

ANNUAL
REPORT
2024

 Carbon to Sea
Initiative

A LETTER FROM THE EXECUTIVE DIRECTOR

In 2023, Carbon to Sea spun out of Additional Ventures (now Outlier Projects), with the ambitious goal to systematically assess the feasibility and desirability of Ocean Alkalinity Enhancement (OAE) as a climate solution. With \$50 million in commitments from 10 leading funders in the ocean-climate space, we have built Carbon to Sea into a powerful team of experts across multiple disciplines who are focused on advancing R&D and building the enablers and guardrails for a responsible sector.

We're taking this moment to reflect on the global momentum we've helped spark and to share what we've learned with you. Here are some highlights of our work so far:

Essentially unknown two years ago, Ocean Alkalinity Enhancement is becoming a hot topic among scientists and policymakers. OAE was featured prominently at this year's Ocean Sciences Meeting in New Orleans, is a focus of grant funding from the National Oceanic and Atmospheric Administration (NOAA) in the United States, and was highlighted as a high-potential carbon removal method during the first ever U.S. congressional hearing on ocean-based carbon dioxide removal (oCDR). This surge in interest from scientists, policymakers, and investors is crucial to fuel research, funding, and innovation for OAE.

Since launching, we have awarded more than \$24 million in grant funding to support OAE science and technology teams around the world. Those teams are systematically evaluating the safety, efficacy, and permanence of numerous OAE pathways; developing prototypes for alkalinity generation and delivery; conducting rigorous techno-economic and life-cycle assessments, and catalyzing groundbreaking field research. For example, Dalhousie University and Planetary Technologies are advancing critical research in Halifax, the Woods Hole Oceanographic Institution has completed a dye release in Massachusetts, and our field research site in Iceland has completed a foundational dual tracer study in a fjord north of Reykjavik. These grantees are building a foundation of baseline data for a highly interdisciplinary community of academics, startups, and NGOs to build on.

We are cultivating the oCDR community and building trust among key policymakers. In 2023, Carbon to Sea convened 50 attendees for the first OAE conference. This year, we tripled the event's size with over 160 attendees to discuss the state of our emerging field, problem-solve ongoing challenges, and facilitate collaboration. We also engaged with more than 100 senior government officials and provided testimony to the first U.S. congressional hearing on oCDR.



Carbon to Sea team meeting in Berlin, Germany. (Brishelle Gamble for Carbon to Sea)

We continue to see OAE as one of the most promising CDR solutions and we have not identified any factors that should prevent further research. Based on our current assessment, OAE pathways continue to hold significant potential to achieve gigaton-scale carbon dioxide removal by mid-century in a cost-effective manner. At this point, no significant environmental or durability concerns have surfaced, and solutions for the reliable quantification of CDR are slowly coming into focus. This does not mean that there aren't upper limits on OAE — but we are identifying what these are so they can be avoided.

As a non-profit, impartial effort, we are heavily hypothesis-driven and outcome-agnostic. If there are scientific, environmental, or economic reasons to stop pursuing a given OAE pathway or

OAE as a whole, we'll be the first to publicly say so.

Thank you for joining us on this journey to evaluate a tool that could help combat climate change while protecting our oceans. With your support and the team we have built, I am confident that Carbon to Sea's impact will only grow. We're just getting started.

Sincerely,

Antonius Gagern
Executive Director
The Carbon to Sea Initiative

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INITIATIVE ONE

SCIENCE AND TECHNOLOGY

The first goal of our program is to help determine whether Ocean Alkalinity Enhancement has a future. Broadly speaking, we are seeking to answer three major questions:

1. Can OAE be conducted in an environmentally safe manner?
2. Does OAE lead to additional and permanent atmospheric carbon dioxide (CO₂) removal?
3. Can OAE be scaled to Gt/yr CO₂ removal at an attractive price?

To seek answers to these questions systematically and quickly, we're advancing several areas of research and development, which are tightly integrated:



Mesocosm research by GEOMAR in Kiel, Germany. (Courtesy of GEOMAR)

FOUNDATIONAL RESEARCH

We committed nearly \$9 million in multi-year grants to multiple international laboratory, mesocosm, and modeling studies across five academic institutions and six principal investigators. This funding is advancing our collective understanding of the efficacy and safety of OAE, while encouraging researchers to

publish their findings in scientific journals. The research signals early positive signs about the safety of OAE field trials.

In lab and mesocosm studies, OAE safety was tested using levels of alkalinity higher than would be expected in real-world deployments. This work is demonstrating safe operating limits for multiple species and marine food webs.



Field research in Halifax, Canada. (Planetary Technologies)

Additional laboratory studies have started to determine OAE efficiency by finding the upper limits of how much alkalinity can be increased before chemical reactions lead to a decrease in alkalinity. Efficiency is also being studied in terms of geography, investigating if and where OAE's potential could be offset by suppressing natural sources of alkalinity. And, modeling studies are beginning to find the best places to conduct OAE.

We have launched a model-intercomparison project, in partnership with Google, to advance our understanding of global OAE efficiency. In collaboration with multiple global-scale modeling groups, we are planning the experiments now. The project aims to be part of a larger model intercomparison project on CDR and to ultimately inform the next United Nations Intergovernmental

Panel on Climate Change (IPCC) report.

In partnership with Ocean Visions, we are developing a comprehensive R&D roadmap to enumerate the full suite of public and private investments needed to evaluate and advance OAE's contribution to CDR.

Overall, the research is starting to identify safe and efficient operating thresholds for different alkalinity feedstocks, deployment pathways, and geographic regions, with no show-stopping challenges identified.

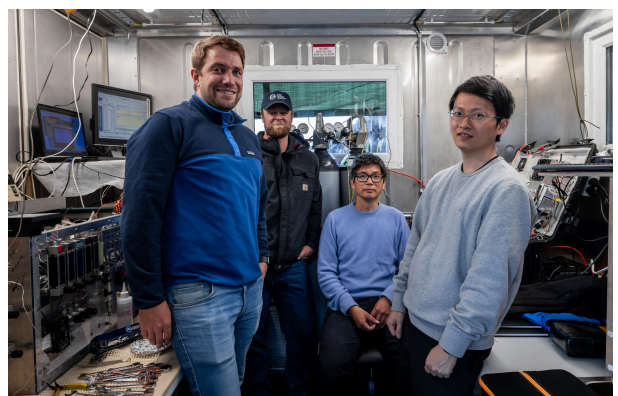
FIELD RESEARCH

We committed more than \$7 million for scientists to conduct field research, including at the Woods Hole Oceanographic Institution and Dalhousie University (Ocean Alk-Align Consortium).

An additional \$4 million was invested to establish sites in Canada and Iceland where field research can take place on a consistent basis. Establishing an OAE field research site requires consideration of several factors, including local partnership capacity, community interest, and regulatory feasibility. These strategic investments will increase the quantity and quality of field data by reducing the logistical and financial burden of field research. We have a unique opportunity to accelerate learning by centralizing trials at each of these sites, saving time and reducing costs by standardizing data collection and leading meaningful community engagement.

In Halifax, grantees at Dalhousie University and Planetary Technologies have begun a multi-year collaboration on a research program. Planetary engineered a dispersal mechanism for releasing alkalinity through existing outfalls, and Dalhousie University is conducting independent scientific evaluation while also developing a regional ocean model and first of its kind observations system.

To build on this partnership, Carbon to Sea partnered with COVE to pilot a new flexible funding mechanism, in part because we believe the public-private model we helped pioneer between Dalhousie and Planetary is working. We recently announced four grants totaling \$250,000 as a “Joint Learning Opportunity” to fund four additional, complementary studies, including benthic impacts of feedstock accumulation, monitoring of environmental DNA, deployment of new sensors, and Indigenous community engagement.



Research in Iceland. (Thrainn Kolbeinsson for Carbon to Sea)

In Iceland, our field site is locally led and operated under the name Röst Marine Research Center and began operations in collaboration with the Icelandic climate company Transition Labs. It is overseen by a Board of Directors (which we chair) and supported by a Science Advisory Board made up of national and international experts. [C]Worthy has led the development of a high resolution regional ocean model for Hvalfjörður fjord, and conducted a dual tracer release study to complement a year long baseline data collection regime by the Marine and Freshwater Research Institute of Iceland. [C]Worthy will collaborate with Ebb Carbon and additional partners on the design and implementation of the site's first alkalinity field trial, permit pending, in 2025.

Our field research strategy is shaped by the generous insights and experience of a Field Site Steering Committee which

includes Dr. Matt Long, Dr. Jamie Palter, Dr. Dariia Atamanchuk, and Dr. Tyler Cyronak.

TECHNO-ECONOMIC AND LIFE CYCLE ANALYSES

We commissioned analytical efforts to identify scaling bottlenecks and cost drivers of a variety of OAE pathways. This bottom-up supply chain analysis powerfully demonstrates that OAE is not just one solution, but a portfolio of many highly distinct pathways that each have their own challenges and opportunities. Here are some of the findings:

- **Coastal enhanced weathering** may be highly scalable and cost less than \$100 per ton, if it can be demonstrated that dissolution kinetics are fast, alkalinity generation is efficient, and natural alkalinity sources are not suppressed.



Site of the Röst Marine Research Center in Arkanes, Iceland. (Thrainn Kolbeinsson for Carbon to Sea)



Field research in Halifax, Canada. (James Ingram for Carbon to Sea)

- **Electrodialysis-based OAE** can be a scalable and cost-effective pathway with simpler MRV when co-located with brine production, cost-negative acid storage, and cheap renewable energy.
 - **Wastewater treatment-based OAE** may be one of the most ready-to-go pathways benefitting from existing infrastructure, permits, municipal emissions reduction targets, and a well-known alkalinity feedstock, limestone.
 - **Ocean liming** is theoretically scalable but will only emerge as a viable solution if and when low-cost electric calcification of limestone, as well as carbon capture and storage technologies, are widely accessible.
- For each OAE pathway, the analysis offers specific R&D priorities that will inform Carbon to Sea's strategy going forward. Once peer-reviewed, we will make the report accessible to a broader audience.
- **Planetary Technologies:** an alkalinity delivery system that was successfully tested in Halifax;
 - **Crew Carbon and Ebb Carbon:** enhancements to acid neutralization and olivine dissolution of electrochemical OAE;
 - **Aquatic Labs:** sensors that can autonomously measure alkalinity and pH of seawater;
 - **University of Toronto and McMaster University:** a more efficient membrane that could decrease costs of electrochemical OAE;
 - **Heriot-Watt University:** a reactor that converts limestone into a more-easily dissolved form.

TECHNOLOGY DEVELOPMENT

We made \$6.2 million in grant funding to

Each of these efforts reached or exceeded their milestones along 12 - 18 month timelines, demonstrating the effectiveness of the grant model and informing future funding priorities.

INITIATIVE TWO

POLICY AND COMMUNICATIONS

The carbon removal field as a whole is moving fast — with more funding, activity, and attention than ever. At the same time, ocean-based carbon removal is lagging behind other approaches in terms of understanding, funding, and attention. As an organization, we want ocean-based approaches to be well understood and considered as part of the CDR portfolio by governments and philanthropies that are set to make sector-shaping decisions on funding and governance in the years ahead.

While our first initiative focuses on asking the question of whether OAE can be done in a safe, cost-effective, and permanent manner, our Policy & Communication initiative is concerned with building support for R&D and the creation of frameworks that allow for the emergence of a responsible and high-integrity sector — if and when risks and opportunities are sufficiently evaluated. We have been working on four major strategies:



Private briefing on messaging research during Climate Week in New York City. (Danny Gawlowski for Carbon to Sea)



U.S. Congressional Hearing on ocean-based carbon removal. (Stephen Voss for Carbon to Sea)

BUILDING GOVERNMENT SUPPORT FOR oCDR RESEARCH

We are directly engaging government agencies and policymakers to help gain approval for current science initiatives and advocate for increased research funding. This includes direct outreach to more than 100 senior government officials and more than \$900,000 in grants to science-first policy organizations in the U.S., China, and Germany. In September, we submitted testimony to the first-ever U.S. congressional hearing on ocean-based carbon dioxide removal and worked closely with staff to help Members prepare. The hearing earned widespread, bipartisan support.

ADVANCING GOVERNANCE THROUGH GUARDRAILS AND ENABLERS

While there is no current law in the United States designed specifically to regulate oCDR, we conducted research on the application of existing legal frameworks to illuminate how existing laws and regulations could govern oCDR research.

Despite the complexity, we're optimistic that responsible in-water research efforts will be able to secure permits under existing laws, and we're working with regulators in the U.S to clarify this.

EDUCATING KEY AUDIENCES AND EXPANDING PUBLIC UNDERSTANDING

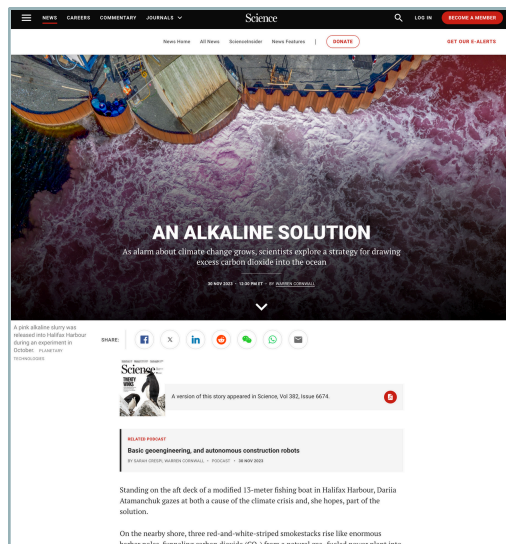
Through strategic communications and our outreach efforts, Carbon to Sea is building credibility and educating key audiences about OAE. At the international level, in addition to grant making to support efforts in Germany and China mentioned above, we are actively engaging and helping shape the conversation about oCDR as a potential ocean-climate solution at the multilateral level. During COP28, we organized a panel conversation that included the Chairman of the U.S. Foreign Relations Committee Senator Ben Cardin, NOAA's CDR lead, as well as representatives from Ebb Carbon and Quadrature Climate Foundation. We also earned news coverage about oCDR in top-tier publications such as the New York Times, Science Magazine, and Axios.

IMPROVING COMMUNICATIONS THROUGH MESSAGING RESEARCH

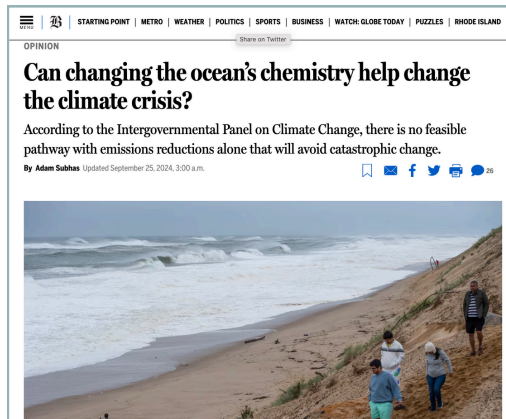
We commissioned three phases of messaging research to identify the best public case for oCDR. Those phases included engaging sector experts, conducting high-level policymaker interviews, and finally a poll of coastal voters across the United States. We identified phrases and communications approaches that were most effective, as well as those that should be avoided. This data now informs all of our communications, and was shared with more than forty sector leaders in a closed briefing during Climate Week. We are planning a wider release this year.



The New York Times: 'Bold plan would turn the world's ocean's into carbon busters'



Science Magazine: 'An Alkaline Solution'



The Boston Globe: 'Can changing the ocean's chemistry help change the climate crisis?'

INITIATIVE THREE

RESPONSIBLE SECTOR DEVELOPMENT

As the oCDR sector develops, Carbon to Sea is committed to guiding the growth towards a responsible and science-driven industry. As work is conducted throughout the globe, there is a rising need for collaboration, coordination, and consensus. Here are steps we have taken as we develop an ambitious sector-building program:



Carbon to Sea's 2024 Annual Convening in Washington, D.C. (Kevin Lowery for Carbon to Sea)

CONVENING THE LARGEST ANNUAL OAE EVENT

In 2023, we gathered 50 OAE leaders at an invite-only Convening event in Washington, D.C. This year, we held a second Convening that drew 160 key leaders and stakeholders. The event has been a key forum for networking, coordination, and knowledge sharing

between academic researchers, private companies, non-profit groups, and government agencies. Our keynote address featured Dr. Sarah Kapnick, Chief Scientist for NOAA.

We have started planning our 2025 Annual Convening and are looking for ways to continue the momentum of collaboration across the oCDR community.



OAE data standards workshop in Halifax, Canada. (Darren Calabrese for Carbon to Sea)

CREATING DATA MANAGEMENT STANDARDS

In September, we convened a workshop of 30 OAE field research experts to lay the foundation of new data standards to be applied across all OAE field research project data. We aim to share our recommended Field Data Standard Protocol at the AGU conference in December, co-publish the protocol with NOAA, and weave the protocol into our funding agreements going forward. This

standards alignment is critical to make field data intercomparable and to enable scientific understanding to advance more quickly.

BUILDING PARTNERSHIPS

In addition to our role as a funder, we are playing a critical role enhancing coordination between a growing coalition of diverse organizations that are working to advance oCDR science and policy – to build a thriving and responsible sector.

BUILDING PARTNERSHIPS

GRANTEES

Organizations that are investigating key program questions and have regular progress check-ins with us.



OPERATIONAL PARTNERS

Firms and experts essential for the successful delivery of our programs.



THE CARBON TO SEA TEAM



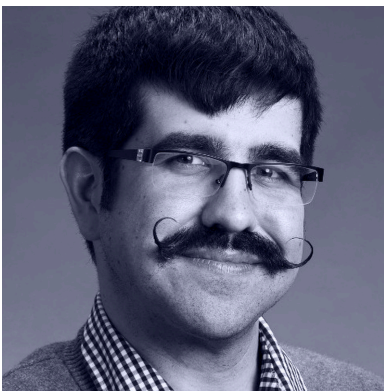
DR. ANTONIUS GAGERN
EXECUTIVE DIRECTOR



LUCY FITZGERALD
SR. MANAGER, OPERATIONS



BRISHELLE GAMBLE
SR. PROGRAM ASSOCIATE



DANNY GAWLOWSKI
SR. MANAGER, COMMUNICATIONS



DIANE HOSKINS
DIRECTOR, GLOBAL POLICY



DR. DAVID KELLER
DIRECTOR, RESEARCH



ANNA MADLENER
MANAGER, MRV



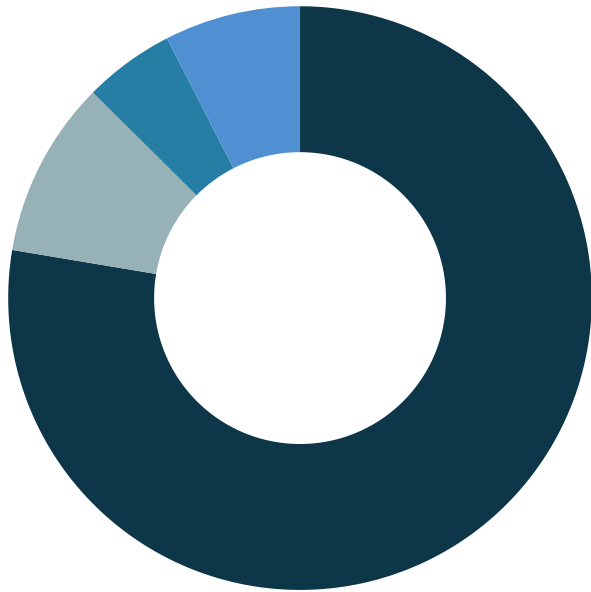
IRENE POLNYI
DIRECTOR, FIELD RESEARCH



MIRIAM ZITNER
GM, CANADA

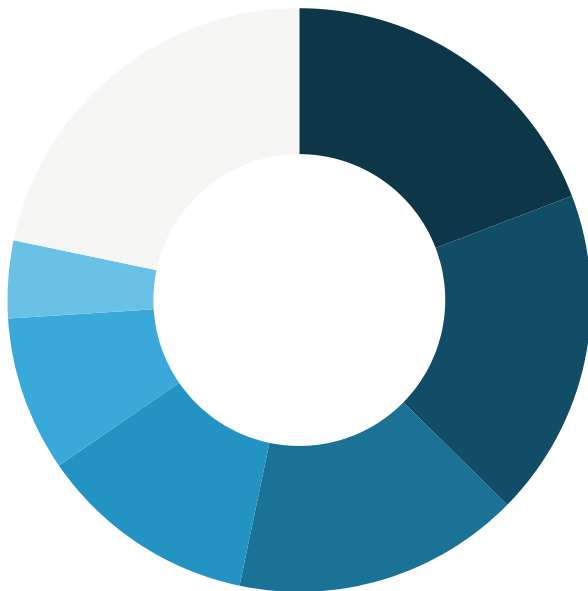
FINANCIAL UPDATE

\$39.7M+

BUDGET SPENT OR COMMITTED, 2022 THROUGH 2027

TOTAL BUDGET SPENT OR COMMITTED ACROSS INITIATIVES, 2022-2027

- SCIENCE & TECHNOLOGY
\$30.9M
- POLICY & COMMUNICATIONS
\$3.9M
- MARKETS & FIELD BUILDING
\$2M
- OPERATIONS
\$3M



BREAKDOWN OF SCIENCE & TECHNOLOGY BUDGET SPENT OR COMMITTED, 2022-2027

- FIELD RESEARCH GRANTS
\$7.6M
- FOUNDATIONAL RESEARCH GRANTS
\$7.2M
- TECHNOLOGY GRANTS
\$6.3M
- FIELD RESEARCH SITES
\$4.8M
- EMPLOYEE SALARIES
\$3.4M
- COST & SCALE ASSESSMENTS
\$1.7M

The logo consists of three white, stylized, curved lines that resemble waves or a stylized 'C' shape, positioned to the left of the text.

Carbon to Sea Initiative

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