stripe

PULLTOREFRESH

Carbon Removal Purchase Application

General Application

(The General Application applies to everyone, all applicants should complete this)

Company or organization name

Pull To Refresh

Company or organization location (we welcome applicants from anywhere in the world)

United States

Name of person filling out this application

Laurel Tincher

Email address of person filling out this application

[redacted]

Brief company or organization description

Ocean-based climate technology company

1. Overall CDR solution (All criteria)

a. Provide a technical explanation of the proposed project, including as much specificity regarding location(s), scale, timeline, and participants as possible. Feel free to include figures and system schematics.

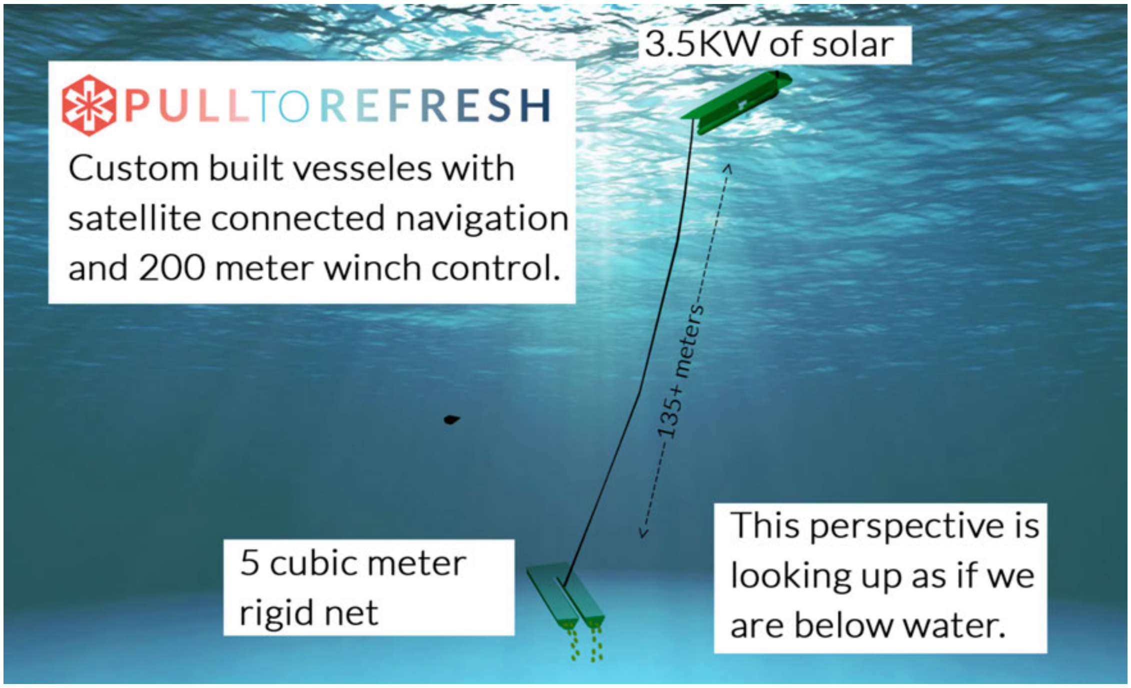
For this project we propose a two-phase deep water macroalgae carbon sequestration project.

Our solution lies at the intersection of nature and technology. We have created a first-in-its-class, renewable, unmanned vessel that can be used for a variety of ocean-based carbon removal methods.

A photo taken by our team member in 2022, this is the first time Sargassum has become a severe issue in Panama.

Caribbean Tonnes:
Our first step is to embark on the removal of invasive Sargassum macroalgae in the Caribbean region, which will be accomplished by deploying a fleet of 10 vessels to gather and sink the macroalgae to depths greater than 1000 meters for durable sequestration of more than 100 years. The vessels utilize a specialized collection receptacle to gather the floating macroalgae and lower it to a depth of 135m+ where, due to pressure, its vesicles are damaged, rendering it negatively buoyant. Additional sinking to a depth of 200 meters will ensure that the Sargassum makes it past the mixed layer and will sink quickly to the ocean floor before grazing can occur.

Through the process of photosynthesis, Sargassum captures CO_2 from the air and water. Since it has a one year lifespan and regional currents typically deliver it to shorelines within a few weeks, its most likely fate is to get washed up on shore and decompose, producing a large amount of methane and rereleasing CO_2. Gathering and sinking not only provides a carbon removal opportunity, but numerous co-benefits to Caribbean communities and ecosystems that are harmed by the collective anthropogenic changes to the earth that contribute to the Sargassum invasion.



Our initial pilot project of 10 vessels will have the capacity to remove at least 500 tonnes of CO_2 per year. The vessels will be built at our team's manufacturing facility in Colón, Panama, and deployed from there to the Caribbean.

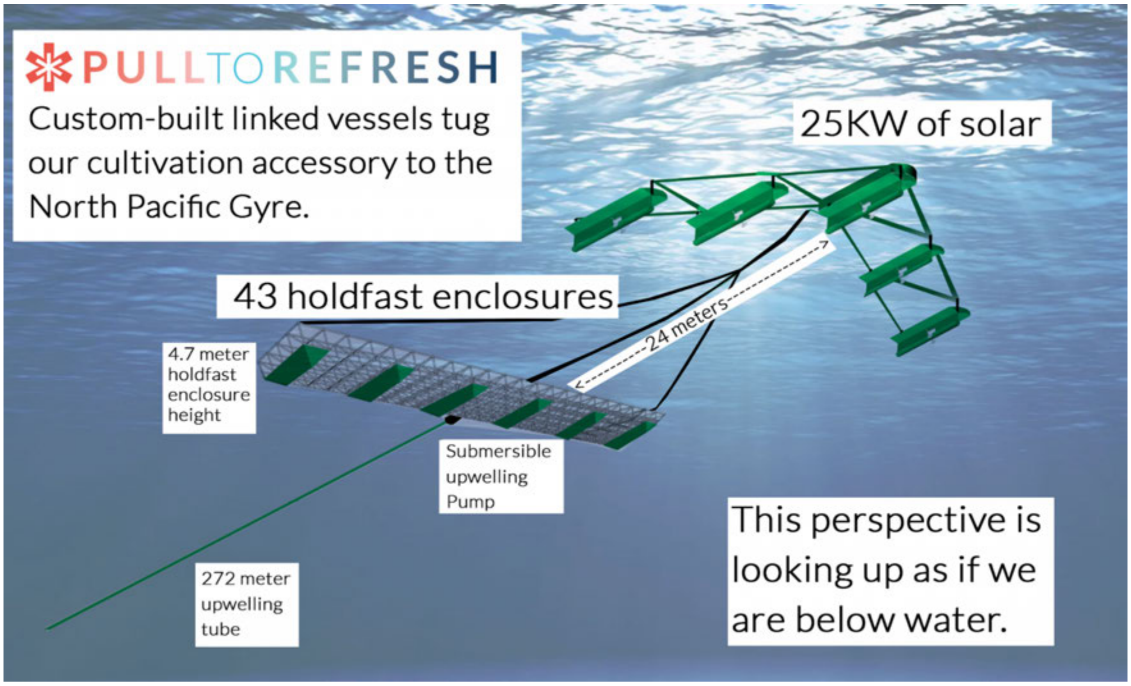
Measurement and verification will be done with a proprietary system that transmits over satellite the GPS stamps of sinking locations, biomass measurements, and edge computing machine vision results indicating every time we successfully empty our collection receptacles. We have built a dashboard to track and display photos, locations, and amounts of macroalgae that we sink. The first version of the dashboard is already functioning with our current prototype.

Sinking Sargassum will be a chance to test the performance of our vessel and enable us to refine our navigation, software, monitoring, and sinking systems in preparation for our kelp cultivation project in the Pacific.

Once we have established a monthly rate that puts us on pace to remove 500 of our Caribbean tonnes then it will be time to roll out our second type of carbon removal using our vessels.

Pacific Tonnes:
Building upon what we learn with our Caribbean tonnes we will build fleets to cultivate and sink giant kelp in the high seas. Our cultivation accessory includes a semi-enclosed substrate

for the kelp to grow on, a system to lower the kelp to damage its bladders, and an automated harvesting system.



Our Pacific tonnes have 1000+ year permanence and unlock our path to Gigatonne scale. We will work with our kelp-seed facility in Canada to produce spores that will be transported out to sea. Nutrients will be provided to the kelp via a proprietary combination of upwelling and onboard tanks filled with our custom formulation that we have demonstrated and had verified by a third party.

Since our vessels can be mass manufactured with a 20 year life span and we cover the costs of a deployment in the first year, we will be able to double the size of our operation every year to gigatonne scale and beyond.

Cultivating kelp also has the added benefits of addressing ocean acidification and removing carbonic acid from the ambient seawater.

Sequestering carbon at the seafloor removes it from the carbon cycle for far longer than the majority of other carbon removal projects. By deploying our project in the open ocean, we nearly eliminate the need for land use, we don't interfere with any coastal or land-based ecosystems or communities, and we open up the possibility of exponentially scaling to have a meaningful impact on the climate.

Ultimately, we can reach a price of $100/tonne by using lower cost renewable energy production and storage methods. These are on the market today but have high upfront development costs. We can also reduce our costs by sequestering kelp into durable materials used to build more of our carbon removal infrastructure. This will also enable the recycling of nutrients for overall lower energy consumption and therefore a lower price per tonne and unconstrained scalability.

b. What is your role in this project, and who are the other actors that make this a full carbon removal solution? *(E.g. I am a broker. I sell carbon removal that is generated from a partnership between DAC Company and Injection Company. DAC Company owns the plant and produces compressed CO_2. DAC Company pays Injection Company for storage and long-term monitoring.)*

Pull To Refresh is the lead in this project. Our vessels will be manufactured at our team member's marine infrastructure factory in Panama. We have a spore production facility in Canada, experts in kelp farm engineering, and partners who pioneered Sargassum-sinking in the Caribbean.

c. What are the three most important risks your project faces?

Science
With our Caribbean tonnes there is a risk that ocean currents overtake our vessel while in a dense patch of Sargassum and that the speed we've calibrated won't be fast enough to overcome them. If this happens we will have to take extra time to develop maneuvers that help get us out of the Sargassum patches when we are trying to go to ideal locations with sufficient depths for gathering and sinking.

For our Pacific project we will be cultivating kelp outside of its normal environment in nutrient-sparse waters. The optimization process of our upwelling and tank delivery systems may take more time than anticipated and we may face unforeseen challenges. Our current yield estimates may not match our actual capacity. We have team members with decades of experience cultivating kelp who can help reduce this risk.

Regulations
Our team is engaged in ongoing conversations with lawyers and regulators to understand the current regulations around this type of project and how those regulations might change in the future. Pull To Refresh is in favor of the establishment of clear regulations that will both protect the ocean from unsustainable practices and enable us to deploy our project with greater confidence.

Verification
In order for Pull To Refresh and other biomass sinking projects to scale and provide high quality and quantifiable carbon removal to the voluntary market, a standardized verification methodology is needed. To move this process forward we are forming a consortium of companies to share resources and data and collaborate on creating this methodology.

d. If any, please link to your patents, pending or granted, that are available publicly.

Our patents are provisional at this stage.

e. Who's the team working on this? What's your team's unfair advantage in building this solution? What skills do you not yet have on the team today that you are most urgently looking to recruit?

Our unfair advantage is our drive. We have all been impacted by climate change in a personal way that gives us an unwavering motivation to not simply work on this problem but actually solve it.

Our team is made up of 25+ volunteers from around the world. We have developed an end-to-end solution that is ready to be built and deployed. Our team includes one of the world's leading experts in kelp reproduction and cultivation, who has been in the field for more than 40 years, as well as a specialist in kelp farm engineering and construction. We have a team member with a marine infrastructure factory up and running in Panama. Another team member has decades of experience in chemistry, has authored more than 80 academic papers, and specializes in semi-autonomous fleet management and software development. Additionally, we have specialists in construction, sustainability, business, marketing, media creation, and more

Currently we are seeking oceanographers who specialize in benthic zones and ocean currents. We are also seeking engineers with experience in custom sonar hardware and software as well as machine vision experts. We also always need more 3D modelers, system controllers, project managers, media team members and people with marine construction experience.

2. Timeline and Durability (Criteria #4 and Criteria #5)

a. Please fill out the table below.

	Timeline for Offer to Stripe
Project duration *Over what duration will you be actively running your DAC plant, spreading olivine, growing and sinking kelp, etc. to deliver on your offer to Stripe? E.g. Jun 2022 - Jun 2023. The end of this duration determines when Stripe will consider renewing our contract with you based on performance.*	Jan 2023-Dec 2024 for Caribbean tonnes Dec 2024-Dec 2026 for Pacific tonnes
When does carbon removal occur? *We recognize that some solutions deliver carbon removal during the project duration (e.g. DAC + injection), while others deliver carbon removal gradually after the project duration (e.g. spreading olivine for long-term mineralization). Over what timeframe will*	The carbon removal will happen during the time frames above.

carbon removal occur? *E.g. Jun 2022 - Jun 2023 OR 100 years.*	
Distribution of that carbon removal over time *For the time frame described above, please detail how you anticipate your carbon removal capacity will be distributed. E.g. "50% in year one, 25% each year thereafter" or "Evenly distributed over the whole time frame". We're asking here specifically about the physical carbon removal process here, NOT the "Project duration". Indicate any uncertainties, eg "We anticipate a steady decline in annualized carbon removal from year one into the out-years, but this depends on unknowns re our mineralization kinetics".*	The Caribbean tonnes are removed through a process of gathering that we estimate will improve 5 percent per year as we improve the system. But other than that it's simple accumulation of monthly capacity based on the number of vessels. Our Pacific Tonnes are more or less the same but depend on 3 growth cycles per year. We will initially do 1.5 growth cycles per year in order to more closely observe the ideal harvesting time and to provide extra time to calibrate our digital scales that will measure biomass buoyancy for verification.
Durability *Over what duration you can assure durable carbon storage for this offer (e.g, these rocks, this kelp, this injection site)? E.g. 1000 years.*	100+ years for Caribbean tonnes 1000+ years for Pacific tonnes

b. What are the upper and lower bounds on your durability claimed above in table 2(a)?

Our lower bound is 100 or 1000 years respectively. The upper bound is millions of years (geological permanence) which can occur if the carbon is buried in the sediment at any time while it is on the seafloor.

c. Have you measured this durability directly, if so, how? Otherwise, if you're relying on the literature, please cite data that justifies your claim. *(E.g. We rely on findings from Paper_1 and Paper_2 to estimate permanence of mineralization, and here are the reasons why these findings apply to our system. OR We have evidence from this pilot project we ran that biomass sinks to D ocean depth. If biomass reaches these depths, here's what we assume happens based on Paper_1 and Paper_2.)*

The Siegel et al. model (2021) uses deep ocean current speed measurements to estimate the time it takes for carbon that dissolves into the deep ocean to resurface. The model shows that carbon sunk to 1000m+ in the Caribbean region will be sequestered for 100+ years if it doesn't make it into the sediment. Carbon sunk to 3000m+ in the Pacific will be sequestered for 1000+ years if it doesn't make it into the sediment. We will monitor in real time from our dashboard the vessel locations and will only sink to depths of 1000m+ in the Caribbean and 3000m+ in the Pacific..

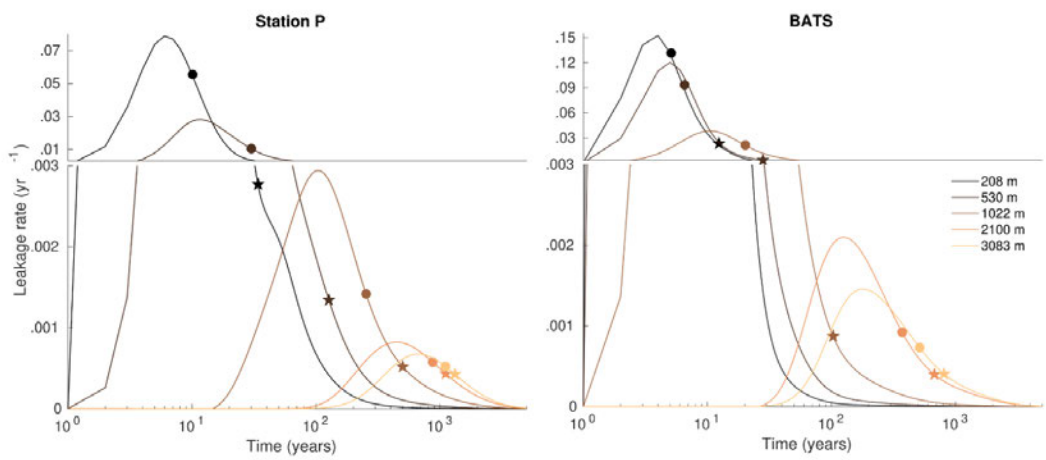
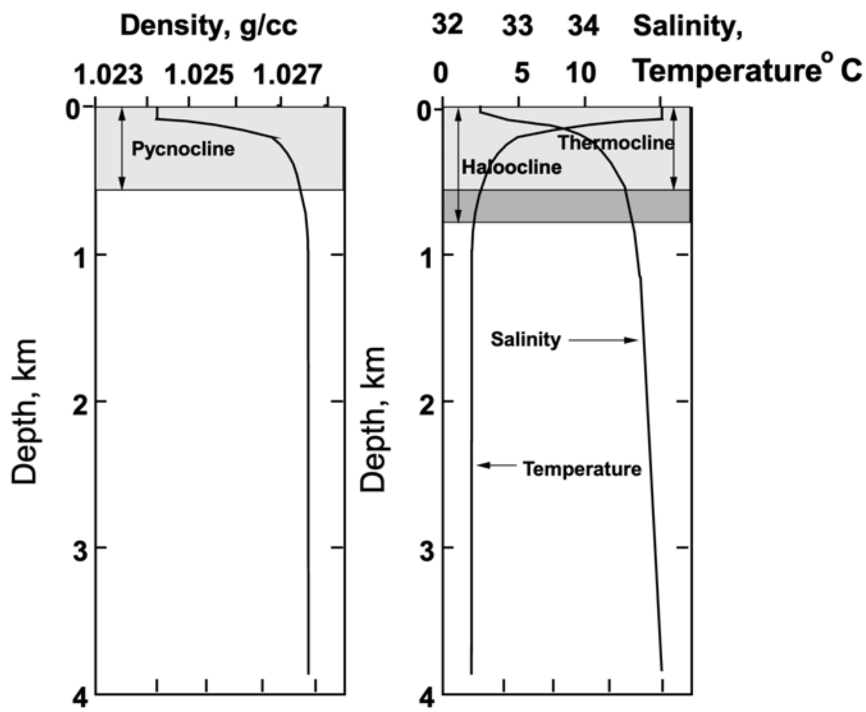


Figure 1. Leakage rate of injected CO_2, $\tilde{G}(t)$, as a function of time since injection for five different depths at two canonical open ocean locations in the Northeast Pacific Ocean (left; Station P; 50° N 145° W) and in the Sargasso Sea in the Western North Atlantic (right; BATS; 32° N 64° W). Locations of the two sites are shown in figure 3 as the 'P' and 'B' letters for Station P and BATS, respectively. Stars give the mean sequestration time while circles represent the median sequestration time. The time integral of $\tilde{G}(t)$ over all times is equal to one by definition. Depths are the mean layer depths in OCIM.

Ensuring that the macroalgal vesicles are fully damaged is essential to the carbon reaching the seafloor. As demonstrated by SOS Carbon (Gray, 2020), we will lower macroalgae past 135m at which point its vesicles are fully damaged and it sinks below the mixed layer of the Caribbean to the seafloor.

As the macroalgae sinks, grazing or early decomposition could present a problem if it slows down in a denser portion of the water column. To ensure this isn't an issue we created a high salt concentration-to-deep sea simulant that mimics the high density that data suggests exists at the bottom of the ocean. In this experiment Macrocystis was demonstrated to still be sufficiently negatively buoyant.



Source: *http://ocean.stanford.edu/courses/bomc/chem/lecture_03.pdf*

Gray, L. A. (2020). *Sequestering floating biomass in the deep ocean: "Sargassum ocean sequestration of carbon"(SOS Carbon)* (Doctoral dissertation, Massachusetts Institute of Technology). https://dspace.mit.edu/handle/1721.1/127483

Siegel, D. A., DeVries, T., Doney, S., & Bell, T. (2021). Assessing the sequestration time scales of some ocean-based carbon dioxide reduction strategies. Environmental Research Letters. https://doi.org/10.1088/1748-9326/ac0be0

d. What durability risks does your project face? Are there physical risks (e.g. leakage, decomposition and decay, damage, etc.)? Are there socioeconomic risks (e.g. mismanagement of storage, decision to consume or combust derived products, etc.)? What fundamental uncertainties exist about the underlying technological or biological process?

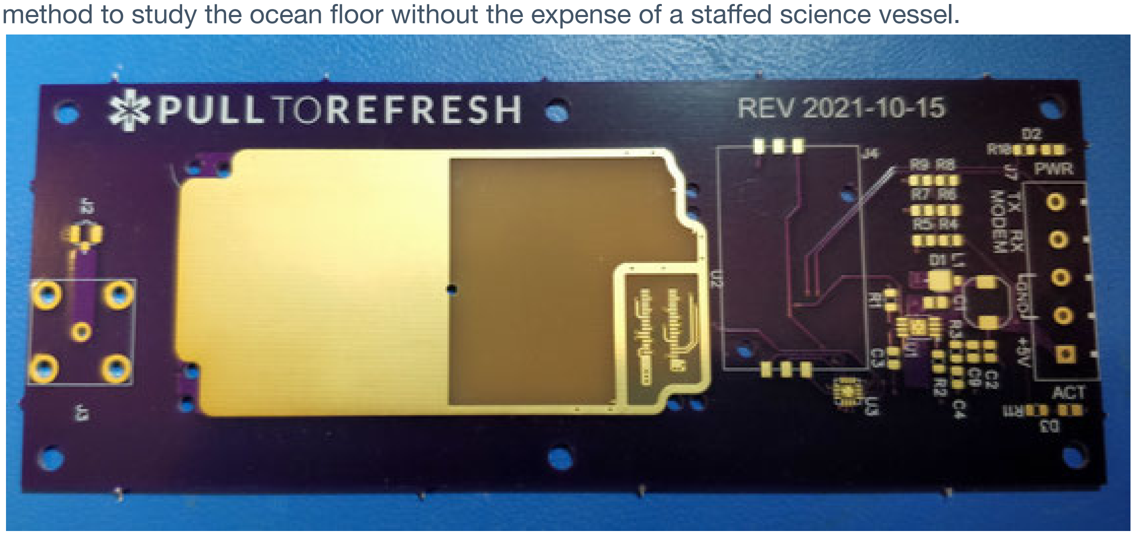
The highest durability is achieved if macroalgae becomes buried in the sediment on the seafloor or is consumed by deep sea life that gets buried in the sediment. Since we can't currently measure sedimentation rates our numbers are based on models in which all biomass breaks down into diffused inorganic carbon. The carbon is moved slowly across the ocean floor until inclinations transport it back to surface ecosystems in 100+ or 1000+ years respectively for our Caribbean tonnes and Pacific tonnes.

When macroalgal biomass reaches the seafloor at depths of 1000m+, the density, cold temperatures, and slowness of currents keeps it in the bottom layer of the ocean until it gets recirculated to the surface.

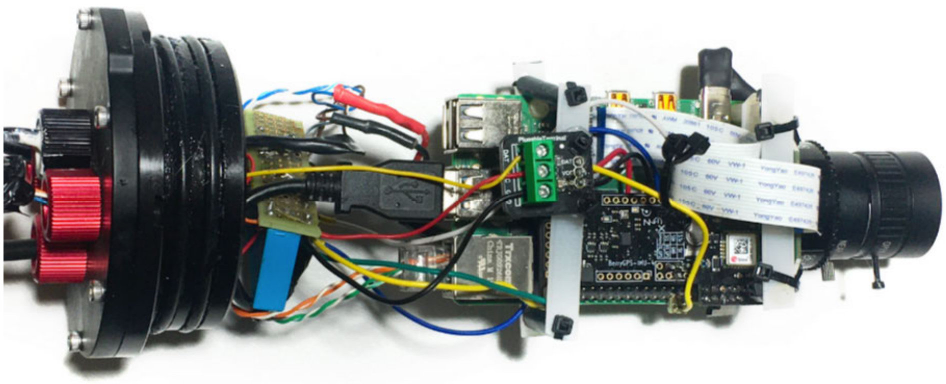
Rare natural events such as a deep sea volcanic eruption would not bring any significant amount of carbon back to the surface since we sink small amounts across a broad area. Other potential disturbances such as human-induced turbulence do not reach the depths or locations we sink to.

e. How will you quantify the actual permanence/durability of the carbon sequestered by your project? If direct measurement is difficult or impossible, how will you rely on models or assumptions, and how will you validate those assumptions? *(E.g. monitoring of injection sites, tracking biomass state and location, estimating decay rates, etc.)*

In addition to relying on scientific literature to understand the fate of macroalgae on the ocean floor, we will also set up monitoring systems using 1000m+ cameras and 3000m+ cameras and sensors to study the long-term breakdown of the macroalgae we sink. An accessory will be created for our vessel to receive signals from a deep sea probe. Signals will be sent via satellite to the cloud for internal study and possibly real-time distribution to the scientific community should the data prove robust. This signal repeater vessel will provide an affordable method to study the ocean floor without the expense of a staffed science vessel.



An additional future test will involve lowering Sargassum to 1000m and Macrocystis to 3000m in a cage to observe and document that when bladders are damaged macroalgae remains negatively buoyant throughout the entire water column.

Our findings will be made available to the scientific community and we will invite researchers to conduct their own experiments with our setup to further understand the durability and downstream effects of open ocean cultivation.  We are also creating a consortium of projects working on sinking biomass in the deep sea to collaborate on establishing a verifiable methodology that will allow additional companies to commercialize this method of carbon removal and we envision studying many types of biomass with these methods.

3. Gross Capacity (Criteria #2)

a. Please fill out the table below. **All tonnage should be described in metric tonnes here and throughout the application.**

	Offer to Stripe (metric tonnes CO_2) over the timeline detailed in the table in 2(a)
Gross carbon removal Do not subtract for embodied/lifecycle emissions or permanence, we will ask you to subtract this later	1000 tonnes total. 500 tCO_2 of Caribbean Tonnes by sinking of invasive Sargassum in the Caribbean. Followed by 500 tCO_2 of Pacific Tonnes by cultivation and sinking of Macrocystis in the North Pacific Gyre.
If applicable, additional avoided emissions	When Sargassum washes up on beaches or is taken to landfills it creates methane emissions. An

e.g. for carbon mineralization in concrete production, removal would be the CO_2 utilized in concrete production and avoided emissions would be the emissions reductions associated with traditional concrete production	estimated 40 million tonnes of Sargassum wash ashore each year (United Nations, 2020). By sinking it, those emissions are avoided. The lifespan of Sargassum is about a year and it takes a few weeks for it to reach land after it grows, suggesting that if we don't collect and sink the kelp it's eventual fate is to end up back in the atmosphere in the form of methane. ________________ United Nations. (2020). *From the field: Weeding out Mexico's unwanted beach invader* . United Nations. Retrieved from https://news.un.org/en/story/2020/01/1055691

b. Show your work for 3(a). How did you calculate these numbers? If you have significant uncertainties in your capacity, what drives those? *(E.g. This specific species sequesters X tCO_2/t biomass. Each deployment of our solution grows on average Y t biomass. We assume Z% of the biomass is sequestered permanently. We are offering two deployments to Stripe. X*Y*Z*2 = 350 tCO_2 = Gross removal.* OR *Each tower of our mineralization reactor captures between X and Y tons CO_2/yr, all of which we have the capacity to inject. However, the range between X and Y is large, because we have significant uncertainty in how our reactors will perform under various environmental conditions)*

Caribbean Tonnes We will deploy 10 vessels to deliver 500 tonnes of removal in the Caribbean. Removal is estimated to take 1 year. Our confidence in these numbers is derived from the following: The 2nd vessel we built is able to propel itself with solar panels and batteries at a speed of 1 meter per second.

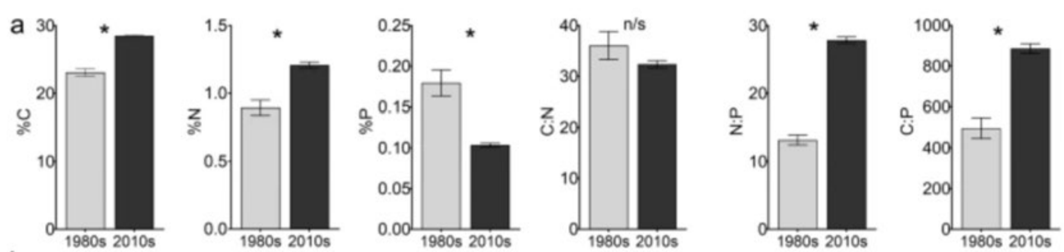
By doubling the number of motors and panels and installing 8x more battery power on our next design, we have modeled that we will achieve an average speed when collecting Sargassum of 1 meter per second. The ocean area that will allow us to cover translates to more than 500 tonnes of CO_2 removal by the end of the year using the following calculation:

$(1382.4 * .03 * 3.66 * 365 * 10) / 1000 = 554.024448$

Using average Sargassum density provided by University of Florida of .01 KG per square meter times the 1.6 meter cross-section of our vessel's collection receptacles times the meter-distance traveled we estimate collecting an average of around 1382.4 KG of wet weight Sargassum per day.

We then multiply our daily collection mass by the known carbon content of Sargassum.

Fig. 2: *Sargassum* tissue nutrient contents.



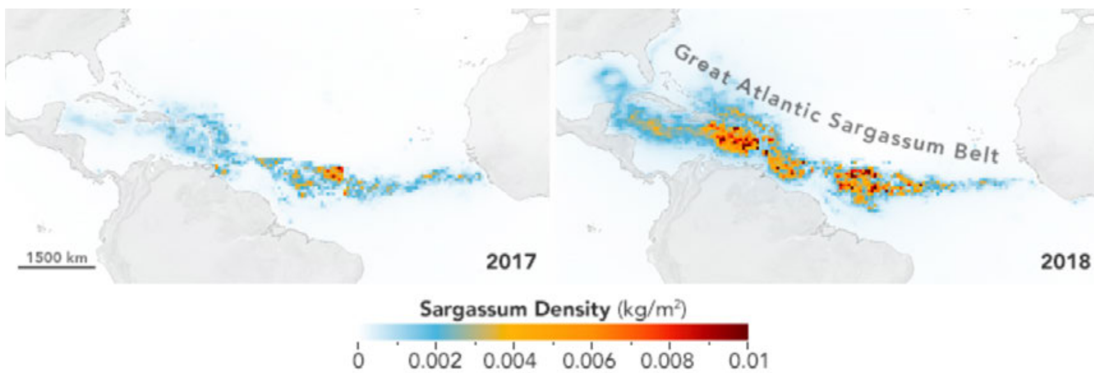
Data from: https://www.nature.com/articles/s41467-021-23135-7

Adding back in the weight of the two oxygens that were removed during photosynthesis, we multiply by 3.66.

We assume the system will run for 365 days & multiply by our planned fleet size of 10.

And then we divide by 1000 to turn the KG value into tonnes.

The final result is that we should be able to remove over 500 tonnes of CO_2 within 1 year using our Caribbean fleet.



[Data](#)

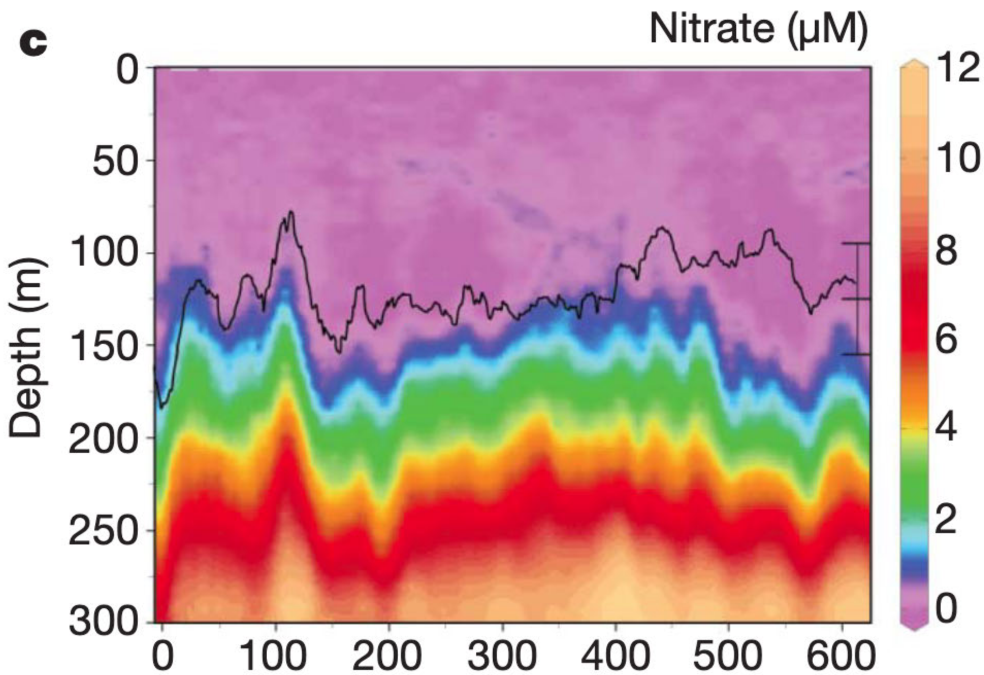
Source: https://doi.org/10.3390/phycology1010004

Once the 10 vessels are operational in the Caribbean and on pace to remove 500 tonnes in one year we will turn our attention to our Pacific Tonnes.

Pacific Tonnes

Our 12 vessel Macrocystis cultivation fleet will have the capacity to host 516 spore/holdfast enclosures capable of achieving at least 500 tonnes of CO_2 removal per year.

Since there are 12 micromoles of nitrogen per liter at depths of 300 meters it's possible to transport nutrient rich water to our holdfast enclosures with 12 submersible radial pumps that which a spec sheet says can move over 800,000 liters per hour running at 15KW. By load shifting across a microgrid and staggering the growth cycles of juveniles and adults we can utilize a solar microgrid across all of the vessels that were used to transport out the holdfast enclosures to now direct all of their power towards upwelling to achieve a daily average of 7.5KW of power across all upwelling pumps. By stretching the length of our vessels a little longer than our Sargassum collecting vessels, and by linking several vessels together to form a vessel array we will be able to maximize the use of our energy resources to effectively transform upwelled nitrates into carbon removal via the biological productivity of Macrocystis.



Source: https://www.nature.com/articles/nature09170

Since we know the dry weight content of Macrocystis to have up to 33.33% carbon and about 2% nitrogen and since one mole of nitrogen is about 14 grams we can base our bioproductivity prediction on the availability of nutrients we provide (Wheeler, 1980).

Macrocystis will absorb as much nitrate as we can provide as long as water temperature and sunlight remain favorable.

By harvesting every 4 months we ensure that we sink the biomass while it's still healthy and before decay and breaking off would naturally occur.

This provides 3 cycles of growth per year with the first cycle taking a little longer to advance from sporophyte.

In one cycle our fleet of 12 deployments containing 516 holdfast enclosures will need to uptake 2.6 tonnes of nitrogen made available by upwelled nitrates. We ignore the micromolar weight of nitrates and focus only on the weight of the nitrogen that the Macrocystis will consume.

Since we know how many micromolars of nitrates per liter we can upwell from the water at 300m depths, we know how much water we will need to upwell. 5312 cubic meters of water will need to be pumped every hour on average to support our 516 Macrocystis holdfasts.

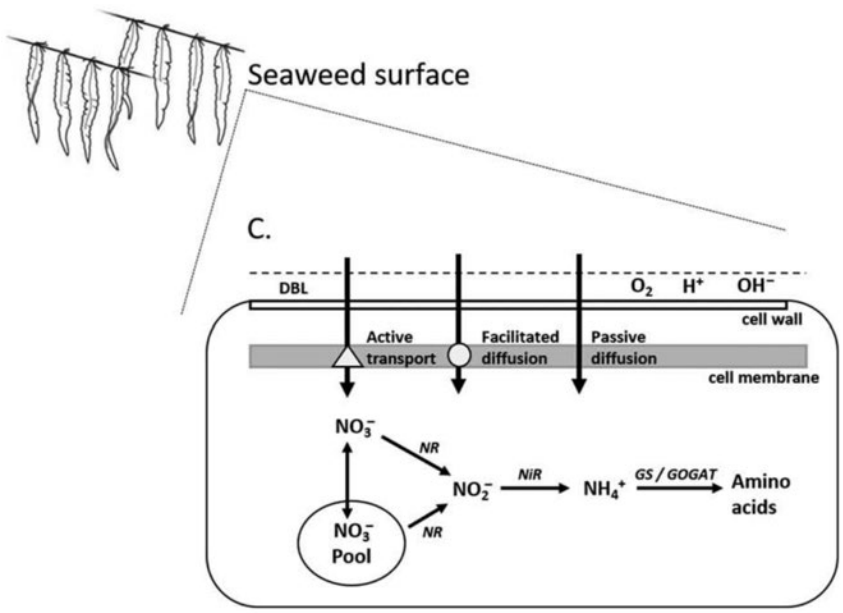
An additional predictor of biomass yield is to have confidence we won't waste our solar energy by creating blooms of other species that block light and waste our limited solar power.

The answer to that is a sensor to detect phosphorus outside of the holdfast enclosure. If nutrients are diffused out of the enclosure then we are pumping too much and can leverage our primary computer that connects to the satellite for an automated intervention and to provide real time data to mission control for constant recalibration.

Macrocystis can grow comfortably with between 2 and 12 micromolars of nitrogen. If we provide 12 micromoles delivered from 300m depths to 1/6th of the adult plant within our holdfast enclosure we expect to get growth rates similar to if the entire adult plant was surrounded by only 2 micromoles.

Macrocystis is well-suited for partial exposure to nutrients due to its ability to both absorb and store, and absorb and transport nutrients within itself. It has shown that it naturally performs a similar feat when it gets nutrients from deep water and sunlight from the surface.

While Macrocystis can grow to 50m or more, we will target 28m on our initial deployments.



Source: Michael Y. Roleda & Catriona L. Hurd (2019) Seaweed nutrient physiology: application of concepts to aquaculture and bioremediation, Phycologia, 58:5, 552-562, DOI: 10.1080/00318884.2019.1622920

Since upwelled nutrients may lack particular trace nutrients, we also have a multi-channel nutrient system up above with ultra-concentrated nutrients that can be provided if needed. With each growth cycle we can improve our system using machine-learning algorithms that record the success and failure of trial and error tests.

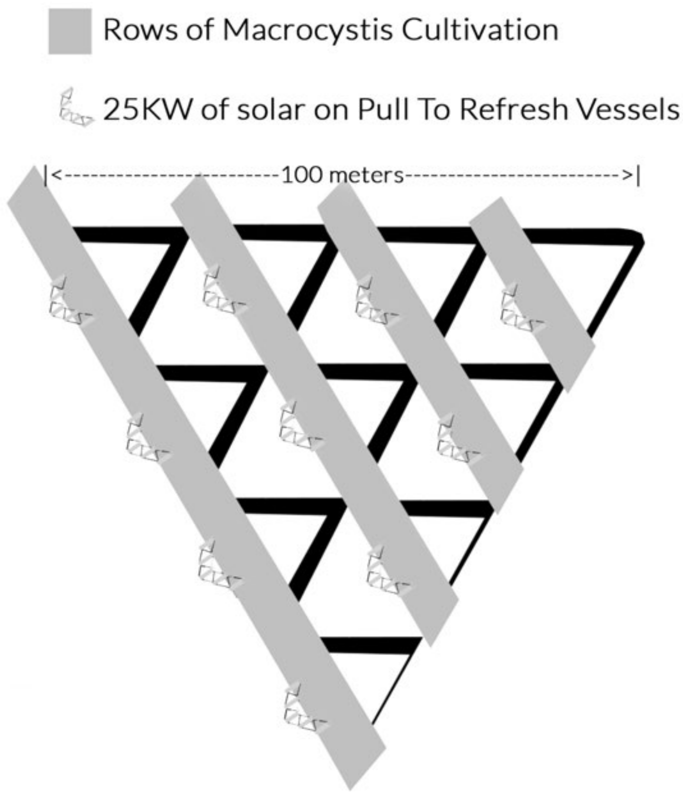
Wheeler, W. N. (1980). Effect of boundary layer transport on the fixation of carbon by the giant Kelp Macrocystis pyrifera. SpringerLink. Retrieved from https://link.springer.com/article/10.1007/BF00397128

c. What is your total overall capacity to sequester carbon at this time, e.g. gross tonnes / year / (deployment / plant / acre / etc.)? Here we are talking about your project / technology as a whole, so this number may be larger than the specific capacity offered to Stripe and described above in 3(b). We ask this to understand where your technology currently stands, and to give context for the values you provided in 3(b).

Our current spore production facility in Canada can seed enough kelp to sequester about 10,800 tonnes CO_2/year.

Our vessel prototype has the potential capacity to sequester over 50 tonnes/year collecting Sargassum but has not yet been fully tested or deployed. For this project we propose a fleet of 10 to deliver 500 tonnes.

Five of our vessels connected into a single vessel and with a stretched length to accommodate extra solar panels have the projected ability to remove 43 tonnes of CO_2 per year. We propose a fleet consisting of 12 of these deployments linked together so that they can share electricity and support staggered growth cycles.



d. We are curious about the foundational assumptions or models you use to make projections about your solution's capacity. Please explain how you make these estimates, and whether you have ground-truthed your methods with direct measurement of a real system (e.g. a proof of concept experiment, pilot project, prior deployment, etc.). We welcome citations, numbers, and links to real data! *(E.g. We assume our sorbent has X absorption rate and Y desorption rate. This aligns with [Sorbent_Paper_Citation]. Our pilot plant performance over [Time_Range] confirmed this assumption achieving Z tCO_2 capture with T tons of sorbent.)*

Our spore production estimates are based on the following calculations:

A 20m spool of string seeded with kelp spores can produce enough viable kelp to remove about 12 tonnes of CO_2. Currently our team's facility can produce 150 spools every two months.

Our rate of Sargassum collection and carbon removal in the Caribbean, 50+ tonnes per vessel per year, is derived from the area our renewable propulsion can cover, times the cross section of the collection receptacle accessory, multiplied by data in the supporting literature showing average Sargassum density and carbon content. This assumes blind navigation that can only

"see" a GPS location on a map. As we improve our machine vision our collection rate can increase. The estimate of carbon removal in the Pacific, 43 tonnes per year on the 5 stretch vessel formation, is based on our collective kilowatts of solar energy when shared on a microgrid of 12 deployments, and the resulting liters per hour of nutrients we can upwell, multiplied by the available nitrogen content in the bioavailable nitrates. If there are fewer nitrates in the location we test, we require new estimates or a new location.

e. Documentation: If you have them, please provide links to any other information that may help us understand your project in detail. This could include a project website, third-party documentation, project specific research, data sets, etc.

This video shows that the vessel can navigate to a set location. This video shows that our dashboard can report what the vessel is doing. This video shows that our satellite system talks to our servers. This video shows our nutrient delivery mechanism can be calibrated.

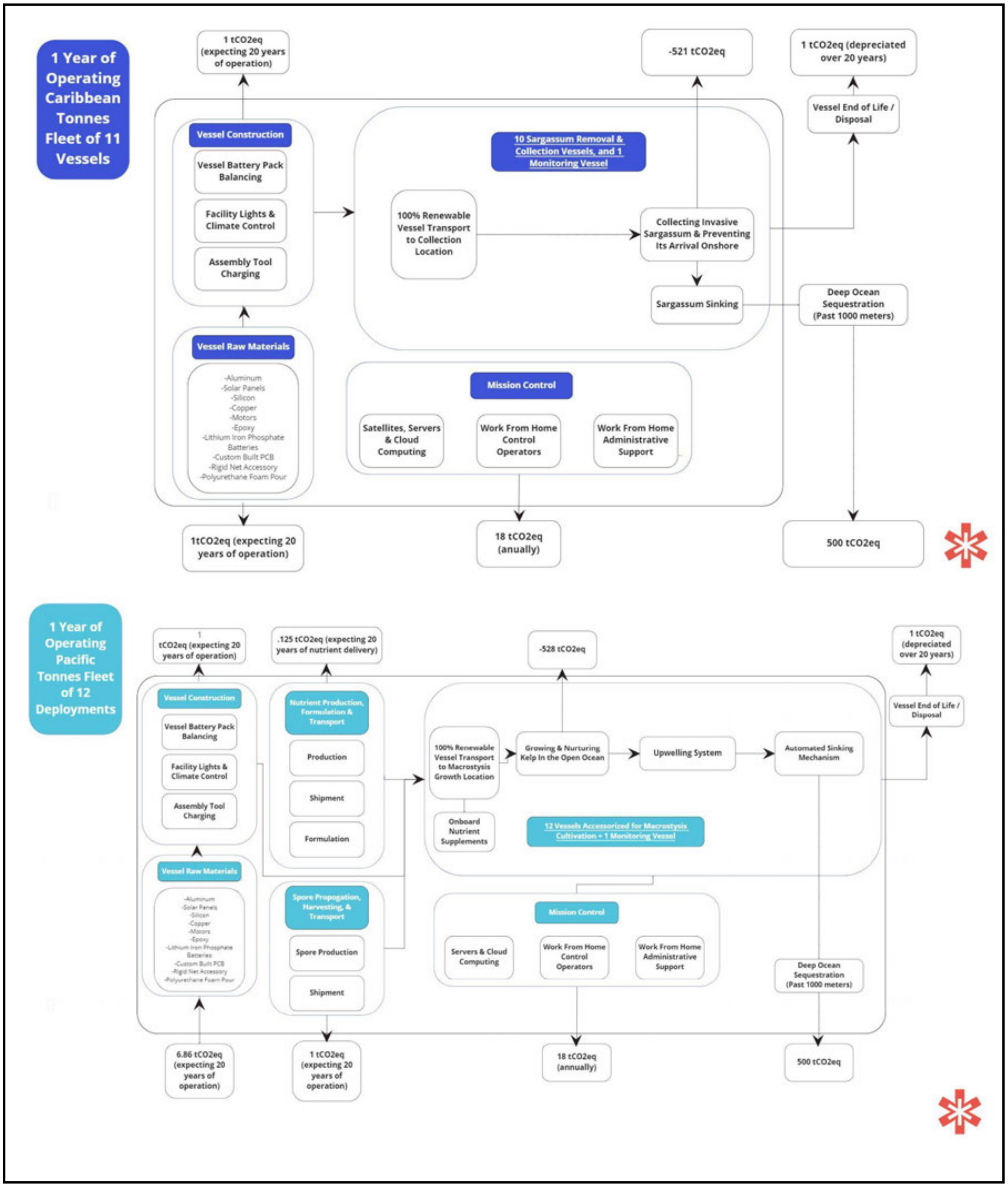
4. Net Capacity / Life Cycle Analysis (Criteria #6 and Criteria #8)

a. Please fill out the table below to help us understand your system's efficiency, and how much your lifecycle deducts from your gross carbon removal capacity.

	Offer to Stripe (metric tonnes CO_2)
Gross carbon removal	521 Caribbean Tonnes & 528 Pacific Tonnes
Gross project emissions	21 tonnes of CO_2 emissions produced by our Caribbean fleet in 1 year. 28 tonnes of CO_2 emissions produced by our Pacific fleet in 1 year.
Emissions / removal ratio	.04 for our Caribbean Tonnes

	.05 for our Pacific tonnes
Net carbon removal	500 Caribbean Tonnes & 500 Pacific Tonnes

b. Provide a carbon balance or "process flow" diagram for your carbon removal solution, visualizing the numbers above in table 4(a). Please include all carbon flows and sources of energy, feedstocks, and emissions, with numbers wherever possible *(E.g. see the generic diagram below from the CDR Primer, Charm's application from 2020 for a simple example, or CarbonCure's for a more complex example).* If you've had a third-party LCA performed, please link to it.



c. Please articulate and justify the boundary conditions you assumed above: why do your calculations and diagram include or exclude different components of your system?

For both our Caribbean and Pacific Tonnes we account for all emissions of raw materials and transport as happening outside of our system. We then consider the use of all marine assets for 20 years before ultimately having an emission expense to retire them. Our Mission Control Center has an annual emission expense but our factory does not because the factory is also feeding the creation of a 20 year asset. The big difference between these two types of removal will be the volume of aluminum and solar panels and that's why the Pacific tonnes have a slightly higher footprint but more than make up for it with the 1000+ year permanence.

d. Please justify all numbers used in your diagram above. Are they solely modeled or have you measured them directly? Have they been independently measured? Your answers can include references to peer-reviewed publications, e.g. Climeworks LCA paper.

The numbers in the diagram are modeled and have not yet been independently measured. We consider our LCA document to be a work in progress. It contains itemized lists of every expected material and process and references to EPA calculations and other literature to support our expected emissions. The document can be provided to Stripe upon request.

e. If you can't provide sufficient detail above in 4(d), please point us to a third-party independent verification, or tell us what an independent verifier would measure about your process to validate the numbers you've provided.

As we build and deploy our vessels we keep thorough records and track all parts of our system, including components supplied by third parties. We are in the process of selecting independent verifiers and auditors to collaborate with and provide this information in Q3 2023.

5. Learning Curve and Costs (Backward-looking) (Criteria #2 and #3)

We are interested in understanding the learning curve of different carbon removal technologies (i.e. the relationship between accumulated experience producing or deploying a technology, and technology costs). To this end, we are curious to know how much additional deployment Stripe's procurement of your solution would result in. (There are no right or wrong answers here. If your project is selected we may ask for more information related to this topic so we can better evaluate progress.)

a. Please define and explain your unit of deployment. (*E.g.* # of plants, # of modules)

Our unit of deployment is a semi-autonomous vessel that can be outfitted to either gather and sink invasive Sargassum or cultivate and sink Macrocystis. Each vessel is built to last up to 20 years.

b. How many units have you deployed from the origin of your project up until today? Please fill out the table below, adding rows as needed. Ranges are acceptable.

Year	Units deployed (#)	Unit cost ($/unit)	Unit gross capacity (tCO_2/unit)	Notes
2022	1	$7,000	0	This was a test unit to validate speed and construction methods.
2021	1	$1500	0	Our first prototype was a remote-controlled, battery-powered fishing boat retrofitted with GPS and remote steering controls, which communicated via WiFi. It validated our software and navigation system.
…				

c. Qualitatively, how and why have your deployment costs changed thus far? (*E.g. Our costs have been stable because we're still in the first cycle of deployment, our costs have increased due to an unexpected engineering challenge, our costs are falling because we're innovating next stage designs, or our costs are falling because with larger scale deployment the procurement cost of third party equipment is declining.*)

Our costs have been stable so far because we have only completed our first prototypes, but they will be decreasing because we are now developing our next prototype at a lower cost.

d. How many additional units would be deployed if Stripe bought your offer? The two numbers below should multiply to equal the first row in table 3(a).

# of units	Unit gross capacity (tCO_2/unit)
10 vessels accessorized to remove our Caribbean Tonnes 1 vessel in the Caribbean accessorized to transmit deep ocean data.	52.1 tCO_2/vessel 44 tCO_2/vessel

12 vessels accessorized to cultivate macrocystis and remove our Pacific Tonnes 1 vessel in the Pacific to transmit deep ocean data.	

6. Cost and Milestones (Forward-looking) (Criteria #2 and #3)

We are open to purchasing high cost carbon removal today with the expectation the cost per ton will rapidly decline over time. We ask these questions to get a better understanding of your potential growth and the inflection points that shape your cost trajectory. There are no right or wrong answers, but we would prefer high and conservative estimates to low and optimistic. If we select you for purchase, we'll expect to work with you to understand your milestones and their verification in more depth. If you have any reservations sharing the information below in the public application format, please contact the Stripe team.

a. What is your cost per ton of CO_2 today?

$900/tonne

b. Help us understand, in broad strokes, what's included vs excluded in the cost in 6(a) above. We don't need a breakdown of each, but rather an understanding of what's "in" versus "out." Consider describing your CAPEX/OPEX blend, non-levelized CAPEX costs, assumptions around energy costs, etc.

85 percent of the purchase price of the Caribbean tonnes will go to the R&D and standing up of our operation with only 15 percent going to the raw material cost and labor to build those 10 vessels. This purchase will not cover the operational expense to continue to remove more tonnes in the future with this equipment. With our Pacific Tonnes 90 percent of the purchase price is going to raw materials with the other 10 percent going towards simply continuing to cover expenses established while standing up our caribbean tonnes operation. Future sales of our Caribbean tonnes will continue to underwrite our Pacific tonnes until eventually enough R&D has been completed to significantly lower the cost per tonne in the future.

c. How do you expect your costs to decline over time? Specifically, what do you estimate your cost range will be as you reach megaton and then gigaton scale? We recognize that at this point, these are speculative and directional estimates, but we would like to understand the shape of your costs over time.

As we reach Megatonne and Gigatonne scale, our material costs will decrease. We estimate reaching a cost $5000 per pacific tonne deployment and increasing the removal to 52.8 tonnes per year resulting in a $100 dollar tonne while still supporting the doubling of our system every year. Our technological optimization and increased access to data will drive vessel costs down. Our Caribbean tonnes offer an opportunity for a steady reliable income which can be funneled into rapid-prototyping and iteration for our Pacific tonnes' structures, accessory design-iteration and more. Our media team will play a significant role in helping us drive the CPT down as we will need to (along with the whole CDR industry, of course), drive home the need for ocean-based CDR and shift the demand curve of the industry as a whole, towards the solution for scaling CDR that is most effective and least impactful on preexisting ecologies.

d. Where are the primary areas you expect to be able to achieve cost declines? E.g., what are the primary assumptions and sensitivities driving your cost projection? What would need to be true for a long-term cost of <$100/ton to be achievable with your technology? (i.e., you are able to negotiate an x% reduction in CAPEX at scale and purchase renewable electricity at $y/kWh)

The biggest cost reducing factor will be the utilization of lower cost energy production and storage methods that are only practical to implement at a much larger scale.

e. In a worst case scenario, what would your range of cost per ton be? We've been doing a lot of purchasing over the past few years and have started to see a few pieces that have tripped people up in achieving their projected cost reductions: owned vs leased land, renewable electricity cost, higher vendor equipment costs, deployment site adjustments, technical performance optimization, supporting plant infrastructure, construction overruns, etc. As a result, we'll likely push on the achievability of the cost declines you've identified to understand your assumptions and how you've considered ancillary costs. We would love to see your team kick the tires here, too.

Our major cost-risks include potential negative interactions between ocean ecology and our technology which would induce a pause or halt of a particular project. Included in this would be higher vendor equipment costs and/or any major supply chain disruptions. Changes to tariff rate structures for import of raw materials into the various countries eventually associated with our vessel's manufacture could also drive up the cost of acquiring renewables.

f. List and describe **up to three** key upcoming milestones, with the latest no further than Q2 2023, that you'll need to achieve in order to scale up the capacity of your approach.

Milestone #	Milestone description	Why is this milestone important to your ability to scale?	Target for achievement (eg Q4 2021)	How could we verify that you've achieved

		(200 words)		this milestone?
1	Complete third prototype	Our next prototype will be deployed in the Caribbean, where we can validate our full Sargassum gathering and sinking system. This will allow us to finalize our vessel design and begin construction of a small fleet.	Q3 2022	We will share videos, data, and progress reports with appropriate partners.
2	Deploy fleet of 10 Caribbean tonne vessels	This is when the carbon removal begins! Demonstration of a functioning fleet will help us acquire more customers and provide us with data needed for verification.	Q1 2023	We will share videos, data via live dashboard, and progress reports with appropriate partners.
3	Demonstrate verifiable sequestration	Once we can demonstrate quantifiable sequestration we can take the next steps to work with third party verifiers and establish a methodology.	Q2 2023	We will be working with third party assessors and auditors and share their reports with appropriate partners.

i. How do these milestones impact the total gross capacity of your system, if at all?

Milestone #	Anticipated total gross capacity prior to achieving milestone (ranges are acceptable)	Anticipated total gross capacity after achieving milestone (ranges are acceptable)	If those numbers are different, why? (100 words)

1	1049	10800	Current number of vessels does not support a full utilization of spores we have access to, a total of 10,800 tonnes/year worth

g. How do these milestones impact your costs, if at all?

Milestone #	Anticipated cost/ton prior to achieving milestone (ranges are acceptable)	Anticipated cost/ton after achieving milestone (ranges are acceptable)	If those numbers are different, why? (100 words)
1	$900	$720-900	We are focused on establishing the methodology, verification, and the blueprint for the path forward; if our technology optimization process scales rapidly enough, we can potentially lower our costs by an estimated 20% or so.

h. If you could ask one person in the world to do one thing to most enable your project to achieve its ultimate potential, who would you ask and what would you ask them to do?

Mr Fredrik Haag, Head of the Office for the London Convention/Protocol and Ocean Affairs at the International Maritime Organization (IMO), could lead efforts to create and implement a clear regulatory framework for ocean-based carbon removal in international waters.

i. Other than purchasing, what could Stripe do to help your project?

Collaborate with us to spread the word about the urgent need for large-scale carbon removal and specifically the potential of ocean-based CDR to address the climate crisis.

7. Public Engagement (Criteria #7)

In alignment with Criteria 7, Stripe requires projects to consider and address potential social, political, and ecosystem risks associated with their deployments. Projects with effective public engagement tend to do the following:

- Identify key stakeholders in the area they'll be deploying
- Have mechanisms to engage and gather opinions from those stakeholders and take those opinions seriously, iterating the project as necessary.

The following questions are for us to help us gain an understanding of your public engagement strategy and how your project is working to follow the White House Council on Environmental Quality's draft guidance on responsible CCU/S development. We recognize that, for early projects, this work may be quite nascent, but we are looking to understand your early approach.

a. Who have you identified as your external stakeholders, where are they located, and what process did you use to identify them? Please include discussion of the communities potentially engaging in or impacted by your project's deployment.

External stakeholders we have identified for our Caribbean project include governments, tourism and other business, tourists, and local residents. We have identified these stakeholders through research into the invasive Sargassum issue and conversations with locals working to solve it, such as our partners in the Dominican Republic.

The Vice President of the University of West Indies stated that the Sargassum problem is "the greatest single threat" to the Caribbean (CARICOM, 2015). The Barbados Government declared a national emergency in 2018 when its beaches became engulfed with Sargassum. The Sargassum that decomposes on the coast causes a myriad of health problems for both locals and tourists, in addition to severe ecosystem damage. As it decomposes, the macroalgae releases hydrogen sulfide gas and ammonia, which can cause sargassum toxicity. Hydrogen sulfide is corrosive, explosive, and flammable. Symptoms of toxic exposure include breathing difficulties, memory loss, impaired balance, fatigue, nausea, headaches, and other neurocognitive problems (Boggild & Wilson, 2019). Tiny organisms, such as jellyfish larvae, live in the Sargassum and can cause rashes if they come in contact with people's skin.

The hydrogen sulfide also damages electronics, so locals have been forced to continuously replace basic essentials such as refrigerators, or forgo using them entirely. Overall, the Sargassum problem is resulting in millions of dollars of damages and lost income for local communities.

Boggild, A. K., & Wilson, M. E. (2019). What every travel medicine practitioner needs to know about Sargassum weed: five key points. Journal of travel medicine, 26(7), taz048. https://doi.org/10.1093/jtm/taz048

CARICOM. Millions of dollars, massive manpower needed to tackle sargassum seaweed. CARICOM. (2015). https://caricom.org/millions-of-dollars-massive-manpower-needed-to-tackle-sargassum-seaweed/

b. If applicable, how have you engaged with these stakeholders and communities? Has this work been performed in-house, with external consultants, or with independent advisors? If you do have any reports on public engagement that your team has prepared, please provide. *See Project Vesta's community engagement and governance approach as an example.*

> We have been attending virtual meetings hosted by community members about the Sargassum issue and reaching out to governments about potential collaboration.
>
> Our Caribbean partners SOS Carbon are from the Dominican Republic and have an established relationship with the local government, tourism businesses, and local residents. We are also forming a consortium to create a carbon removal methodology, and one of the companies involved has team members based in the Caribbean. They are researching solutions to the invasive Sargassum problem using deep sea sinking. We are all working together to engage with stakeholders and communities to address both the Sargassum crisis and the climate crisis.

c. If applicable, what have you learned from these engagements? What modifications have you already made to your project based on this feedback, if any?

> We learned that the majority of Sargassum currently being removed in the Caribbean is taken to landfills where it produces methane emissions. Also, efforts to remove Sargassum have struggled to stay up-and-running because they rely on seasonal and intermittent revenue from beachfront hotels and they require expensive equipment. We have compared our costs and estimated removal rates to existing solutions to ensure that the technology we are developing is superior.

d. Going forward, do you have changes planned that you have not yet implemented? How do you anticipate that your processes for (a) and (b) will change as you execute on the work described in this application?

> We intend to incorporate machine learning to create autonomous robotic abilities such as species recognition, mass analysis, and storm/danger avoidance. We also intend to automate most of the assembly of new units, and we are planning the development of new materials that will both decrease our carbon footprint and increase our capacity for durable carbon sequestration.

8. Environmental Justice (Criteria #7)

a. What are the potential environmental justice considerations, if any, that you have identified associated with your project? Who are the key stakeholders?

> For our Caribbean project, it is important that we establish open communication with locals, government officials, and stakeholders such as tourism businesses in the Dominican Republic and other nations. We want to ensure that we are providing value to the region and addressing any concerns about our operation. The most equitable outcome is one in which the residents

living in the Caribbean don't have to bear the financial cost of cleaning up Sargassum. The voluntary carbon market makes that outcome possible.

b. How do you intend to address any identified environmental justice concerns?

Our team is committed to upholding corporate social responsibility practices based on the guiding principles of ISO 26000 (ISO, 2018). This includes ethical labour practices, providing jobs and educational opportunities for local student involvement, accountability and transparency.

We will have team members present at our manufacturing facility in Panama and our deployment location in the Dominican Republic, so we will be available to converse with community members and relevant stakeholders and prepared to immediately address any concerns that may arise. Our build process is simple and vessels can be transported quickly and easily in the event that we need to shift locations or procedures. We can pause our operation at any moment if issues arise.

In addition to carbon removal, eradicating invasive Sargassum can benefit local communities and industries in the Dominican Republic, so we will communicate with locals to direct our efforts to remove Sargassum from the specific areas where it is most likely to have negative effects when it reaches the coast. We are collaborating with SOS Carbon, a local company removing invasive Sargassum from the Santo Domingo area. Their team works with the government and Navy, providing removal services for hotels and jobs to local fishermen.

Expanding to the Pacific, will move operations into international waters, far from any coastline. Eventually, through vertical integration, we will largely diminish our reliance on land-based factories and resources, removing the risk of disturbing communities or using their essential resources. At Megatonne and Gigatonne scale, we will communicate with the international community about our whereabouts and project expansion, since we will be operating in areas where shipping and other activity occurs. We will continuously share our data and progress with the scientific community to monitor environmental and human impacts.

9. Legal and Regulatory Compliance (Criteria #7)

a. What legal opinions, if any, have you received regarding deployment of your solution?

Caribbean
Our Caribbean partners have permission from the government of the Dominican Republic to gather and sink Sargassum within the nation's EEZ. We will be collaborating with them to legally sink in that region, and we are in conversations with government officials in other regions to establish similar agreements..

Pacific
We have received unofficial legal opinions on how our project fits within current regulatory frameworks as well as steps we can take to work with regulatory agencies. Growing kelp in international waters does not fall under specific language in international treaties.

b. What domestic permits or other forms of formal permission do you require, if any, to engage in the research or deployment of your project? Please clearly differentiate between what you have already obtained, what you are currently in the process of obtaining, and what you know you'll need to obtain in the future but have not yet begun the process to do so.

Our partners SOS Carbon have a permit from the Ministry of the Environment of the Dominican Republic to harvest and sink Sargassum within the nation's EEZ. We have an LOI in place with SOS Carbon stating that we will collaborate on ways to combine our technologies in the DR, and they are assisting us with getting an operational permit to run our vessels in the DR by the fourth quarter of 2022.

Additionally, one of our team members has a 25 acre kelp farm lease off the coast of California that allows kelp harvesting. Another team member operates a permitted kelp research farm and spore production facility in British Columbia, Canada. Our manufacturing facility in Panama is operated by a team member who has been building marine infrastructure there for the past two years.

c. Is your solution potentially subject to regulation under any international legal regimes? If yes, please specify. Have you engaged with these regimes to date?

While the United States is not legally bound to the Law of the Sea, there are several sectors of the agreement that are considered customary international law. Customary international law is not self-executing, there is also no implementing legislation within US law that concerns the research being conducted by the Pull To Refresh team. The London Convention, which the US is a Contracting Party to, lays out restrictions on dumping pollutive materials into the ocean. However, Article III b ii) states that, "'Dumping' does not include: Placement of matter for a purpose other than the mere disposal thereof, provided that such placement is not contrary to the aims of this." Under these provisions, any material that would be placed into the ocean by Pull To Refresh would be for the purpose of sequestering carbon, and would therefore not be considered "dumping" under the Convention's definition.

This practice is also in accordance with the regulations established by the US Ocean Dumping Act, prohibiting the dumping of materials into the ocean that have come from US ports. The 1996 London Protocol treaty attempted to update regulations on the practice of dumping materials into the ocean. While the agreement was signed by the US, it has not been ratified.

d. In what areas are you uncertain about the legal or regulatory frameworks you'll need to comply with? This could include anything from local governance to international treaties. For some types of projects, we recognize that clear regulatory guidance may not yet exist.

There is not a set of standard agreements for our practice of growing kelp in international waters.

e. Has your CDR project received tax credits from any government compliance programs to-date? Do you intend to receive any tax credits during the proposed delivery window for Stripe's purchase? If so, which one(s)? (50 words)

No.

10. Offer to Stripe

This table constitutes your offer to Stripe, and will form the basis of our expectations for contract discussions if you are selected for purchase.

	Offer to Stripe
Net carbon removal *metric tonnes CO_2*	500 Caribbean Tonnes & 500 Pacific Tonnes
Delivery window *at what point should Stripe consider your contract complete?*	Jan 2023-Dec 2024 for Caribbean tonnes Dec 2024-Dec 2026 for Pacific tonnes
Price ($/metric tonne CO_2) ***Note on currencies:*** *while we welcome applicants from anywhere in the world, our purchases will be executed exclusively in USD ($). If your prices are typically denominated in another currency, please convert that to USD and let us know here.*	$900/tonne

Application Supplement: Biomass

(Only fill out this supplement if it applies to you)

Feedstock and Physical Footprint (Criteria #1)

1. What type of biomass does your project rely on?

For our Caribbean tonnes we will be gathering and sinking invasive Sargassum fluitans and Sargassum natans in the Caribbean. Sargassum is a floating brown macroalgae.
As we transition into kelp cultivation we plan to grow Macrocystis pyrifera in the Pacific. If and when we expand into other regions we will grow species that are native to that oceanic region. Even though we will be operating in the middle of the ocean and it would be next to impossible for this to have an impact on coastal environments we still feel it is important to take this precaution.

2. Are you growing that biomass yourself, or procuring it, and from whom?

The invasive Sargassum we will be gathering grows across the Caribbean, spanning from West Africa to Mexico. It is most abundant during the summer months, and the amount that grows each year depends on several factors, such as temperature patterns and currents.

When we initially start growing kelp for our Pacific tonnes we will procure spores from our team members in Canada who run a spore production facility with several different species. Ultimately we will work with them to either expand their facility or open an additional land or sea based facility.

3. Please fill out the table below regarding your feedstock's physical footprint. If you don't know (e.g. you procure your biomass from a seller who doesn't communicate their land use), indicate that in the table.

	Area of land or sea (km^2) in 2021	Competing/existing project area use (if applicable)
Feedstock cultivation	Currently prototyping	Negligible in the open ocean
Processing	Currently prototyping	Negligible in the open ocean

Long-term Storage	Currently prototyping	Negligible in the open ocean

4. Imagine, hypothetically, that you've scaled up and are sequestering 100Mt of CO_2/yr. Please project your footprint at that scale (we recognize this has significant uncertainty, feel free to provide ranges and a brief description).

	Projected # of km^2 enabling 100Mt/yr	**Projected competing project area use (if applicable)**
Feedstock cultivation	*6000 square KM in the open ocean*	
Processing	Vessels provide trimming and lowering capabilities	
Long-term Storage	*Ocean floor*	

Permanence, Additionality, Ecosystem Impacts (Criteria #4, #6, and #7)

5. How is your biomass processed to ensure its permanence? What inputs does this process require (e.g. energy, water) and how do you source these inputs? (You should have already included their associated carbon intensities in your LCA in Section 6.)

Our vessel has a system to lower the macroalgae to depths where its vesicles are damaged and it becomes negatively buoyant. Once processed the macroalgae sinks to the seafloor and is sequestered. This process uses onboard solar energy inputs.

6. (Criteria 6) If you didn't exist, what's the alternative use(s) of your feedstock? What factors would determine this outcome? *(E.g. Alternative uses for biomass include X & Y. We are currently the only party willing to pay for this biomass resource. It's not clear how X & Y would compete for the biomass resources we use. OR Biomass resource would not have been produced but for our project.)*

Our feedstock consists of nutrients that would otherwise be made into agricultural fertilizer. As we scale our kelp cultivation we plan to upwell nutrients and therefore will no longer rely on that feedstock supply. The spores we use could alternatively be used on lines for coastal kelp farms, but the large amount of spores produced would not be created but for our project.

7. We recognize that both biomass production and biomass storage can have complex interactions with ecological, social, and economic systems. What are the specific negative impacts (or important unknowns) you have identified, and what are your specific plans for mitigating those impacts (or resolving the unknowns)? *(200 words)*

Caribbean
Using nets to collect the invasive species would introduce a risk of collecting species other than Sargassum. To mitigate this we have designed a rigid collector that prevents animals from being trapped. We also avoid collisions with other vessels by only operating outside of known maritime routes.

Pacific
Feeding kelp in the high seas has a risk of nutrients escaping. To mitigate this we have developed a method for surrounding the kelp with an HDPE shroud that keeps nutrients from dispersing. We also have a fine-tunable nutrient pump system so that we only deliver small bursts very close to the kelp to ensure maximum uptake and minimum leakage.

8. Biomass-based solutions are currently being deployed around the world. Please discuss the merits and advantages of your solution in comparison to other approaches in this space.

We believe our sequestration method is more scalable than other operations due to the simplicity of our vessel design, the location of our project in the expansive open ocean, the speed at which our chosen species grows, and our ability to monitor and continually adjust feeding schedules and nutrient formulations. Our solution has very low energy, water, and land use requirements.

Also, at the heart of our approach is a first-in-class unmanned vessel that can be accessorized to suit different purposes, much in the same way terrestrial farming tractors are often capable of accessorizing for a variety of tasks. This means we can easily transition from Sargassum into kelp and adjust our system design as needed.

Application Supplement: Ocean

(Only fill out this supplement if it applies to you)

Physical Footprint (Criteria #1)

1. Describe the geography of your deployment, its relationship to coastlines, shipping channels, other human or animal activity, etc.

Caribbean
We will be operating our vessels in areas of the Caribbean with depths greater than 1000m and the highest concentrations of Sargassum. To avoid coastal ecosystems and human activity, we will operate far from shore. Our vessels are small and move slowly, and we have remote navigation control for collision avoidance.

Pacific
We will be deploying to the North Pacific Gyre, thousands of miles from any coastline. The same circular currents that form the Great Pacific Garbage Patch help our vessels remain in orbit with little energy input. There are seasonal whale migrations across the Pacific, but our vessels move very slowly so the whales will easily be able to avoid them. Otherwise there is very little animal activity in the region. There are shipping lanes between North America and Asia. Again, our vessels move slowly and they will have obstacle avoidance capabilities. We will be sharing our location with the maritime community so that vessel operators are aware of our whereabouts.

2. Please describe your physical footprint in detail. Consider surface area, depth, expected interaction with ocean currents and upwelling/downwelling processes, etc.
    a. If you've also filled out the Biomass supplement and fully articulated these details there, simply write N/A.

Caribbean
The sargassum collection & monitoring vessels are each 8' by 25'. We will use satellite imagery to track locations of Sargassum and will direct the fleet to gather in those areas, cross referencing to work in locations optimal for the longest duration of sequestration.

Pacific
The kelp cultivation vessels have an additional 60' submerged substrate structure. The vessels will operate in the North Pacific Gyre where there are fairly stable currents. They also house 8 times the solar power to support the upwelling pump.

3. Imagine, hypothetically, that you've scaled up and are sequestering 100Mt of CO_2/yr. Please project your footprint at that scale, considering the same attributes you did above (we recognize this has significant uncertainty, feel free to provide ranges and a brief description).
    a. If you've also filled out the Biomass supplement and fully articulated these details there, simply write N/A.

We plan to create a system that leverages a network of vessels and hatcheries, with the occasional (optional) floating platform distributed every few km to facilitate ocean-based manufacturing and decentralized maintenance and control. We can foresee deployments, as designed right now, occupying a footprint of 949 km^2 total, spread out amongst the 5 major oceanic Gyres.

Potential to Scale (Criteria #2 and #3)

4. Building large systems on or in the ocean is hard. What are your core engineering challenges and constraints? Is there any historical precedent for the work you propose?

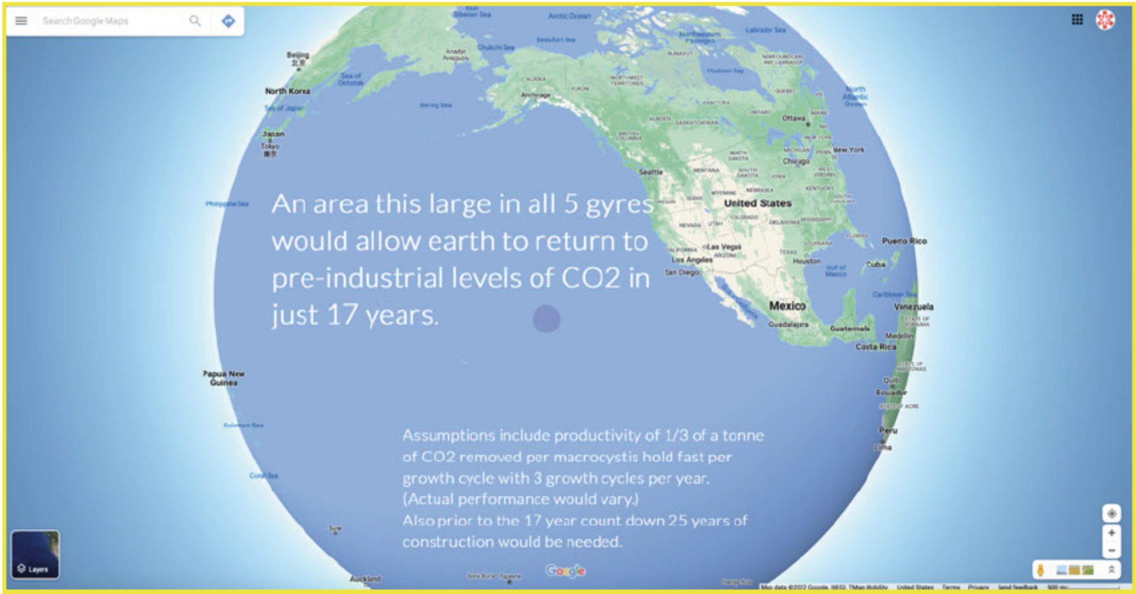
Our core engineering challenges are remote operation, automating actions, tuning nutrient delivery, and optimizing our center of buoyancy, especially as we add accessories and our weight distribution changes.

We reduce difficulty and cost by building modular, unmanned, reusable systems.

In the Caribbean, the biggest constraint is real time data about the current location of Sargassum. We can sink a lot more if we have this information and can reduce our search time. Capturing data from space is costly, so another solution would be to develop companion drones that search out high Sargassum concentrations. However, even without this data our models suggest that in a blind trajectory assisted by the available satellite imagery we will gather and sink 10x more than our baseline goal of 52.1 tonnes per vessel per year.

For our Pacific project, the biggest limiting factor is nitrogen. Therefore it is advantageous to find a way to recycle the nitrogen in the long term. We can do this while also creating the required additional production space. We will synthesize a portion of the macroalgae we grow into plastics used to expand the system further, quantity of available nutrients, which we plan to mitigate with upwelling, and access to solar panels, which we intend to address via expansion into a variety of more efficient long-term energy-providing innovations.

Our team member Dr. Louis Druehl worked with GE to develop plans for open ocean kelp cultivation in the 1980s, but the plan was never realized. Another team member has successfully deployed floating, off-grid single-family homes 13 miles offshore. There is historical precedent for most aspects of our system, including unmanned renewable vessels, upwelling, and Sargassum gathering and sinking.



Externalities and Ecosystem Impacts (Criteria #7)

5. How will you quantify and monitor the impact of your solution on ocean ecosystems, specifically with respect to eutrophication and alkalinity/pH, and, if applicable, ocean turbidity?

Caribbean Tonnes

The new Sargassum belt exists in part because of the increased output of nutrients from the Amazon River. By gathering and sinking the grown Sargassum before it hits the shore we prevent methane emissions while still absorbing nutrients to reduce eutrophication. With the invasive Sargassum gone, the smaller native organisms will have more light and the regional biological makeup will likely reflect historical populations. But we have to take care to study and understand the ecosystem that this invasive macroalgae is creating and offer protection to the new life that now depends on it. We do this by not using blades and instead offer a very slow and gentle gathering into a metal container and then lower. But not being plastic we also prevent critters from getting trapped and by moving slowly when we start to sink we provide ample time for anything with a will to live to escape. Because the full scale of the caribbean tonnes is only 4 Megatonnes of CO_2 max we don't expect major ecological side effects from sinking. But we do need to understand the ocean floor and the ecosystems that exist down their and any potential interaction between their cycles and ecosystems and ours.

Pacific Tonnes

Growing Macrocystis in the North Pacific Gyre with a combination of onboard nutrients and upwelled nutrients runs the risk of creating a bloom. Our unique approach to mitigating this risk includes digitally-connected sensors that can switch off nutrient pumping when the ambient water outside our holdfast enclosure shows an increase in phosphorus and total dissolved solids. This way we can exclusively feed the Macrocystis. That said we undoubtedly would create a new ecosystem. Cycles of animal-to-animal consumption in the ocean requires further research to better understand how our Pacific Tonnes will affect a new ecosystem. Our project presents a unique opportunity to discover what actually eats macrocystis when you grow it in the middle of the gyre, and which populations that increased population would support. The best case scenario is making a good place for whales to grab a snack and the worst case scenario is shuttering the project because something worse than other climate-solution side-effects are discovered. The great thing about our system is that it's all 100 percent remote controllable.

Thank you for the opportunity to submit this application to Stripe and we look forward to a continued growing business relationship.

NOTE:

The Pull to Refresh team submitted a follow up amendment with additional information in response to reviewer questions that can be reviewed here: https://pulltorefresh.earth/stripe-addendum