The Data
Behind A Credit

The Data Behind A Credit

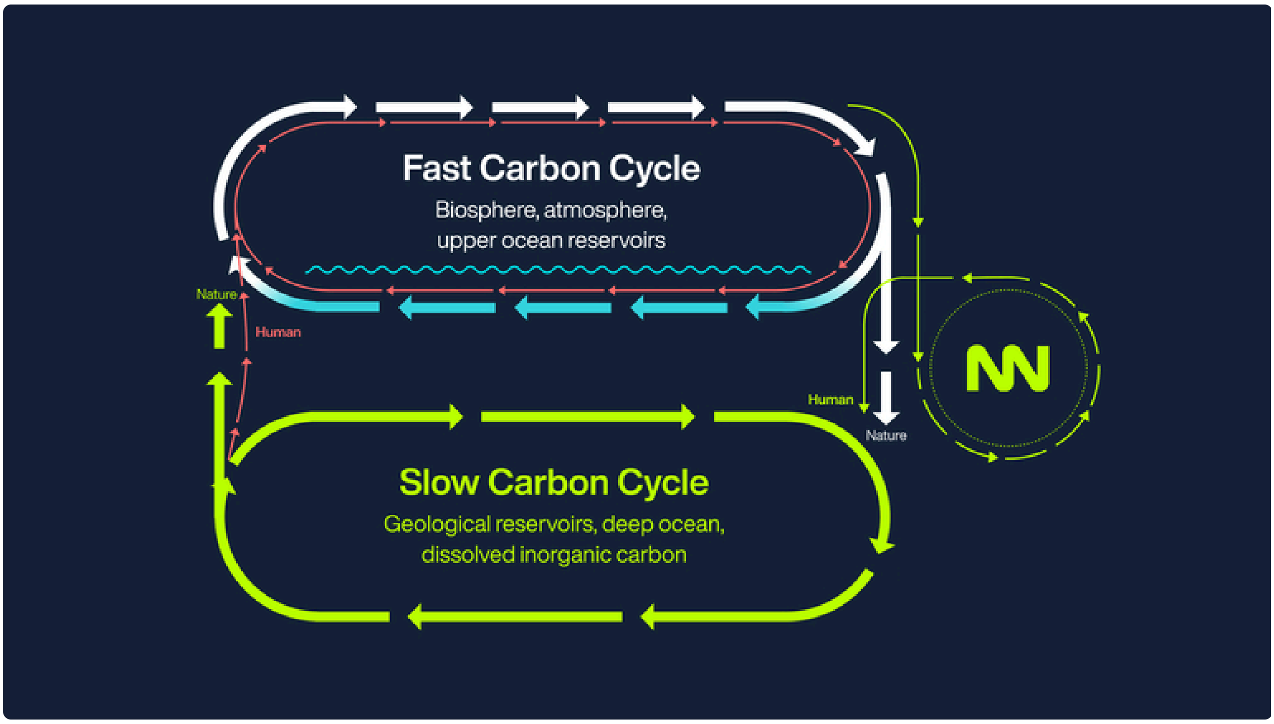
Running Tide has posted a database of carbon removal credits delivered to customers from work conducted in 2023. This database is the culmination of a massive monitoring, quantification, and carbon accounting effort conducted across Running Tide's team and with external partners and warrants a deep dive into the data behind these credits.

Why?

By extracting and burning fossil fuels, humans are moving more than 9 billion tonnes of carbon from the slow to the fast cycle every year, causing widespread damage to natural systems, including increased warming, ocean acidification, habitat loss, and biodiversity loss.

We have a small window of time to rebalance Earth's carbon cycle by combining decarbonization and carbon removal, transporting massive amounts of carbon back to durable storage deep in the Earth.

Specifically, we need to move carbon from the fast carbon cycle to the slow carbon cycle responsibly - with a net positive global impact beyond just carbon - and immediately.



The fast and slow carbon cycles

The 2023 Icelandic Research Project

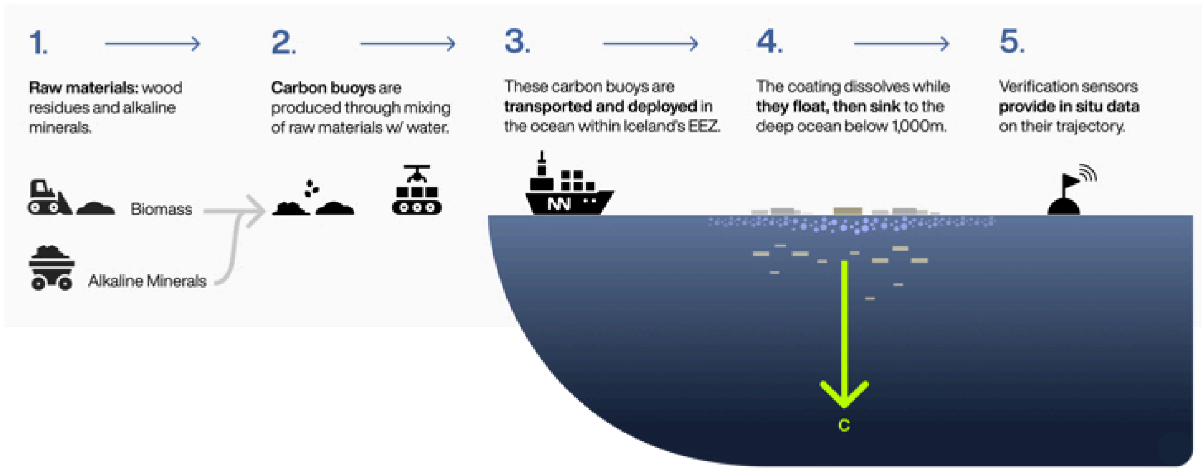
In 2023, Running Tide conducted a joint applied science and ocean modeling undertaking in Iceland to initiate, evaluate, and evolve first-of-a-kind ocean carbon removal projects. We loaded a barge with fast-carbon-rich materials and dispersed this carbon in the North Atlantic 15 times over five months. These Deployments consisted of mixtures of sustainably sourced wood residues from forestry operations in Canada, alkaline mineral residue material, including lime kiln dust from Sweden, and water, all of which were mixed and passively cured on-site at a port in Iceland.

Many thousands of tonnes of wood ready to be mixed with alkaline coating in Iceland.

The mixing process.

The tug and loaded barge sailing towards the open ocean for a deployment.

Once deployed in the ocean, the wood floated for a few weeks, with the alkaline coating dissolving on the surface ocean - helping to draw down even more carbon - before most of the carbon-rich wood sank below 1,000 meters, where it will be out of contact with the fast carbon cycle for centuries. The ocean is one of the world's largest natural carbon reservoirs, and by doing the work to amplify its existing biological and solubility pumps, it has the potential to be one of humanity's greatest allies in the fight against climate change.



Running Tide's 2023 operational process deploying from Iceland.

We've claimed that these 2023 operations have removed at least 25,000 tonnes of carbon. However, measuring each carbon molecule on any practical timeline would be impossible while operating in an open system such as the ocean. Instead, we had to rely on earth-system modeling, lab testing, and Deployment observations to arrive at a conservative amount of carbon removed per Deployment. This quantification process allows us to measure our impact on the carbon cycle as we piggyback on the thermodynamic work already occurring in nature.

Learning Loops: Model -> Test -> Measure

Running Tide combines three approaches to build confidence in calculations when operating in the open ocean.

- Modeling: Ocean modeling allows us to forecast where wood from a Deployment will float before sinking and how the coating will dissolve. It also allows the team to correlate ocean measurements with third-party ocean data. Oceanographers and data scientists improve these modeling systems by running more simulations to increase confidence in the results.

- Lab Testing: Using Running Tide’s lab facilities and partner laboratories, the team characterized the performance of the coated wood in controlled settings. They determined bounds for recipe composition, float time, size grading, alkalinity addition, DOC, moisture content, and carbon content.
- In-Situ Measurement: The team also captured data directly from these 15 Deployments, allowing scientists to ground-truth the models and provide additional bounds to the labs' data sets. In 2023, the team monitored a wide range of data, everything from vessel camera footage to verification hardware GPS locations, and we’ll go into much more detail on the types of measurements below.

How Running Tide Quantifies Carbon Removed

$$Net\ CO_2e\ Removed = Gross\ CO_2e\ Removed - Project\ Emissions$$

One credit equals one net tonne CO_2e removed.

Net CO2 removed is the net amount of carbon moved from the fast to the slow cycle after deducting the additional emissions from doing the carbon removal work. While Running Tide quantifies Carbon (C) throughout the project process, it’s converted to Carbon Dioxide (CO_2) when reporting to partners and minting credits by using a conversion factor of the molar mass of CO_2 vs. C, which is 3.66 (44.009 / 12.011).

Carbon is converted to CO_2 in Running Tide’s methodology because it allows carbon accountants to quantify emissions using established methods within the GHG Protocol. The resulting net CO2 equivalent (CO_2e) amount is an industry-accepted unit for a carbon removal credit.

A Deep Dive Into Deployment 10

For a practical demonstration of how Running Tide applied these principles, let's look at the data behind Deployment 10, which represents the type of work done for each deployment. The data below feeds into the latest Running Tide methodology to produce a bounded final value.

Loading the barge

Loading the barge with coated wood.

Carbon mass is calculated by evaluating the loaded material's overall mass, moisture content, and total organic carbon content.

A surveyor visited the site to determine the cargo's mass by conducting a draft survey after the vessel was loaded and before its departure. Well-conducted draft surveys are accurate within 0.5%, so Running Tide also includes that uncertainty range in the final calculations. The Deployment 10 survey resulted in a total mass of 3,037.30 t.

INITIAL DRAUGHT SURVEY

VESSEL: **M.V. "UR 93"**

PORT: GRUNDARTANGI
DATE: JUN. 3. 2023

DRAFTS	PORT	STB	MEAN	CORR.	C. MEAN
FORW.	1,500	1,575	1,538	-0,0826	1,455
MIDSHIP	1,880	1,940	1,910	0,0000	1,910
AFT	2,260	2,305	2,283	0,0826	2,365
		TRIM	0,7450	C. TRIM	0,9102

Density	1,025
LCF	-0,02
TPC	23,05
Dm/Dz	23,89
LBP	91,44
Fw correction	-8,3
Mid correction	0,00
Aft correction	8,30
Corrected LBP	74,84

Quarter mean draft = $\frac{(6 \times Dm) + Df + Da}{8}$ = 1,910

Trim correction 1 = $\frac{T \times TPC \times LCF \times 100}{LBP}$ = -0,36

Trim correction 2 = $\frac{T \times T \times 50 \times Dm/Dz}{LBP}$ = 10,82

Σ = 10,46

Density correction = $\frac{1.025 - Dens.}{1.025}$ Displ. = 0,00

DEDUCTIBLES:

Fuel oil:	0,00
Marine diesel:	0,00
Lub. oil:	0,00
Fresh water:	0,00
Ballast:	0,00
Slop:	0,00
Cargo:	0,00
Others:	0,00
TOTAL	0,00

Displacement:	4.242,96
Trim corrections:	10,46
Displ. corr. for trim:	4.253,42
Density correction:	0,00
Displ. corr. for density:	4.253,42
Total deductibles:	0,00
Net displacem.:	**4.253,42**
Light ship	
Stores	
CARGO	

VESSEL

SURVEYOR

FINAL DRAUGHT SURVEY

VESSEL: **M.V. "UR 93"**

Running Tide's ref. No. IS-CD-10

PORT: GRUNDARTANGI
DATE: JUL. 27. 2023

DRAFTS	PORT	STB	MEAN	CORR.	C. MEAN
FORW.	2,540	2,650	2,595	-0,1281	2,467
MIDSHIP	3,120	3,225	3,173	0,0000	3,173
AFT	3,700	3,800	3,750	0,1281	3,878
		TRIM	1,155	C. TRIM	1,4112

Density	1,025
LCF	0,1788
TPC	24,73
Dm/Dz	18,03
LBP	91,44
Fw correction	-8,300
Mid correction	0,000
Aft correction	8,300
Corrected LBP	74,84

Quarter mean draft = $\frac{(6 \times Dm) + Df + Da}{8}$ = 3,173

Trim correction 1 = $\frac{T \times TPC \times LCF \times 100}{LBP}$ = 6,82

Trim correction 2 = $\frac{T \times T \times 50 \times Dm/Dz}{LBP}$ = 19,64

Σ = 26,46

Density correction = $\frac{1.025 - Dens.}{1.025}$ Displ. = 0,00

DEDUCTIBLES:		INITIAL
Fuel oil:	0,00	0,00
Marine diesel:	0,00	0,00
Lub. oil:	0,00	0,00
Fresh water:	0,00	0,00
Ballast:	0,00	0,00
Slop:	0,00	0,00
Cargo:	0,00	0,00
Others:	0,00	0,00
TOTAL	0,00	0,00

Displacement:	7.264,26
Trim corrections:	26,46
Displ. corr. for trim:	7.290,72
Density correction:	0,00
Displ. corr. for density:	7.290,72
Total deductibles:	0,00
Net displacem.:	**7.290,72**
Final displacement	7.290,72
Initial displacement	4.253,42
CARGO	3.037,30

VESSEL

SURVEYOR

Two draft surveys are conducted to determine the difference in mass before and after loading the coated wood.

To determine the deployment's moisture content, operators collected fifty 100g carbon buoy samples at even time intervals during the barge's loading, vacuum sealed them on site, and shipped them to an external lab where the samples were analyzed. The Deployment 10 mean moisture content was 55.63% with an uncertainty factor $u_{f_{moisture}}$ of 0.0076.

				Description		9124-07.26.2023-1		9124-07.26.2023-2		9124-07.26.2023-3		9124-07.26.2023-4	
				Sample number		123122382		123122383		123122384		123122385	
Parameter	**Lab**	**Accr.**	**Method**	**LOQ**	**Unit**	**ar**	**db**	**ar**	**db**	**ar**	**db**	**ar**	**db**
Physico-chemical parameters from the original substance													
Moisture	FR	F5	DIN EN ISO 18134-2: 2017-05	0.1	% (w/w)	56.0	-	54.4	-	54.7	-	54.1	-
Inorganic sum parameters from the original substance													
Ash content (550°C)	FR	F5	DIN EN ISO 18122: 2016-03	0.1	% (w/w)	1.5	3.4	1.1	2.5	1.2	2.8	1.2	2.6
Elements from the original substance													
Carbon	FR	F5	DIN EN ISO 16948: 2015-09	0.2	% (w/w)	21.7	49.3	22.8	49.9	22.5	49.5	22.6	49.2

This is a subset of the moisture data from a partner lab. In total, 50 samples were tested.

Carbon content tests are not representative of the carbon in the wood since the coating—lime kiln dust—also contains carbon. To effectively measure the carbon content of just the biomass, a partner lab conducted total organic carbon (TOC) tests. Every fifth sample from the 50 mentioned above (10 samples per deployment) was tested for TOC. The Deployment 10 mean organic carbon content was 50.33%.

Due to a smaller sample size than the other lab tests, these results had higher uncertainty $u_{f_{TOC}}$ at 0.00989.

				Description		14099-IS-CD 10-1		14099-IS-CD 10-6		14099-IS-CD 10-11		14099-IS-CD 10-16		14099-IS-CD 10-21	
				Sample number		123193736		123193737		123193738		123193739		123193740	
Parameter	Lab	Accr.	Method	LOQ	Unit	ar	db	ar	db	ar	db	ar	db	ar	db
Determination from the original substance															
Moisture	FR	FS	DIN EN ISO 18134-2: 2017-05	0,1	% (w/w)	51,6	-	55,9	-	53,2	-	56,5	-	54,2	-
AOC (TOC-400)	FR		DIN 19539: 2016-12	0,2	% (w/w)	-	50,5	-	51,2	-	51,5	-	50,5	-	51,0

Explanations

LOQ: Limit of quantification
ar - as received
db - dry basis
Lab: Abbreviation of the performing laboratory
Accr.: Abbreviation of the accreditation of the performing laboratory

This is a subset of the organic carbon data from a partner lab. Ten samples were tested in total.

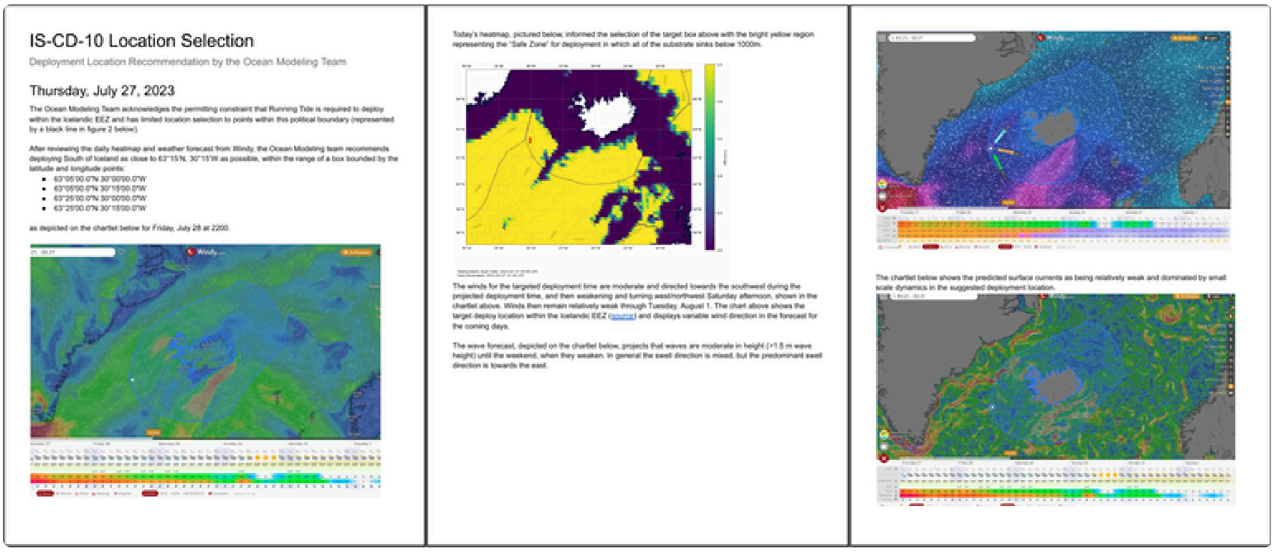
Once all this data was collected, the quantification team was able to determine that the total mass of carbon from the wood loaded on the barge was 2,485.17 tonnes CO2e. Using equation 4 from the methodology:

$$Terr_{added} = m_{load} * f_{weight} * (1 - f_{moisture}) * f_{TOC} * MR_{CO_2}$$

Variable	Value	Units	Comment
m_{load}	3,037.30	tonnes	
f_{weight}	100.00%	unitless	Only one recipe was used so this variable was not applicable for Deployment 10.
$f_{moisture}$	55.63%	unitless	
f_{TOC}	50.33%	unitless	
MR_{CO_2}	3.664	CO2e	Fixed molar ratio of CO2:C, i.e. 44.009/12.011
$Terr_{added}$	2,485.17	tonnes CO2e	

Traveling to the deployment location, and deploying

The oceanography team worked with operations and the vessel captain to select a viable deployment location for carbon removal coupled with the right seafaring conditions. The team considered forecasted wind and wave patterns, as well as ocean depth, on the predicted trajectories. For Deployment 10, the team recommended deploying South of Iceland as close to 63°15′N, 30°15′W as possible.



The Location Selection report handed to the vessel captain for Deployment 10.

Once a location and time are agreed upon, the tug, towing the barge, departs from the port and sails to the deployment location. At least two onboard cameras monitor the coated wood pile and allow the team to document any loss during transport. In the case of Deployment 10, there was no observed or reported loss. To cover the potential for undocumented loss of material, a 5-tonne discount was included in the uncertainty calculations.

Smooth sailing for Deployment 10. This onboard camera shows the full operational deployment process from vessel loading, to deployment in the open ocean, to returning to port.

The vessel began deploying the coated wood on July 30th, 2023, at 63.24667° N, 30.09333° W, and completed the deployment after 5 hours. At the deployment site, the vessel operators used the tug's onboard firefighting equipment to spray seawater onto the barge to gradually push the wood into the surface ocean.

Determining where the wood floats and when it sinks

Deployment 10 was a success. 90% of the carbon sank below 1,000 meters with a 95% confidence interval, durably moving carbon from the fast cycle to the slow cycle. The ocean is a chaotic system that's hard to predict, so these results were determined through a combination of in-situ measurements, labs, and models following the structure described above.

In-situ measurements

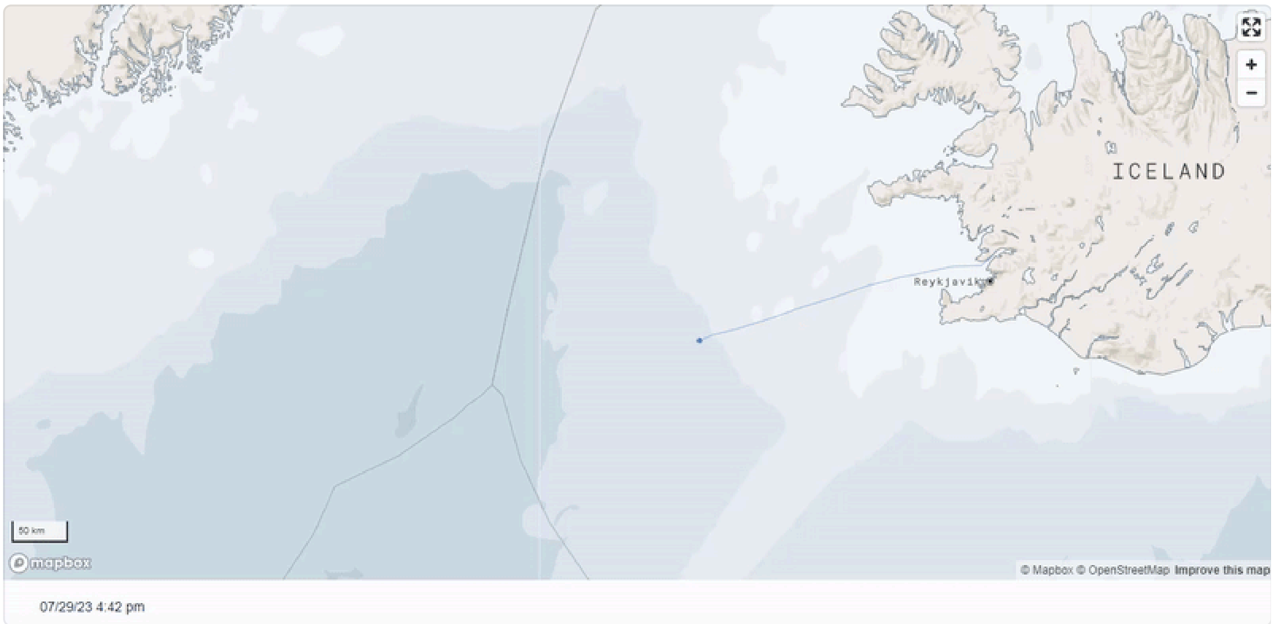
Running Tide engineers and manufactures verification buoys in Portland, ME. These buoys are designed to be rugged, reliable, and withstand the harsh conditions of the North Atlantic open ocean. Buoys are powered by solar panels and batteries and equipped with various sensors to monitor a deployment. The data these buoys collect is transmitted in near real-time to Running Tide via satellite, where it is processed and made available to internal teams and partners.

One of Running Tide's camera buoys. Each cage has a camera facing it to capture images underwater within the cage.

Running Tide's accel buoy (left) and trajectory buoy (right). The trajectory buoy sends GPS coordinates at regular intervals to help the team model the trajectories of the coated wood when it's floating on the ocean surface.

25 trajectory buoys and 2 camera buoys accompanied Deployment 10. Five trajectory buoys were tossed into the water at 0%, 25%, 50%, 75%, and 100% of the coated wood mass deployed, ensuring representative GPS coverage of the material plume.

The crew tosses in GPS trajectory buoys with the deployment to track the movement of the material plume over time.

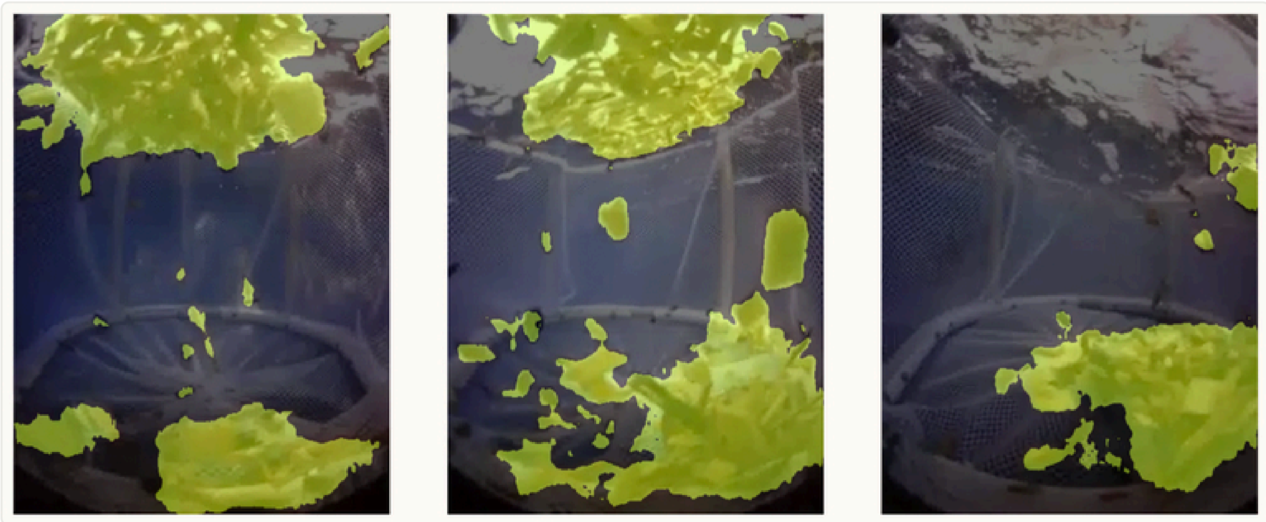


The approximate trajectories of the carbon buoy plume after being deployed. Each dot represents one verification buoy that sends Running Tide GPS coordinates to model the carbon buoys' terminal sinking location. The blue line represents the deployment vessel route.

The two camera buoys, with four cages total, were loaded with representative samples of the coated wood. As the buoys floated in the ocean, photos from the buoys allowed the team to use machine vision algorithms to determine what percentage of the wood was floating over time. Each camera provides several photos each day, and over time, it produces enough data to determine the wood's float times.

A subset of photos from Camera Buoy CB3.4 on July 30th, 2023.

A subset of photos from the same buoy CB3.4 on August 22nd, 2023. Note how much wood has sunk.



An example of the machine vision detection of wood vs not wood in the photos.

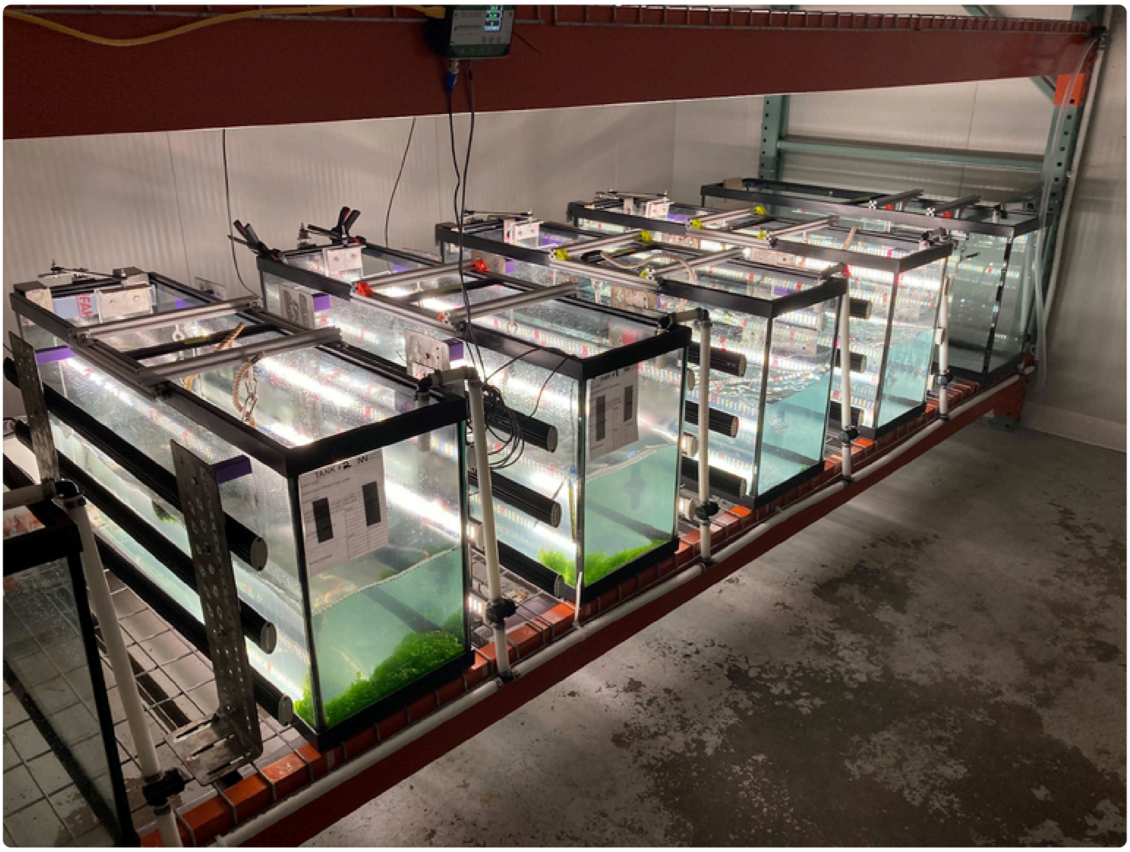
Labs

In addition to collecting the in-situ data, Running Tide's labs also conducted tests on the coated wood and individual materials to provide additional parameters for the deployment models.

Float times were tested in Running Tide's labs using samples of the coated wood deployed. These tests help validate and determine bounds for the float times observed at sea. These tests included:

- **Static Testing**: Static testing involves a substrate being placed in static saltwater, either floating on the surface (i.e. "Static Surface") or held underwater (i.e. "Static Submerged"). The goal of static testing is to measure material absorption rates in a highly consistent environment while removing other factors like surface erosion.

- **Wave Testing**: In wave tests, a substrate is placed into a custom wave tank in 4-6″ tall waves. The substrate can either be left unconstrained and free to interact with the tank walls, or constrained on a slider rod on the wave's peak. The intention of wave testing is to measure water absorption and volume loss rates in a dynamic environment closer to offshore conditions.



Wave tanks in the Portland, ME Running Tide Lab.

Once per day, the material that remained floating in the tanks was manually retrieved and weighed, and the fractional mass was reported.

Additionally, Running Tide's Ocean Hub laboratory in Portland, Maine, tested the reactivity of the terrestrial biomass and alkaline coating. Samples of the coated biomass were tested to measure the rate at which carbon and alkaline minerals dissolve from the deployed material. These tests confirm that any acid leaching off of the terrestrial biomass was more than offset by the addition of the alkaline mineral.

As Running Tide studied the potential for acid leaching from the material, a partner lab tested the rate of mass of carbon leached as dissolved organic carbon (DOC). Those results informed our final quantified values for another variable in our equation, $Terr_{shed}$ - the amount of CO2e in terrestrial biomass separated from the carbon buoys prior to or during the sinking process, which is shown below.

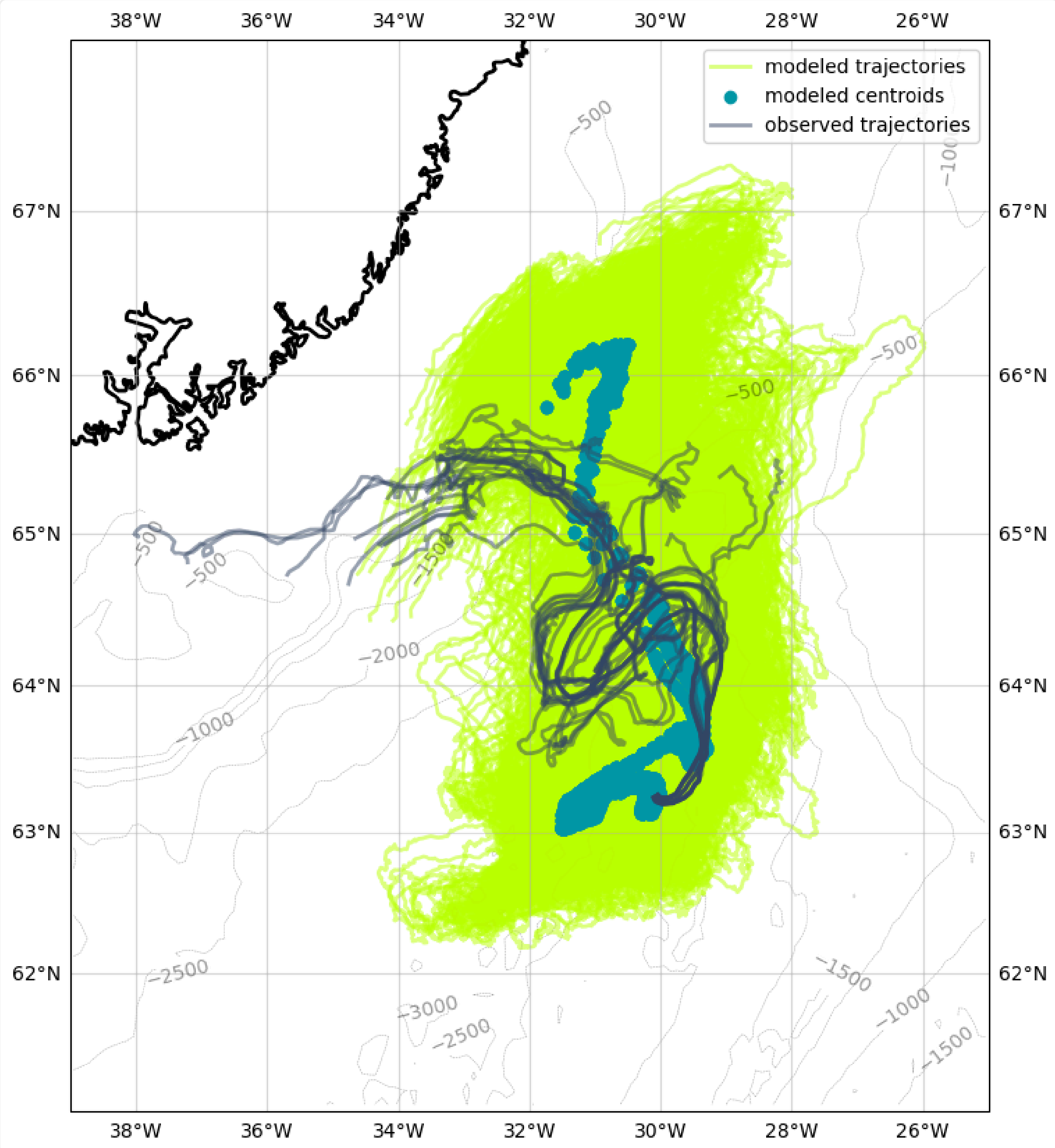
$$Terr_{shed} = f_{DOC} * (Terr_{added} - Terr_{loss}) + f_{acid} * (Terr_{added} - Terr_{loss})$$

Variable	Value	Units	Comment
f_{DOC}	1.243E-03	unitless	
f_{acid}	0	unitless	Zero because the alkaline coating fully offsets the acid leaching from the wood.
$Terr_{added}$	2,485.17	tonnes CO2e	
$Terr_{loss}$	0	tonnes CO2e	No observed loss on this Deployment.
$Terr_{shed}$	3.09	tonnes CO2e	

Ocean Modeling

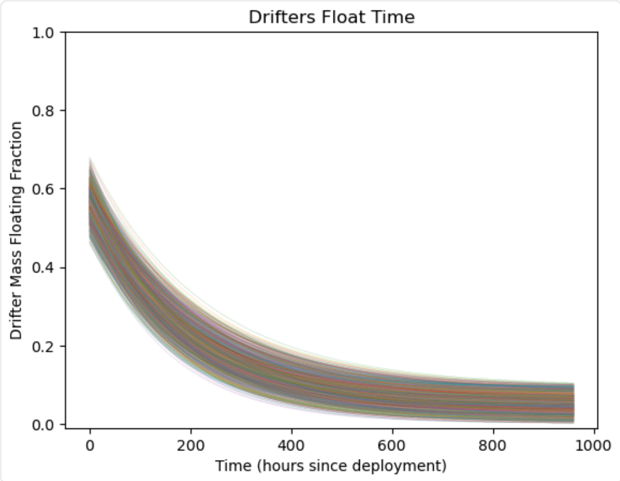
Once the team has collected and aggregated both the in-situ and lab data, models are used to determine where the wood floats (what's referred to as ocean surface transport), when it sinks (referred to as float time distribution), and what depth it sinks to (terminal location).

Running Tide's Ocean Surface Transport Methodology states, "To model the surface transport of the material, both third-party datasets as well as in-situ data are integrated into a Lagrangian simulator that models the trajectories of simulated deployed material. We use an open source library called OceanPARCELS (Kehl et al., 2023), which uses an efficient implementation of a Runge-Kutte integration scheme to simulate multidimensional Lagrangian transport with a provided velocity vector field." In plain language, the team uses ocean data to determine where the wood floats. Here's the output of the model:



Plot of modeled and observed trajectories. The observed trajectories are used to tune the model. The modeled trajectories depicted here represent 100 simulated parcels with different scenarios that yield the best results.

The modeling team can combine these trajectories with the float times observed and measured in labs. The coated wood has much variability in floating duration, so the model results show a range of sinking depths because the material is spread out over a significant distance on the ocean floor. This is an intended result of this system since this distribution limits any localized negative impacts on the benthic environment.



Plot depicting the float times for modeled trajectories during the simulations.

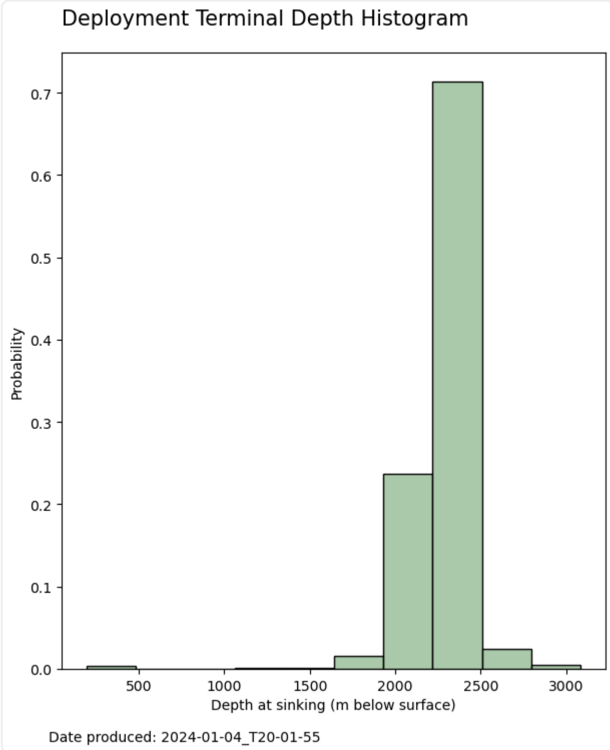


Chart depicting the probability of the terminal depths of deployed material for all simulations.

These models also produce a probability distribution of carbon sunk below 1,000 meters. To ensure the results are conservative, the value used is the 5th percentile, representing 95% confidence in the results.

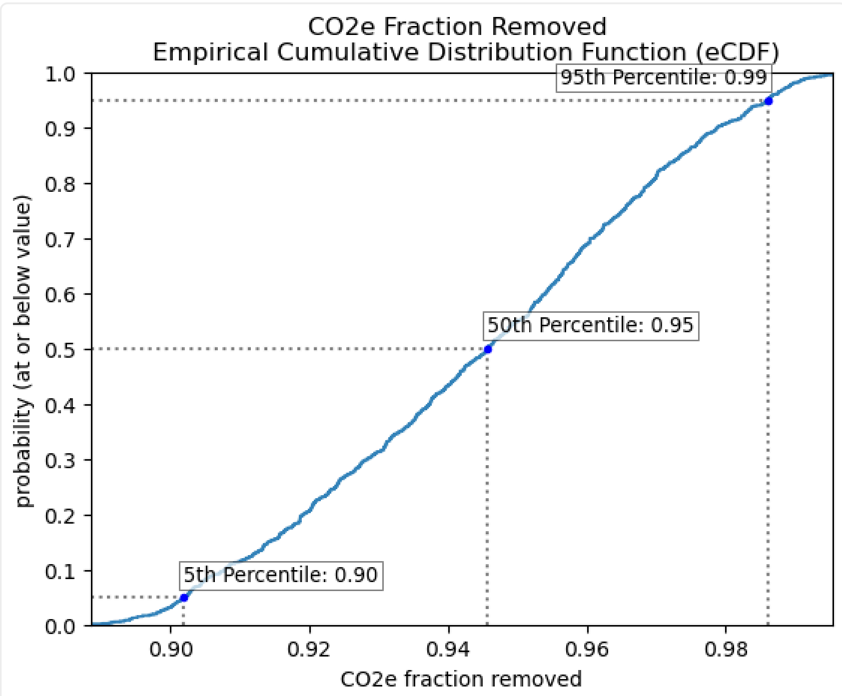


Chart representing the fraction of CO2e removed in each of the 1000 simulations. The final calculations use the 5th percentile value for a conservative estimate of the deployment's removal of CO2e.

These values are then input into the methodology formula for Terr_shal, which produces a quantified amount of CO2e in terrestrial biomass that is not durably sequestered below 1,000 m depth. The results for deployment 10 are below.

$$Terr_{shal} = (Terr_{added} - Terr_{loss} - Terr_{shed}) * f_{shal}$$

Variable	Value	Units	Comment
$Terr_{added}$	2,485.17	tonnes CO2e	
$Terr_{loss}$	0	tonnes CO2e	No observed loss on this Deployment.
$Terr_{shed}$	3.09	tonnes CO2e	
f_{shal}	0.054	unitless	
$Terr_{shal}$	134.83	tonnes CO2e	

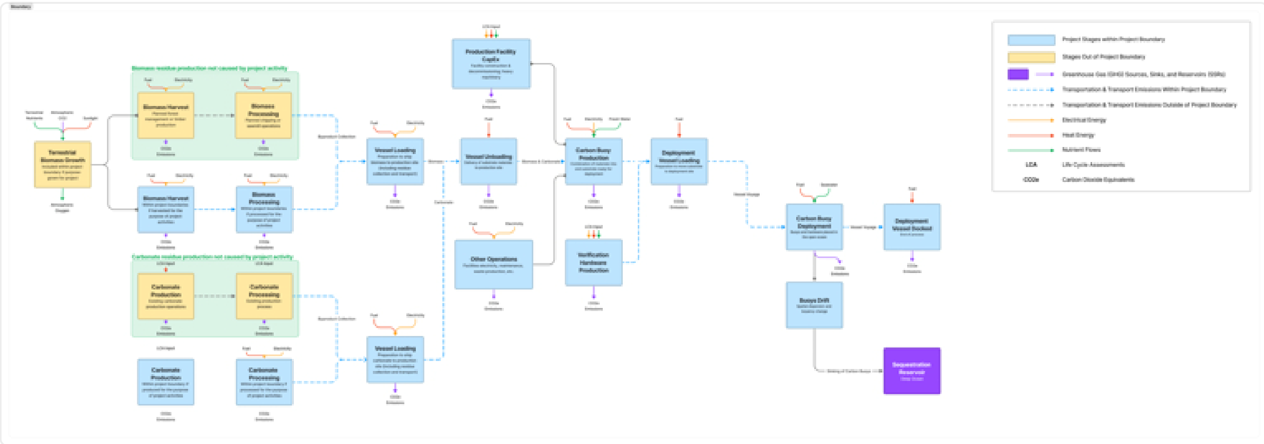
Gross Carbon Removed in Deployment 10

These variables allow the team to quantify the gross amount of carbon removed from the wood sinking below 1,000 meters in the ocean by subtracting the $Terr_{shed}$ and $Terr_{shal}$ variables from $Terr_{added}$. For this deployment, that was 2,347.25 tonnes CO2e. Alternative use discounts and land use change discounts were not applied in this instance due to the all-residue byproduct material composition of this deployment and the information provided via supplier attestations. Running Tide is confident that none of the biomass utilized in this deployment had a realistic alternative use that would lead to its movement into the slow carbon cycle.

Variable	Value	Units	Comment
$CO_2eTerrestrial$	2,347.25	tonnes CO2e	

Accounting For The Emissions

Running Tide's carbon accounting team worked with suppliers and operators on-site to collect all fuel use and activity data within this project's boundaries to quantify this deployment's carbon footprint.



2023 Project boundaries for carbon accounting

This data includes all Scope 1, 2, and 3 emissions sources and ensures the project's net carbon impact was reported correctly. Once the team collected the data, industry-standard emissions factors were applied to convert it into emissions values. The total embodied emissions for Deployment 10 was 370.65 tonnes CO2e.

Variable	Description	Value	Units
$CO2e_{mat}$	The embodied emissions of carbon buoy materials loaded onto the deployment vessel. Includes emissions from material supply, material freight, and material offload.	126.88	tonnes CO2e
$CO2e_{prod}$	The emissions associated with production of carbon buoys and site operations. Includes emissions from carbon buoy handling.	3.46	tonnes CO2e
$CO2e_{deploy}$	The emissions associated with deployment vessel loading and transport, as well	118.80	tonnes CO2e

Variable	Description	Value	Units
	as the associated emissions of verification hardware.		
$CO2e_{cons}$	The emissions associated with construction operations.	13.77	tonnes CO2e
$CO2e_{equip}$	The emissions associated with equipment & machinery purchases, rentals, and repair.	100.47	tonnes CO2e
Gap_{CO2e}	The emissions potentially within the project boundary that are not currently quantified according to a gap analysis.	7.27	tonnes CO2e
Total Emissions		370.65	tonnes CO2e

The Net Results

With both the total carbon removal from the sinking wood and the carbon emissions from the project quantified, Running Tide's quantification team determined a conservative net amount of carbon removed. The team also quantified the uncertainty of this data. Details of how Running Tide's scientists quantified and propagated uncertainty can be found in Appendix I of the Methodology. The results of these calculations are published as a Net Removals Statement, which is shared with Running Tide's customers, partners, and assurers alongside a credit issuance.

End User Deployment Summary IS-CD-10 v1

Net Removals Statement

The following section details the net removals of this deployment.

Net Removals	
Gross Tonnes CO_2e Moved Fast → Slow	2,222.11
Gross Tonnes CO_2e Emitted	370.65
Net Tonnes CO_2e Moved Fast → Slow	1,851.46

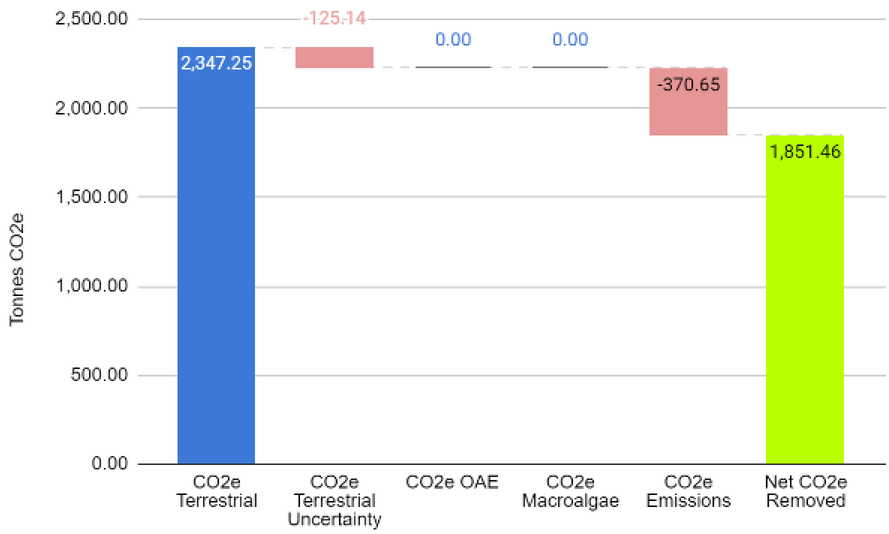


Figure 7: Net carbon removal histogram.

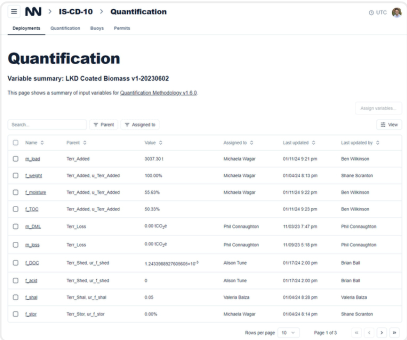
- CO_2eTerrestrial = CO_2 Removal by Sinking of Terrestrial Biomass
- CO_2eOAE = CO_2 Removal by Alkaline Mineral Dissolution
- CO_2eMacroalgae = CO_2 Removal by Macroalgae
- CO_2eEmissions = End-to-End System Emissions

A Net Removals Statement shared with Running Tide customers

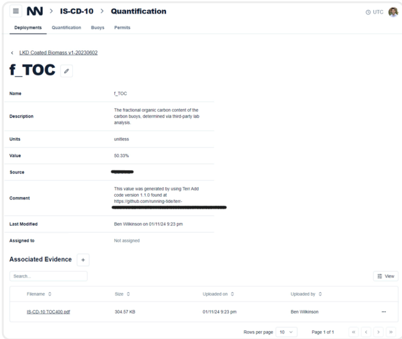
Deployment 10 resulted in 1,851.46 tonnes of CO2e being removed from the fast carbon cycle and moved to the slow carbon cycle. While this is only a tiny fraction of the amount of carbon removal the world will need soon, it is a demonstration of a combined operational mass moving, data science, and earth systems research effort that had a net positive impact on the carbon cycle and served as a proof of concept for future work to scale this system.

Automation and Traceability

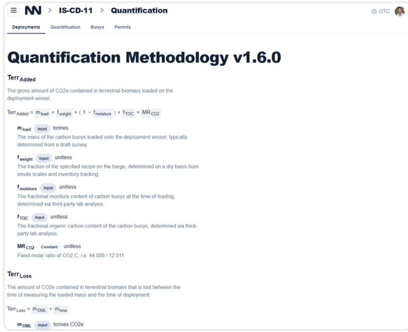
All the data from Running Tide's quantification work is stored in a traceable, immutable database. The quantification dashboard provides a platform for the team to collaborate across many intertwined workstreams and ensures that all data lives in a central repository. This internal tool also allows team members to upload supporting records and track changes made to variables. Once all the data has been uploaded to a deployment, the tool automatically quantifies the net carbon removed by running the latest methodology in code.



Data summary page for Deployment 10



A specific variable entry



The methodology in code

What's Next?

Carbon removal is the work of moving massive amounts of mass and measuring it in such a way that it's possible to prove that there was a net positive impact to the planet. By operating in an open system, Running Tide has chosen pathways that have the potential for massive scale but are more complex to quantify. By applying the model/test/measure philosophy to quantification, the team can ensure the results are conservative, and customers can have high confidence in the results.

By starting with quantifying wood, Running Tide selected the simplest—but not simple—pathway in the system. Next, the team planned work to quantify the carbon drawdown from ocean alkalinity enhancement and macroalgae growth in the open ocean. Both of these pathways have been tested in prior deployments, and the work done to quantify terrestrial biomass sinking can also be expanded upon to support these materials.

There are also now real numbers behind "doing the thing." The team can point to specific areas to improve efficiency, drive a greater understanding of the system, and ensure that the secondary effects of the work are understood and quantified. Carbon removal needs to scale up this decade, and open system approaches such as Running Tide's may be one viable path when paired with this quantification and data management philosophy.