

Running Tide 2023 Iceland Experiment Overview

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Below we outline the experiments that Running Tide has planned, started in 2023 and are part of the work related to the research permit issued by the government of Iceland on July 8, 2022 (“**the permit**”) to research and test Running Tide’s Carbon Removal System (“**the system**”). For each experiment, we outline the purpose and goals and how we aim to reach those goals. The substrate used in these experiments are individual pieces of woody biomass (woodchips) coated with alkaline materials (calcium carbonate and/or calcium oxide).

Please note that experiments might be added to this from time to time. In those cases, an updated version will be shared. Updates are highlighted in yellow.

More details can be provided on request.

For any questions, please contact:

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Overview of in progress and planned experiments in and around Iceland

Deepsea Benthic Experiment #2	
Status	In progress (since September 2023)
Purpose	To actively monitor the ecological and environmental impact and degradation of carbon buoy materials on the seafloor.
Method	Terrestrial biomass (wood rounds and mycelium) and <i>Saccharina latissima</i> were sunk to the seafloor (approximately 1300m) in a benthic lander system with a camera connected to Ocean Networks Canada cable infrastructure. Camera images and data from sensors are transmitted back in near real-time, providing information on visitation by larger organisms, visible changes to biomass over time, and environmental conditions. In addition, seawater and radial sediment samples were recovered during the deployment of the experiment and will be collected again at the ~1 year mark by an ROV. Sediment samples collected both before and after the experiment will be analyzed with regards to macrofauna, microbial community composition and diversity, as well as carbon and nutrient content. After approximately one year, the benthic lander will be recovered and biomass materials analyzed.
Reporting plan	Data is available to Running Tide through ONC's Oceans 3.0 system in near-real time. Video of the platform is available (example video here) and sensor data is available here . Running Tide will prepare status reports. This collaborative project will likely result in formal presentations and publications from both ONC and RT.
Notes	In partnership with Ocean Networks Canada

Deepsea Benthic Experiment #1	
Status	In progress (since June 15, 2023)
Purpose	To test the degradation rate of carbon buoy materials on the deep seafloor and monitor impact to the deep benthos.
Method	Terrestrial biomass, <i>Ulva lactuca</i> , and <i>Saccharina latissima</i> was sunk to the seafloor (approximately 4000m) during the Polarstern Hausgarten Cruise, along with <i>Sargassum</i> , as part of a collaboration with researchers at the Alfred Wegener Institute for Polar and Marine Research and Seafields. The study site will be revisited after one year to collect sediment samples, subsamples of the sunk material, and other environmental variables using sensors. The study site may be revisited after a second year pending the first year results.
Reporting plan	This collaborative project will ideally result in a publication driven by Running Tide's academic partners. Regardless, Running Tide will summarize results after the one year sample collection and analysis is complete.
Notes	In partnership with the Alfred Wegener Institute for Polar and Marine Research and Seafields.

Iceland Coastal Benthic Experiment	
Status	In progress (since June 14th, 2023)
Purpose	To actively monitor the impact of deposited biomass on the benthic environment.
Method	Substrate (wood coated with a mixture of CaCO_3 (80%) and Ca(OH)_2 (20%)) was deposited in nets (100kg wet weight each) at the bottom of Hvalfjörður at 30m depth. Water and sediment samples are collected routinely to monitor the effects of the substrate on the benthic environment at the sediment interface. This includes analysis of ocean and sediment chemistry, composition of microbial communities, as well as epifauna and infauna. Samples are also collected at a control plot in the same area. Dissolved oxygen, temperature, conductivity and pH are monitored continuously at both experimental and control site.
Reporting plan	This 12 month long experiment will have a mid-way report and a final report.
Notes	<p>14 weeks after the start of the experiment, no significant effects of the deposited biomass have been observed on pH, total alkalinity, calcium and dissolved organic carbon in seawater and total nitrogen and total organic carbon in sediment.</p> <p>This is one of multiple benthic experiments Running Tide is conducting this year. They will be conducted in several locations at varying depths down to the abyssal zone.</p>

Iceland Carbonate Dissolution #2	
Status	In preparation (target start date: Q1/Q2 2024)
Purpose	To understand the comparative transport of substrate, trajectory buoys, and dissolved alkalinity, as well as the dissolution rate and addition of trace metals in open ocean environments.
Method	<p>LKD and rhodamine coated substrate and trajectory buoys will be deployed in an exposed area. Measurements of DIC, pH, and TA taken in the plume post-deployment will be compared against baseline values collected prior to the deployment to determine whether changes to surface ocean chemistry can be detected. Furthermore, trace metal concentration and dissolution will be measured.</p> <p>To address questions about the differences between buoy trajectories and substrate trajectories the trajectory of the substrate will be determined using aerial imagery and in-situ rhodamine dye measurements ultimately comparing to the GPS coordinates of the trajectory buoys.</p>
Reporting plan	Study report several months after experiment finishes.
Notes	N/A

Open Ocean Ulva Growth	
Status	In progress (Since week of June 5, 2023)
Purpose	<p>To understand growth rates and potential of <i>Ulva lactuca</i> in open ocean conditions.</p> <p>To collect water samples to enable us to recreate the ocean environment for continued lab studies.</p>
Method	<p>Cotton rope seeded with <i>Ulva lactuca</i> was placed in ocean observation platforms with cameras and deployed in the open ocean. Four observation platforms with two cages each were deployed at a time. Images were automatically captured four times per day during float time and images analyzed manually and using machine vision for <i>Ulva</i> growth. Water samples were collected at the deploy site and analyzed for N, P, Fe, and salinity.</p>
Reporting plan	Key results from the open ocean growth experiments performed, show a successfully demonstrated baseline of visual growth.
Notes	We expect between 5-6 repetitions of this experiment.

Open Ocean Carbon Removal System Deployments	
Status	In progress (start date: May 15 2023) Phase 1 completed as of Sept 30/2023
Purpose	<p>To understand the immediate environmental impacts of deploying Running Tide’s carbon removal system on the surface layer of the ocean.</p> <p>To understand the transport, dispersion, and sinking of the substrate.</p> <p>To understand and quantify the net carbon impact of deploying Running Tide’s system.</p> <p>To gather real world in-situ data to train our oceanographic models.</p>
Method	<p>Substrate will be deployed far off shore (~190 Nm) in batches of 500-1000 bone dry metric tons (BDMT) of substrate (estimated 40-60% moisture content). Multiple material samples will be collected prior to deployment and analyzed for carbon content and moisture, as well as ash content. Moisture will also be analyzed continuously as the deployment vessel is loaded using a moisture sensor.</p> <p>Deployment site will be selected based on weather and current forecast using Running Tide’s prediction models. Water samples will be collected at the deployment site before (baseline) and after deployment. Trajectory buoys will be deployed alongside the material to track dispersion and ocean currents. Ocean observation platforms with samples of the substrate will be deployed to track float time.</p> <p>Weather allowing, aerial photographs (drone) of deployed material will be captured right after deployment to visually analyze dispersion. Net carbon impact will be calculated according to Running Tide’s framework protocol using data gathered in the field, material samples, and other inputs defined in the protocol.</p>
Reporting plan	Regular updates on results of deployments (water chemistry, dispersion and sinking, net carbon removed). End of season final report on experiment outcomes.
Notes	N/A

Overview of completed experiments and experiments being processed

Open Ocean Sensor Suite Deployment	
Status	Processing (start date: December 2, 2022)
Purpose	To gather real world in-situ data to train our oceanographic models. To gather and analyze water samples in similar areas to where deployments will take place.
Method	Deploy our suite of sensors (trajectory buoys and ocean observation platforms) mimicking a research deployment without substrate. Map trajectory data from sensors to oceanographic models. Train machine learning models to analyze data from observation platforms for sinking rate calculations. To gain information on ocean conditions around future deployment sites, TA, pH and conductivity values are obtained from seawater samples collected at time of sensor deployment.
Reporting plan	Final report under way.
Notes	N/A

Iceland Carbonate Dissolution #1	
Status	Processing (Start date: May 17, 2023)
Purpose	To determine the dissolution, dilution, and potential impact of LKD (lime kiln dust, CaO) deployment in the surface ocean.
Method	LKD coated substrate will be placed in the ocean and water sampled with high frequency following the deployment. Analysis of alkalinity and trace metals will be used to estimate the environmental impact of the substrate coating over time in a more controlled manner than is possible in an open ocean deployment.
Reporting plan	Final report under way.
Notes	This is a pilot study for Iceland Carbonate Dissolution #2. Iterations of the experiment are expected.