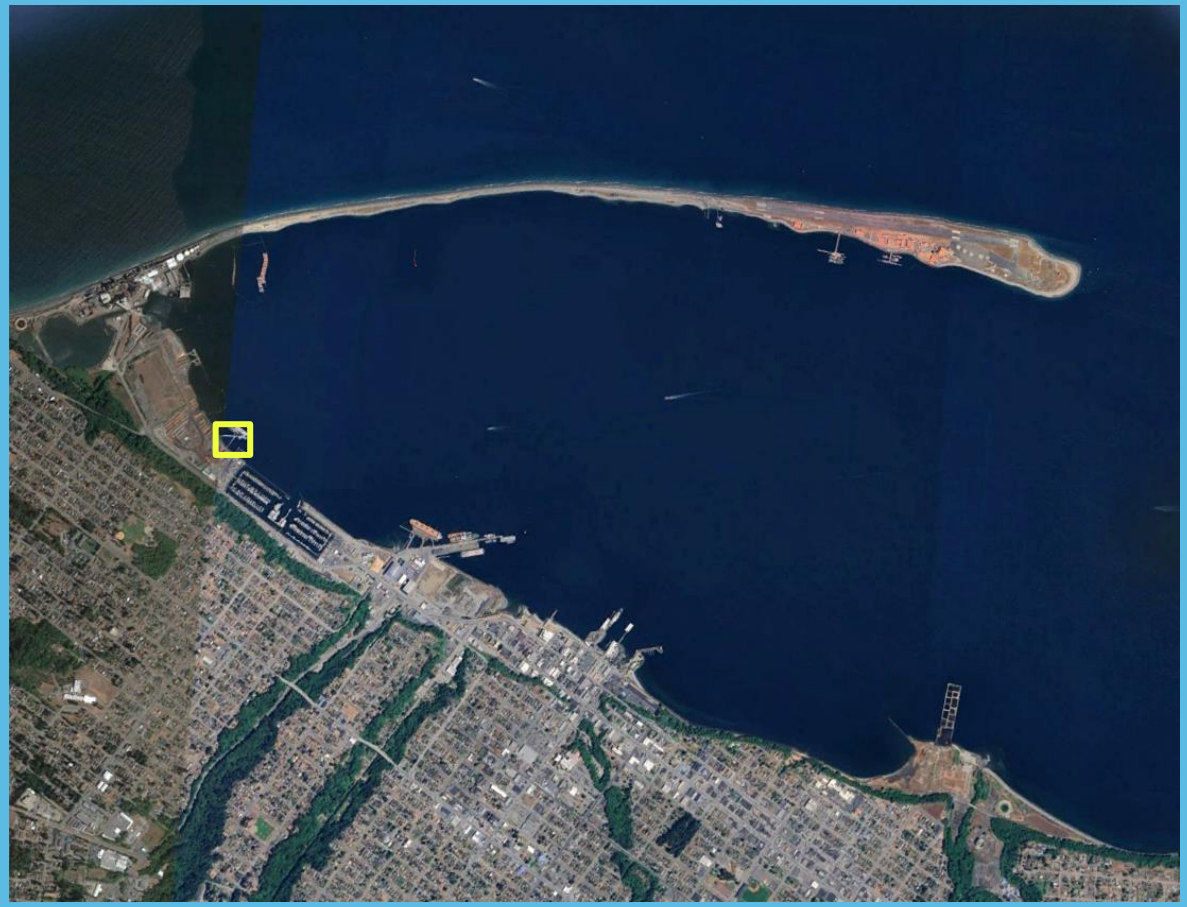
Preliminary species response studies

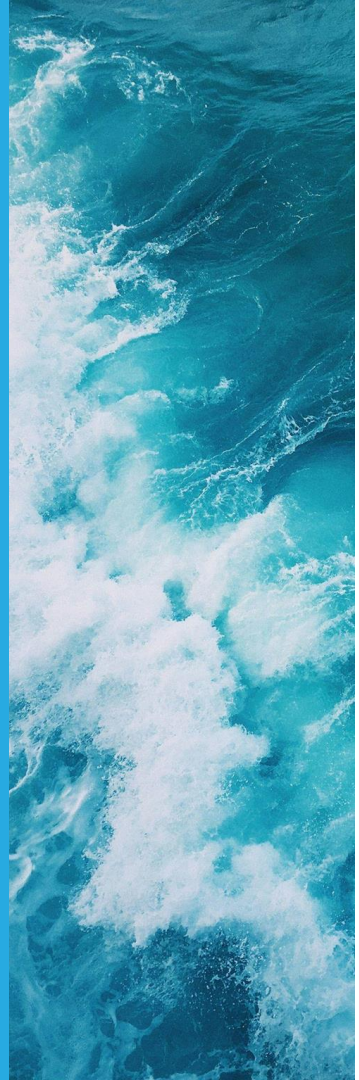


OAE simulations in Salish Sea Model

project macoma

500 ton system proposed for the Port of Port Angeles





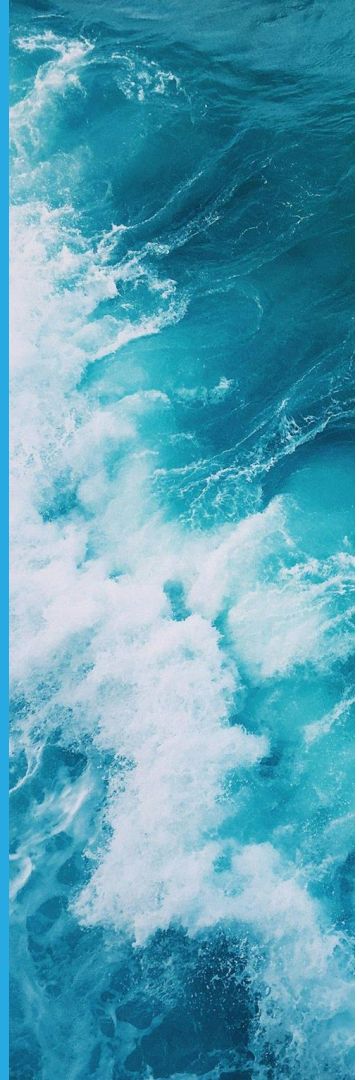
Project scope

Task 1.0 – Project Management and Planning (incl. TMP, TEA, LCA, TGA, EH&S)

Task 2.0 – R&D Community Benefits Plan (CBP)

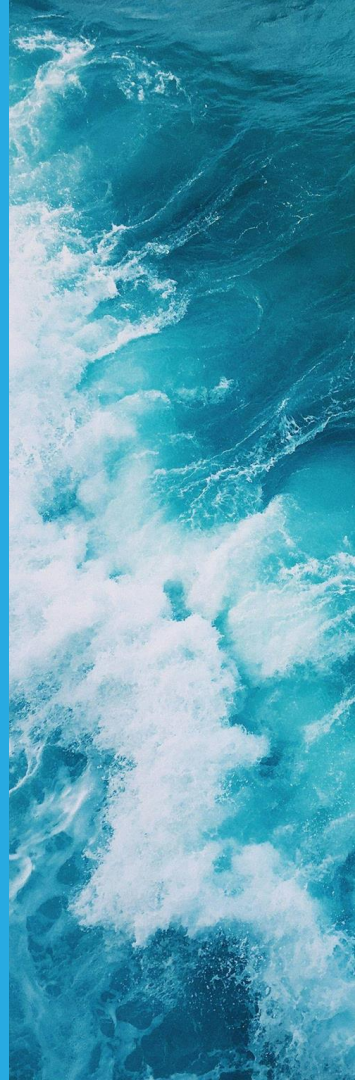
Task 3.0 – Experimental Work - Impacts and benefits of alkalinity enhancement to marine species (two parts: ecosystem impacts and relevant species)

Task 4.0 - Design an alkalinity enhancement system optimized to meet shellfish industry *and whole ecosystem* needs



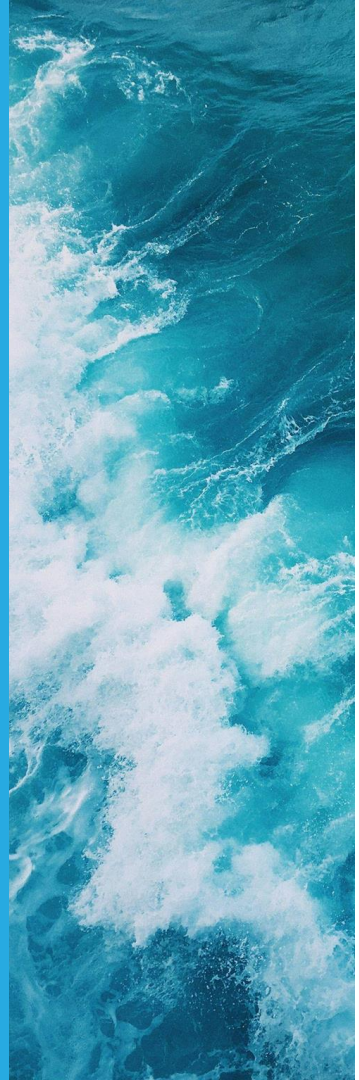
Task 1.0:
Project Management and Planning

- Completed Project Management Plan and Technology Maturation Plan
- Deliverables in progress
  - State Point Data Table
  - Preliminary Techno-Economic Analysis (TEA)
  - Preliminary Life Cycle Analysis (LCA)
  - Technology Gap Analysis (TGA)
  - Technology Environmental Health & Safety (EH&S) Risk Assessment



Task 2.0:
R+D Community Benefits Plan

- Stakeholder analysis and engagement plan in progress
- Phase I relationship building
  - Community organizations, policymakers, eNGOs, elected officials, scientists
- Tribal and stakeholder input to inform ecosystem studies and system design
  - ID'd species of cultural and economic significance (shellfish, salmon)
  - Scoping experimental work
- J40, quality jobs, and DEIA planning in progress

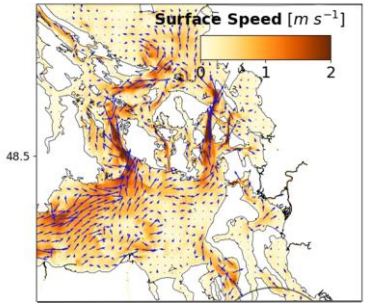


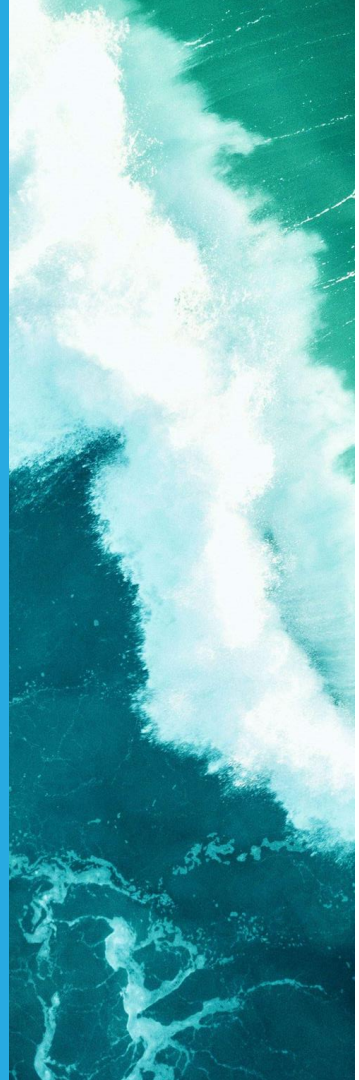
Task 3.0: Experimental work

Impacts and benefits of alkalinity enhancement to marine species (two parts: ecosystem impacts and relevant species)

- Defined multi-trophic ecological data collection framework
- Assessing appropriate multi-trophic food web/ ecosystem models
- Identified experimental work for phase 2:
  - In-situ biological studies during pilot operations
  - Ex-situ species response studies

Task 4.0:
Design OAE system





Lessons learned

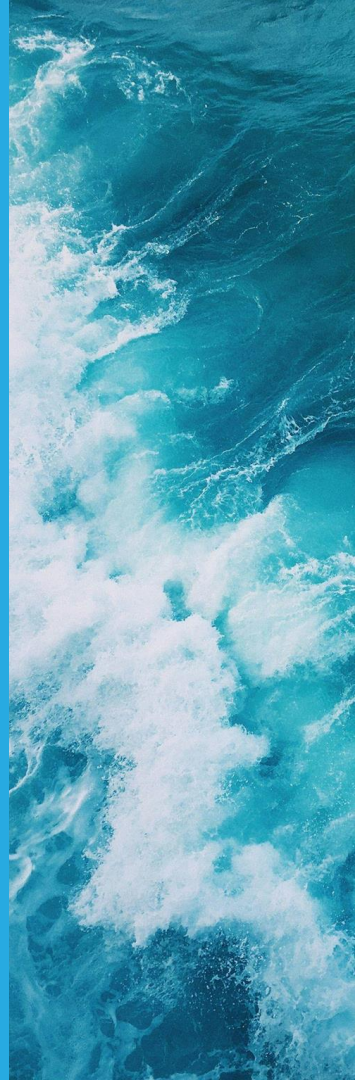
Ecological safety is a top priority for communities

We can use the tools for MRV for carbon removal to also understand and ensure ecosystem health

In addition, piloting mCDR technology safely and responsibly requires:

- Before operating: laboratory experiments and model development, site characterization
- During operations: ongoing monitoring and modeling, field experiments
- Throughout: wide-ranging community outreach

Significant multidisciplinary expertise is crucial to the success of mCDR



Roadmap for science-driven, responsibly deployed OAE technology

Critical path	Laboratory research	PNNL-Sequim demonstration	Project Macoma pilot	Future sites
Develop MRV methodology	✓	✓	✓	✓
In-situ operations			✓	✓
Technology design and validation	✓	✓	✓	✓
Modeling: predict near-field and far-field impacts		✓	✓	✓
Tribal, public and stakeholder engagement			✓	✓
Assess environmental response to OAE	✓	✓	✓	✓
Life-cycle analysis			✓	✓