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Microalgae Carbon Fixation and Sinking Methodology

Public Consultation feedback summary and responses

15 September 2025

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Public Consultation: Microalgae Carbon Fixation and Sinking methodology

Context

Puro.earth held a public consultation on its proposed Microalgae Carbon Fixation and Sinking (MCFS) methodology.

This initial public consultation was announced on Puro's homepage on the 11th of June 2025 and in Puro Newsletter on the same day. The time frame for the consultation spanned from the 11th of June 2025 until the 2nd of July 2025.

The proposed draft with the title **Microalgae Carbon Fixation and Storage** included eleven (11) Sections. The feedback received includes 100 comments from 11 organizations. This document summarises the feedback received during the public consultation, responses, and the revisions included by Puro.earth due to the comments.

We want to thank all participants for your time and contributions to helping us improve the Microalgae Carbon Fixation and Storage methodology to better serve this growing ecosystem.

General Observations

1. The Public Consultation showed a **significant engagement** in the number of participants (11) and their comments (100).
2. Many valuable improvements and clarifications were incorporated into the methodology because of the public consultation process.
3. As the methodology is brought into operation, some suggestions received during public consultations may still be considered in the future.

Detailed Comments and Responses

In the following tables, we will share the comments received and the responses provided by the Puro.earth Team. Comments are shared anonymously. The comments are grouped per Section in the consulted version of the **Puro Microalgae Carbon Fixation and Storage** methodology.

All comment were addressed, and changes incorporated to the final draft. We want to thank all participants warmly for improving the rules and the integrity of Voluntary Carbon Markets (VCM) in general.

Public Consultation feedback and responses

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Comment no.	Rule or section	Comment	Response	Action
1	General	Several years ago we offered you cooperation to develop a methodology for removing CO2 from seawater using micro algae and received the answer that this technology would not be able to store carbon for a long time... During this time, micro algae have not changed their properties and new cultivation technologies have not appeared. This is the problem that can be approved in the proposed methodology. Now you are making a mistake relying on one company and one technology and all this will lead to only one thing - greenwashing. There are only four factors that affect the growth of microalgae in the ocean: 1. Nutrients; 2. Dissolved and bound CO2; 3. Light; 4. Temperature. Any change in one of these parameters leads to a change in the growth activity of microalgae. However, the most important parameter of them is light. No light and there will be no photosynthesis. I would also like to note the inconsistency of the statement about the harm of changing the carbonate system of the ocean. In fact, the main goal is to change the balance of the buffer carbonate system of water, which will lead to a decrease in acidity and, with accelerated kinetics, will ensure the precipitation of carbonates. If your goal is to get a positive result from the application of the methodology, you can contact us for an explanation of our position.	Thank you for your feedback. Although the methodology development was initiated by Gigablue, the methodology is designed to be used by any project whose approach fits the scope of the proposed MCFS methodology. This is how all Puro Standard methodologies are developed. The MCFS approach is one of many with a potential to utilise microalgae as a way to capture and store CO2, each with their individual advantages and limitations. An important factor is the carbon storage: where and how to store the carbon in a durable manner. The MCFS methodology requires enhanced growth of phytoplankton on substrate material, and then rapid sinking of the substrates and microalgae to deep oceans, and through careful site selection the carbon remains stored in the deep ocean for several centuries. We agree that light is an important factor om microalgae growth. However, in the scope of this methodology, it is not considered a limiting factor. Seasonality strongly impacts the ocean surface conditions, including light availability and phytoplankton growth. Therefore, site selection and timing of the operation impacts the success of the deployment. However, this is not a topic to be determined on a methodology level, but is a matter which the CO2 Removal Suppliers need to assess when developing their project at a given site. This methodology does not undermine the importance of light, but instead aims to make use of nutrient imbalances in HNLC regions of the ocean. As for the carbonate system changes: as stated in the webinar, we are aware that pH increase is a potential co-benefit of the MCFS methodology. We nevertheless included pH increase as part of the environmental risks section out of an abundance of caution regarding excessive and rapid pH changes - this is not contradictory but too-much-too-fast of a good thing can be a bad thing. For clarification, section 1.6. is slightly modified to clarify the importance of light. Importantly, we want to highlight that the MCFS approach is in most regions highly seasonal. While in some regions the growth conditions may be optimal for most of the year, in most cases any CO2 Supplier can only operate during spring and summer, when there is enough light to sustain growth.	Added a mention of sufficient light conditions to section 1.6., which introduces eligible deployment areas.
2	General	Please forward this to whoever is managing this affair. See attached for a recent presentation related to Macroalgae. I have another presentation on microalgae biofuels next week. Please note that the concept of your process is misguided. Even sinking seaweeds, macroalgae, is problematic, at best. Sinking microalgae is even further from any plausible reality. Even with Fe Fertilization, the C sequestration is doubtful.	Thank you for your feedback and the material. All Puro Standard methodologies are based on rigorous scientific background (see the references section of the methodology). The MCFS approach includes strict requirements on ensuring enhanced microalgae growth and controlled sinking mechanism. These are key criteria to ensure the safety and efficacy of the approach - as well as making the process quantifiable. The technology is still advancing, and the methodology will be updated as the science advances, as we do with all of our methodologies.	No change
3	General	Thank you for the opportunity for a public airing of the MCFS concept. With respect to the Puro.earth Microalgae Carbon Fixation and Sinking (MCFS) Public Consultation Webinar I have the following observation. I appreciate from Puro.earth's perspective the aim of the webinar was to introduce the content of the draft audit SOP/methodology for this new MCFS technology to be able to generate carbon credits. Re: Section 1.1 Overview and scope. The concept in a seashell (sic) shell addressing (mega) CDR. I had the feeling there was missing in the slide slate/document a statement on the context of the perspective scale* and where the MCFS technology would be employed. Later on the descriptives suggested HNLC regions (not within?) 12 nautical miles from a coastline within an exclusive economic zone (EEZ) - not already involved in some other marine use. This feels too loose for the public to appreciate and I think need to be stated upfront. As a context of the MCFS technology and as a professional biologist myself, I would also like to see a side comparison of how natural microalgae blooms, toxic or not, in the ocean affect carbon dioxide removal, (albeit perhaps not as "locked in carbon") as a scientific baseline. The public will be well aware of satellite pictures showing huge oceanic green blooms of micro-alga and that image will be in their heads. I will be interested to see the Gigablue technology employed. Perhaps, not just in a marine setting. I say this based on my past experience of researching the techno economic value and practicality of using marine Red sea algae to mitigate low value carbon dioxide waste streams from Saudi Arabia's chemical industry in the desert! I thought the MMRV points were thorough. The only scientific question I had was how much micro-algal colonization (coverage) of the substrate is needed and does colonization affect substrate buoyancy preventing its rate of sinking? *other than assuming Giga - based on the name of the company	Thank you for your feedback on the webinar and the methodology draft. We agree that introducing the site criteria in more detail at the beginning of the webinar might have been useful for many of the attendees. In the proposed MCFS methodology draft the site criteria are introduced already in the introduction (section 1.6), which links to the eligibility criteria in section 3.7. where the site criteria are further determined. Indeed, eligible sites must be located at least 12 nautical miles from a coast, and importantly, must be located within a sovereign state's Exclusive Economic Zone. This is to ensure that the projects operate under an environmental permit overseen by a local, regional or national authority. The MCFS approach is based on the concept of enabling the growth of the native microalgae already present at a given deployment site on the surface of a substrate, which is designed to include micronutrients and sink in a controlled manner. Therefore, the enhanced microalgae growth happens within the substrate, and the substrates are not enhancing growth of free-floating microalgae in the water column. The enhanced phytoplanton bloom is contained within the substrates and when the substrates sink, the attached microalgae as well as any excess nutrients which might not have been utilised, sink in to the deep ocean and are not available at the surface anymore. They will not remain in the short carbon cycle in the upper layers of the ocean, as they are not effectively consumed by e.g. grazers. Some degradation will happen during the fixation and sinking phases, which is addressed in the assessment of the sinking efficiency (see section 6.1.). In contrast, the massive microalgae blooms, which are often composed of harmful species, float freely on the surface ocean. While some of those algae sink to the deep ocean, a majority is either degraded or consumed at the upper mixed layer, which then re-releases the carbon and the nutrients to be re-utilised in the surface ocean. The MCFS methodology does consider multiple potential environmental risks, such as nutrient robbing, harmful algal blooms and changes in biodiversity and food web disruption. In adddition to the pre-determined risks required to be assessed by any CO2 Removal Supplier (see section 4.5), each Supplier must also assess any other relevant risk their project may include, as determined in section 4. The methodology does not include requirements on the minimum amount of microalgae attached to the substrates, or microalgae to substrate ratio. These may vary based on the substrate material used as well as project-specific considerations, and the CO2 Removal Supplier must design their project to comply with all of the crtieria set for the substrate as determined in section 3.6. This includes e.g. the criteria for the eligible material, size, density, inclusion of a sinking mechanism and determination of the floatation time. The CO2 Removal Supplier may use various mechanisms to ensure the sinking, taking into consideration the impact of phytoplankton growth on the substrate. The methodology does not speficically require a certain technique to be used, but rather sets the boundary conditions which the CO2 Removal Supplier must comply. Additionally, section 9.4. includes requirements on assessing the substrate floatation period in laboratory setting, and finally section 9.6. sets criteria for in-field validation of the sinking variability of the substrates.	No change.

Comment no.	Rule or section	Comment	Response	Action
4	General	I read through the methodology you posted and wanted to provide a brief overall impression during this public consultation period. A more rigorous review of this more than 160 page legal and scientific document would require significantly more time and resources. The methodology is designed to lay out fundamental principles of what is termed Microalgae Carbon Fixation and Sequestration (MCFS) and a methodology for accessing the amount of additional, durable (here >200 yr) atmospheric CO2 removed and its impacts on the ocean. It should be noted that MCFS is unique in that is uses the patented Gigablue floating and sinking "substrate" so this methodology would not apply to other mCD approaches as is. While I applaud the efforts of Puro to advance the field of mCDR verification, this area is still very nascent and must move forward with extreme caution. False starts, or ultimately poorly verified carbon removal, has the potential to hold back the entire spectrum of mCDR community. My overall impression is that while the various pathways of C removal and ocean responses are well defined, and no major pathways are missing, the methodology relies on theoretical calculations that are not well enough constrained to lead to verifiable C credits or estimates of impacts. As one example, the durable C removal due to enhanced phytoplankton growth on the substrate and its transport to the seafloor requires knowing (eqn. 6.1) how much C is added to the substrate (C-fixed) and how much of that C reaches the seafloor (sink efficiency) along with an air-sea exchange term (I will ignore this last term here). They cannot measure/separate their substrate from the much higher abundance of natural materials, say via sampling, so the methodology relies for C-fixed on parallel "control" measurements of C added (6.1.4-subject to bias) and does not measure export or arrival to the seafloor associated with their substrate directly (sink efficiency). The amount of C that reaches the seafloor relies on a couple of respiration equations (6.3 & 6.4) that are too simple, parameterized largely by O2, temperature and sinking rates, yet in the real ocean, respiration of sinking C is much more complex. Key model input parameters are indirect, such as sinking rate, as it relies on acoustics (method not well define here & never been shown to work), or lab based (settling columns, not same as in-situ rates). A methodology that does not somehow quantify directly the amount of their product that arrives on the seafloor with its additional C, will always be subject to great uncertainty. Another missing aspect is consideration of variability in the ocean in space and time for sampling. This is important for verifying impacts and C balances in a variable ocean. This takes more than simply saying a certain number of CTD profiles, net tows, or bottom samples are needed (these specifications are not even well defined), as there is huge variability in a spatially and temporally (4-D) evolving ocean. The state of current biogeochemical models differs greatly regarding their resolution, and they all lack adequate biological and C parameterizations to be a replacement for ocean observations. Better specifications are needed for how they would track the evolving plume of particles, in part to obtain a mass balance of added substrate, losses, and to assess added impact on C and how much gets how deep. The methodology never acknowledges that samples and assessments of any particulate material will contain both added substrate particles and more abundant natural organic matter, and variability in water column measurements will reflect the complexities of the skill in tracking and monitoring the plume boundaries and outside baseline. There are other areas of weakness, but I will stop here. The methodology is complete in terms of conceptualizing C pathways, but inadequate in its ability to directly, or via models, quantify the fate of C and the impacts of the floating/sinking substrate on the ocean. Determining these impacts on carbon, ecology and geochemistry suffers from not being able to define the affected area in a 4-D evolving ocean.	Thank you for your thoughtful review and feedback. You are correct in that this is a narrowly tailored standard suited to a specific mCDR pathway. Given the evolving and nascent state of mCDR standards development, particularly with biological pathways, we feel this is appropriate. Constraining the scope allows us to focus on carbon accounting and environmental risks specific to this particular method. This focus is not meant to suggest there are not other viable mCDR pathways. Future versions of this standard may be expanded in scope to accommodate related methods, or we may continue to develop tailored specifications that are focused on the challenges that pertain to the pathway being evaluated, while incorporating the relevant learnings from prior projects. The reliability and verifiability of carbon sequestration claims are the crux of any CDR methodology. In open system, and especially open ocean pathways, this can be particularly challenging. One advantage of this approach is that only carbon in biomass affixed to the sinking substrate is eligible for consideration. Properly quantifying the quantity of fixed carbon is challenging, but these claims are based on in situ evaluation of the deployed and sinking substrate and not on model projections. Your points on the sinking efficiency, C_fixed, and the challenges of ocean modeling and monitoring, as well as the limitations of the specification draft in these areas, are all well-taken. These, and other areas, are being reviewed, revised, and strengthened. Developing standards for novel methods is, by necessity, an evolutionary process. By documenting and codifying these protocols, and then through the feedback and review process, we are able to refine the standards. This evolution, education, review, and refinement will continue in the coming years through small-scale projects and monitoring system deployments, audits, and regular revisions to the methodology. As the underlying science advances, including data gathered from the projects themselves, our understanding of these vital issues will increase, and the methodology will be improved accordingly. In all cases, we agree with the need to proceed with due caution, scientific rigor, and an open, transparent process that welcomes feedback and critique. We thank you, and all of our reviewers, for participating in that process.	Minor revisions of various sections, including quantification and monitoring requirements.
5	General	It is currently not clear what the Organic Polymer that is sprayed onto the substrate made of, this should be clarified.	Thank you for the comment. The MCFS methodology describes the eligibility criteria for substrates in sub-section 3.6. Specifically, the requirements for the substrate materials are presented in 3.6.1. Organic polymers are not mentioned in the methodology, but rules 3.6.7 and 3.6.8 describe the requirements for the micronutrients that are added to the substrate. The CO2 Removal Supplier may choose to incorporate the nutrients into the substrate using various technologies, and the methodology does not require a certain process to be followed, given that the CO2 Removal Supplier fulfils the eligibility and safety requirements.	No change.
6	General	It is currently not clear how the microalgae access the nutrients if the nutrients are bonded to the substrate? Won't the nutrients need to go into solution to be taken up by phytoplankton?	The nutrients are precipitated or adsorbed onto the surface of the substrate. The CO2 Removal Supplier shall specify the technique used in their project description, which is then verified during the audit. Microalgae can consume nutrients from surfaces like minerals or dust or be assisted by other microbial species to do so (Basu, S., et al. 2019; doi: 10.1038/s42003-019-0534-z). This processes was demonstrated in literature and varies by species and uptake mechanisms (e.g. Cruz-López, R., et al. (2023); https://doi.org/10.1007/s10534-023-00489-7).	No change
7	General	It is currently not clear how much microalgae can accumulate on one substrate particle? I.E. What is the ratio of substrate to microalgae on each particle at sinking? There should be a methodology for this included with the document.	Thank you for the comment. The methodology does not set strict criteria on the substrate to microalgae ratio. Based on the substrate material, the ratio may vary between different projects or deployments. In all cases, the CO2 Removal Supplier must follow the requirements for the substrate material, shape and integrity (section 3.6.). Additionally, the CO2 Removal Supplier must be able to distinguish the sourve of the organic carbon, in cases where the substrate material contains organic carbon - this is to ensure that only the carbon fixated by the phytoplankton is accounted for when quantifying the net removal (see section 6.1.).	No change
8	General	Can the authors confirm there is no sediment/ seabed sampling even at gigatonne scale?	Thank you for your feedback. We have introduced rule 2.2.4 limiting the application of this version of the MCFS methodology to below 1 megatonne scale per facility. This decision was based on the need to reassess certain requirements related to environmental safeguards as well as baseline carbon removal assessment as the MCFS approach matures and scales up. While there may be furher revisions to the MCFS methodology already prior to any project reaching a megatonne scale, this requirements sets an additional safeguard to ensure that the requirements match the updated information available at the time, potentially introducing additional requirements.	Introduction of rule 2.2.4 limiting to 1 Mt scale per facility.
9	General	In conclusion, meeting the protocol's eligibility criteria will likely require an applicant to define limits of disturbance, impacts, and the MMRV and engagement necessary for consideration at complex and broad scales. The tools suitable for this task are still being developed, and while we think your methodology is a means to promote MCFS R&D, including the MMRV and engagement practices desired for responsible project activities, we want to note its early nature to achieve responsible and verifiable crediting.	Thank you for your comment. The methodology defines eligibility criteria in section 3, and limits for e.g. environmental impacts are set both in the methodology (section 4) and the local regulations which the CO2 Removal Supplier must comply with. The MCFS methodology relies on existing monitoring, measurement and modelling approaches, which are commonly accepted as standard oceanographical protocols. However, as the scientific understanding of the ocean processes are advancing, the methodology is also updated accordingly, as we do with all of our methodologies. We are happy to discuss this further if necessary, and welcome feedback at any stage after the methodology is published to understand and address any remaining concerns or issues raised.	No change

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10	Glossary	Under Glossary of Terms, the definition of Substrate is defined in a way that only one company, Gigablue, can utilize it for dispersals – only really can be used by Gigablue. Recommend the definition of substrate to be broadened to include native, healthy phytoplankton or nutrient-impregnated particles. This is because unlike a purely chemical solution like Gigablue's, OUR COMPANY's biological-first approach encompasses entirely different substrate as inputs (i.e., healthy, native phytoplankton to strengthen local biodiversity of phytoplankton assemblages).	Thank you for your comment. The definition provided in the glossary refers to the main criteria for substrates under this methodology (see section 3.6). These criteria are purposely set to differentiate MCFS from other concepts such as ocean iron fertilisation (OIF) or microalgal ballasting, and meet other requirements detailed in sections 3 and 4. The substrate material may be organic or inorganic, and may not contain any harmful compounds. This leaves flexibility for multiple types of materials to be used by any project developer, given that they fulfil the criteria set in the methodology. The scope may be expanded in the future when the methodology is updated.	No change
11	p. 11	200 years seems too short of a minimim sequestration time for meaningful CO2 reduction. There should be a section explaining and justifying this choice.	Thank you for your comment. The Puro Standard introduced the 200-year durability claim for our methodologies earlier this spring (CORC 200+). The CORC200+ category guarantees sequestration timescales over several centuries. This is in line with emerging EU quality criteria for high-durability removals and considered permanent removal in the EU framework. The CORC200+ category has been currently set for for three Puro methodologies: Biochar, Marine Anoxic Carbon Storage and the proposed Microalgae Carbon Fixation and Sinking methodology. Importantly, the durability category is a guarantee, not a limit. Effectively this means, that the durability for each MCFS project will be dependent mainly on the sinking site characteristics. We consider the CORC200+ label as a conservative, science-based estimate to ensure durable removals in eligible regions globally, but acknowledge that in certain regions, the actual sequestration durability may be much higher. A blog post discussing the durability categories was posted on the Puro.earth webpage in June 2025, explaining the reasoning behind this and the other categories in more detail. The blog can be accessed through https://puro.earth/blog/our-blog/Toward-a-Harmonized-Market-The-Puro-earth-Approach-to-Defining-Carbon-Removal-Durability.	No change.
12	Section 1.1	Section 1.1 -durable length of time being just 200 years is based on the current MRV methodology, which is largely focused on modeling and assumptions. If depositional environment can be broadened so that it focuses on regions of our oceans that are best suited for organic carbon burial including coastal waters that can be polluted such as bays, estuaries, and deltas that are over 30 meters deep (or where most of the organic carbon gets buried), which is not high nutrient low chlorophyll regions of the open ocean, then by adding in direct measurements into the MRV protocol (see below), the durability can be extended to over 1000 years. -comment about how just 1% of carbon accumulates in the deep ocean relates just to HNLC regions of the open ocean, if depositional environments were to expand to continental shelves and shallower (e.g., bays, estuaries), then the amount of organic carbon export to the underlying sediments would be higher and why the vast majority of organic carbon accumulates in waters that are shallower than 1000 ft depth. The point about inorganic carbon relates to marine snow deposition that really only dominates at abyssal depths of the oceans (or where HNLC regions are located).	Thank you for your comment. Please see the above response for comment no. 11 for the discussion on the 200+ year CORC label. The current scope of the methodology is limited to HNLC regions only. However, the scope may be expanded in future updates of the methodology, pending robust scientific understanding of the safety and efficacy of the approach in other regions. HNLC regions were selected due to the limited phytoplankton growth and the availability of specific macronutrients. The sinking site depth is also a crucial factor to consider when evaluating durability. Since it is currently not possible to accurately estimate which fraction of the deployed substrates and adjacent microalgae are buried in the sediments, for quantification purposes, the methodology assumes that 100% of the material deployed will remain in the deep waters. Generally, deeper sites have longer ventilation timescales. The fraction that remains in the sediments likely has a longer storage durability. At deeper sites, there is expected to be less disruption of the sediments due to storms or other events, which may cause turbulence at the water-sediment interface.	No change
13	Introduction	In footnote 2 in the Introduction to this document it states: "For avoidance of doubt, this methodology does not apply for ocean iron fertilization (OIF) approaches. While OIF – defined as an addition of small amounts of iron to the surface water to stimulate algal blooms - meets the first criteria, it doesn't meet the second as it lacks additional sinking mechanisms." The definition of ocean fertilisation in the 2013 amendment to the LP is not as you state above but: "Ocean fertilization is any activity undertaken by humans with the principal intention of stimulating primary productivity in the oceans." The fact that the LP definition does not explicitly cover "additional sinking mechanisms" is irrelevant as it covers all techniques stimulating primary productivity in the oceans. Consequently, the Gigablue technique does fall within the LP definition of ocean fertilization.	Thank you for your comment. The footnote does not explicitly refer to the definition of OIF based on the London Protocol. We have clarified the footnote to emphasise the key concept on how the MCFS approach differs from OIF approaches in general, which does not only rely on the efficient sinking mechanism. Importantly, this methodology does not allow for free dispersal of nutrients into the water. All nutrients must be contained in the substrates and cannot leach. When the substrates sink, any potentially excess nutrients will not be available at the surface waters. These requirements differentiate the MCFS approach from nutrient fertilisation approaches, minimising or mitigating many of the well-known negative environmental impacts and allowing to accurately quantify the carbon delivered to the deep ocean. The eligibility requirements are described in section 3 and risk assessment criteria in section 4.	Clarified the footnote: "For avoidance of doubt, this methodology does not apply to processes in which nutrients are added to the water without an additional sinking mechanism such as ocean iron fertilization (OIF) approaches."
14	p.13	The paragraph beginning with 'The MCFS pathway' implicitly indicates that MCFS enhances the organic biological pump exclusively and does not impact the carbonate counter pump or solubility pump. It is possible that if the micronutrient addition led to changes in community composition that favored calcifies, or if particles with more calcifies are exported more efficiently due to ballast, amplifying PIC export relative to POC export. Also, theoretically the solubility pump could also be indirectly impacted, as changes in primary production or community composition can cause shading and impact the shortwave radiation penetration which influences temperatures in the mixed layer (I think this is unlikely to be a substantial effect, but the point here is that indirect effects on the other carbon pumps are possible).	Thank you for your comment. It is correct that these are complex and interrelated systems. The intervention focuses on the biological pump; however, these changes will also have an impact on solubility and carbonate formation. These changes are expected to be minor and we have clarified this in the text. The intent of this section is to indicate the primary system that is being evaluated to make claims about carbon sequestration and to clarify it relative to other mCDR pathways that focus on other systems. The impact of the intervention on all ocean systems is considered and subject to evaluation for ecological and environmental risks.	Clarification added: The MCFS pathway enhances the organic biological pump to increase the amount of phytoplankton that grows in the surface ocean and sinks to the deep ocean and sediments but does not significantly impact the carbonate pump.
15	Section 1.3	Section 1.3-says lab grown algae EXCLUDED. If the lab grown algae is native and healthy to the algae being released, is this still excluded?	Thank you for your comment. Indeed, this methodology excludes any import of lab-grown microalgae, even if it's naturally "native" to the environment. This is done to minimize ecological risks and integrate with the dynamic biodiversity in the ocean.	No change

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16	p. 14	“However, upwelling of deep water does occur in certain areas (e.g. Pacific Ocean eastern boundary, equatorial upwelling zones, etc. (Bograd et al., 2023; Kessler, 2006; Morrison et al., 2015), resulting in high productivity in surface waters due to the influx of macronutrients.” Upwelling regions don’t necessarily drive high productivity, a notable exception is the Southern Ocean (as referenced from Morrison et al. 2015), where there is upwelling broadly but it’s largely an HNLC region.	Thank you for your comment. We clarified this in the text.	"However, upwelling of deep water does occur in certain areas (e.g. Pacific Ocean eastern boundary, equatorial upwelling zones, etc. (Bograd et al., 2023; Kessler, 2006; Morrison et al., 2015), in some conditions resulting in high productivity in surface waters due to the influx of macronutrients."
17	Section 1.4	Section 1.4- the small fraction of carbon preserved in sediments as described in this section is only really applicable for the HNLC regions of the open ocean – it is vastly different and can be much more efficient in more coastal to shelfal settings – this is in different depositional settings (much better in many cases).	Thank you for your comment. We acknowledge that the the export of organic matter to the seafloor varies across various depositional environments. As the scope of the proposed methodology is limited to HNLC regions only, the estimates are accurate. The CO2 Removal Suppliers must also determine the local baseline for the phytoplankton growth at any given area of operations, as determined in sections 3.7. and 6.2.	No change
18	Section 1.5	Section 1.5-can be broadened if the definition of substrate can include live, healthy phytoplankton we release (not just substrate as a nutrient cocktail). Note: certain phytoplankton are denser than others so are more likely to sink. The ocean does NOT require the substrate to be dense due to the chemical infusion, just that it needs to be dense enough to sink efficiently.	Thank you for the comment. The scope of the current version of the proposed MCFS methodology is limited the the use of substrate material on which the phytoplankton grow and is prevented to be released into the surrounding water. One purpose of the substrate is to ensure the sinking of the additionally grown phytoplankton. This technique sets MCFS apart from Ocean Iron Fertilisation or microalgal ballasting, or even artificial downwelling. Given the criticality of the sinking mechanism, at this point the methodology does not include free or otherwise sinking phytoplankton. However, Puro may consider expanding the scope during future updates of the methodology.	No change
19	Section 1.6	Section 1.6 Eligibility areas – can this be broadened so its not just oligotrophic gyres?	Thank you for your comment. The current scope of the methodology does not include the oligotrophic gyres as eligible sinking sites, where the phytoplankton growth is mainly restircted by lack of macronutrients. Instead, the methodology is strictly limited to HNLC regions only, where micronutrients inhibit the phytoplanton growth.	No change
20	p. 19	Give a more specific sequestration permanence estimation, with more detailed explanation of how this is calculated and monitored.	Thank you for your comment. The introduction does not yet set the requirements for assessing the site performance, including the durability of the carbon storage. Further criteria on the sinking site selection is described in section 3.7., and for carbon quantification, sections 5 and 6. These are supported by the monitoring requirements (section 9).	No change
21	p.18	Reliance of carbon removal on natural ocean circulation is risky when climate change impacts and changes these circulation dynamics. With the assumption that ocean temperatures will rise by some degree before net-zero is achieved, is there evidence that this process will function as the environmental processes it relies on change?	Thank you for your comment. While the impacts of climate change on ocean circulation is indeed a concern for long-term durability, the projections of changes in ocean circulation are highly uncertain and subject to a wide range of climate projections and model estimates. Further, as the required storage depth shall be deep enough to allow for a durability of at least 200 years, such deep water masses are likely to be less vulnerable to surface ocean impacts. However, given that the risk of ocean circulation changes for the deep ocean still exist, we believe the more conservative permance label of 200 years rather than 1000 years act as a safeguard against an overconfidence in the permanence of MCFS. In an unlikely event where there would be a major rapid shift in the oceanographical system, the CO2 Removal Supplier needs to assess any potential reversal events due to such changes, following the process described in thr Puro Standard General Rules and section 4.2., 4.3. and 9.7. of the methodology.	No change
22	Section 1.7	Section 1.7 – It is a false narrative that deeper sites will store more carbon. What is correct: deeper sites will impact the composition of the carbon that gets stored. At abyssal depths, such as below HNLC regions, inorganic carbon will be the main form of carbon that gets delivered (i.e., see what many refer to as marine snow) but roughly 80% of all organic carbon burial in our oceans takes place at much shallower depths – at depths less than 750 ft approximately in inner to outer continental shelf and upper slope depositional settings on the margins of continents.	Thank you for your comment. While section 1.7. introduces the overall impact on ocean circulation on CO2 removal, we have clarified the text to emphasize, that the MCFS approach is based on CO2 storage in the deep waters, not incorporated into the sediments.	Removed a sentence "A smaller fraction of organic carbon escapes decomposition and is buried in sediments, contributing to more permanent sequestration." for clarity.
23	p. 20	“For example, Southern Ocean circulation patterns indicate that deep water in the South Pacific Ocean at a latitude of ~45-50°S will flow northward as part of Antarctic Bottom Water (AABW; Solodoch et al., 2022) in the Deep Western Boundary Current which can upwell ~350 years later in the North Pacific Ocean depending on sequestration site (Matsumoto, 2007).” ‘Deep water’ at this latitude in the Southern Ocean below depths of >3000 m will flow northward in AABW along the DWBC (and can be stored in the deep North Pacific for a long time), but there is a ‘deep water’ southward return flow of Pacific Deep Water above the DWBC between ~1000-3000 m depth that will upwell quite rapidly (decades from 45-50S) in the Southern Ocean (e.g. Tamsitt et al. 2017), so the specific depth here is very important and >1000 m is not sufficient.	Thank you for your comment. Section 1 is a general introduction to the methodology and the underlying mechanisms and scientific principles. In section 1.7., 1000 meters was mentioned as an example based on the Siegel et al. (2021), but it does not reflect a criteria for this methodology. After a careful consideration, Puro decided not to introduce a minimum sinking site depth into the deployment and sinkign sire requirements (section 3.7), as we acknowledge that the required depth to ensure at the required minimum sequestration time of at least 200 years must be assessed individually for each site. At some sites, the oceanographic conditions may allow for durable sequstration at 1000 m depth, while in others, considerably deeper conditions might be necessary, as pointed out in the comment. This is why the CO2 Removal Supplier must provide site- and project-specific evidence of the water column properties, circulation patterns and ventilation timescales at each specific sinking site.	No change.
24	Section 2	Section 2 -Organic Biological Pump. Part about how 1% of carbon reaches the deep ocean limited to just abyssal depths. Unrelated to the depositional settings companies like OUR COMPANY's work – where carbon efficiency is much higher.	Thank you for your comment. Please also see the response to comment no. 17 above. The scope of the current MCFS methodology is limited to HNLC regions only. Puro may consider to extend the methodology scope to include other depositional environments when the mwthodology is updated in the future. Requirements would then be adjusted accordingly.	No change.

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Comment no.	Rule or section	Comment	Response	Action
25	Section 3.1	Section 3.1 – why do local phytoplankton species have to be on engineer substrates? One is not dependent on the other. Why not just have local phytoplankton species that are dense enough to sink themselves? As the substrate is the what initiates the sinking in all cases, it is the biomass remains of the phytoplankton that do.	Thank you for your comment. One purpose of the substrate is to ensure the rapid and efficient sinking of the additionally grown phytoplankton. This technique sets MCFS apart from OIF or microalgal ballasting, or even artificial downwelling. Given the criticality of the sinking mechanism, at this point the methodology does not include free or otherwise sinking phytoplankton.	No change.
26	Section 3.1	In the final paragraph of section 3.1 it states: "While adherence to the above-listed external documents is not required in this methodology…". This is not true for the LC and the LP – see above. You have also omitted any mention of the 2008 resolution of the LC and LP Parties 'Resolution LC-LP.1(2008) on the Regulation of Ocean Fertilization' and the 'Ocean Fertilization Assessment Framework' adopted in 2010 that are also key documents with regard to ocean fertilization activities. Please amend the document to correct these incorrect statements.	Thank you for your feedback. The full sentence states: "While adherence to the above-listed external documents is not required in this methodology (except if/when explicitly stated in a numbered rule, or required by local regulations), they can be a useful source of background information to assist the CO2 Removal Supplier in creating a well designed and monitored MCFS project." Importantly, this means that each project must comply with the requirements set in the methodology as well as the relevant regulations which they operate under - essentially a local, regional, national or international authority such as an environmental agency. As such, the CO2 Removal Supplier must identify and assess any regulation, act, protocol, convention or similar, which they must comply with and enclose that information in the project description. The CO2 Removal Supplier must in all cases comply with all of the requirements set by the MCFS methodology or the relevant local authority. In cases where the requirements differ, the CO2 Removal Supplier must always follow the strictest requirement. While the international agreements would bind the CO2 Removal Supplier regardless of the region they operate in, there are multiple regional or local regulations, which may vary significantly. The list presented in section 3.1. includes examples of such agreements and documents and some of those may be referred to in the numbered rules in the methodology or required by the governing authority. We are happy to revise the list when necessary, and have added Resolution LC-LP.1(2008) to the list.	Resolution LC-LP.1 On the Regulation of Ocean Fertilization (2008) has been added to the list of international agreements.
27	Section 3.2.1	Section 3.2.1 (please also see my comment about section 1.7 as this one is similar)-limits carbon to organic carbon, yet HNLC are regions with very poor organic carbon burial – it is just the water that gets trapped in deepwater that can hold organic carbon in these particular settings prior to upwelling somewhere else within hundres to a thousand years – why not expand to inorganic carbon?	Thank you for your comment. While your suggestion is relevant for depths below HNLC, this methodology aims to capture CO2 through organic means (i.e., enhanced phytoplankton growth) and efficiently sink it in the deep ocean conditions for durable storage. The scope of the MCFS methodology is not currently including burial in deep-sea sediments. This limits the scope to ocean areas and depths that can accommodate this. MCFS prioritizes the export of organic matter into deep-water masses (those overlying the sediments) over sediment burial, and therefore does not typically preserve phytoplankton biomass in its organic form. Within a short period on the sediment, phytoplankton and all labile organic matter will be remineralized into dissolved inorganic carbon (DIC), which will then be stored in the deep water. The primary goal is to achieve a deep-water layer retention time exceeding 200 years, preventing the water parcel from ventilating.	No change.
28	3.2.4	What is considered 'sufficient' air-sea gas exchange following phytoplankton growth here? Presumably even if a theoretical project only has 50% uptake efficiency following CO2 depletion from surface waters, provided there was still positive net CDR for the project it could still be credited. Might need to be more specific for this criteria.	Thank you for your comment. The question of sufficient air-sea gas exchange flux is not straigthforward, and therefore it is not possible to set an absolute lower limit for a minimum flux for a given deployment and sinking site. As you mention, it is possible that a project may be net-negative even if the uptake efficiency is relatively low. However, if the uptake efficiency is only 50%, this would have a major impact on the amount of CORCs issued for a given project (see section 6.1. Carbon stored). Ultimately, it is the CO2 Removal Suppliers who determine the feasibility of their project at any given deployment and sinking site, and CORCs may be issued as long as the project fulfils the criteria set in the Puro Standard General rules and the MCFS methodology. These include the requirement for net-negativity.	Revised rule 3.2.4., removed "sufficient".
29	Sections 3.6.2 & 3.6.3 & 3.6.4 & 3.6.5 & 3.6.6 &3.6.7 & 3.6.8 & 3.6.9	Sections 3.6.2 & 3.6.3 & 3.6.4 & 3.6.5 & 3.6.6 &3.6.7 & 3.6.8 & 3.6.9 – this is written as if the substrate is purely chemical. But if the substrate term can be broadened so that it can be biological and the sinking is based on some of the densest, native, healthy phytoplankton (not just sinking velocities) – then this would help enable companies like OUR COMPANY to be able to utilize this methodology. It would also allow a higher degree of certainty of carbon delivery – regardless of method used (so that it is not so specific to just one company).	Thank you for your comment. The scope of the proposed MCFS methodology is limited to the use of a substrate material. The methodology does not strictly require the substrate material to be chemical. Rule 3.6.1 states, that the substrate material may be eirher organis or inorganic, but in all cases, must be non-toxic and non-hazardous. Trace elements may only contribute up to 2% of the total mass of the substrate. Additionally, section 3.6. details the criteria to ensure the nutrients do not release into the surrounding water, being freely available for free-floating phytoplankton, as well as ensuring the substrates include an autonomous sinking mechanism. The substrates are used to ensure that the phytoplankton which gworn on them are not released into the surrounding water. One purpose of the substrate is to ensure the sinking of the additionally grown phytoplankton. This technique sets MCFS apart from Ocean Iron Fertilisation or microalgal ballasting, or even artificial downwelling. Given the criticality of the sinking mechanism, at this point the methodology does not include free or otherwise sinking phytoplankton. However, Puro may consider expanding the scope during future updates of the methodology.	No change.
30	3.6.2 – a	"A range of diameters or thicknesses or ..." | An important factor is the thickness of the substrate, and if we talk only about the diameter, then there are restrictions on the shape of the substrate.	Thank you for your comment. For the purposes of this methodology, certain restrictions on the shape of the substrates is necessary. This is why the eligibility criteria set limits to the diameter or geometrical face of the substrates, limiting the use of very small structure (<0.5mm) or very large ones (>100mm). This referes to any of the geometrical faces or diameters which ensures efficient sinking of the substrates.	Revised rule 3.6.2. to increase the eligible size of the substrate up to 100 mm.
31	3.6.2. – b.	"... unless special sinking weights are used." | Natural materials can be used as weights for submerging the substrate and microalgae and this will eliminate many possible negative consequences.	Thank you for your comment. The MCFS methodology does not include a requirement or a possibility to use a sinkign weight to ensure the sinking of the substrate. The substrates will need to float on the surcafe ocean to ensure enough time for the phytoplankton to grow on them, and the sinker would not allow for this extended floatation period. Instead, the substrates themselves must contain an autonomous or controlled sinking mechanism (rule 3.6.3.) to ensure that the substrates and the atatched phytoplankton sink in a controlled manner after a certain, pre-determined amount of time. The methodology sets boundary conditions for the floatation period and sinking rates, and each CO2 Removal Supplier may design their substrate material to suit the specific conditions in which they operate in.	No change
32	3.6.2. – c.	" ... unless special sinking weights are used." | Natural materials can be used as weights for submerging the substrate and microalgae and this will eliminate many possible negative consequences.	Thank you for your comment. Please also see the response above for comment no. 29. The substrate material itself must contain an autonomous sinking mechanism (rule 3.6.3.). Furthermore, the substrates cannot contain any toxic or harmful components rule 3.6.1, rule 3.6.9), which already eliminate or mitigate many potential harmful impacts.	No change
33	3.6.5.- e.	".. 100 units of substrate or at least 100 cm3 of substrate." | The amount of substrate should be correctly estimated by volume, but not by pieces.	Thank you for your comment. We have incorporated the suggestion into the text.	Rule 3.6.5.e edited: All analyses shall be performed on a minimum sample size of 100 Substrate units or at least 100 cm3 of substrate.

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34	Section 3.6	We also note that the methodology does not include details about the substrate(s) being used in a MCFS being considered for credits. While the dimensions and characteristics of substrates are noted, what are actually being released into the water is not. This ambiguity hinders the ability to assess whether eligibility requirements—particularly around lab, modeling, and mesocosm testing—are adequate and achievable with current MMRV technologies. The nature of the deployed material will have a direct bearing on carbon durability, potential environmental interactions, and, ultimately, whether the proposed intervention meets the standards required for credible crediting.	Thank you for your comment. The current version of the MCFS methodology does not consider the organis carbon possibly included in the substrate material to be considered as carbon stored. However, regardless of the substrate material used, it must comply with the requirements set in the Puro Standard General Rules and this methodology on e.g. sourcing of the materials and safety to the environment. Section 3.6. includes requirements for the substrate. The criteria is not limited to the physical composition and characteristics of the substrate, but also includes requirements on the added micronutrients and preventing their release into the water (rule 3.6.8), requirement to exclude toxic elements (rule 3.6.9) and ensuring the substrates include a sinking mechanism (rule 3.6.3). Rule 3.6.4., as well as requirements set in section 9.4. (Laboratory-based monitoring) include details on how to measure or assess the substrate quality.	No change
35	Section 3.7.1 & 3.7.4 & 3.7.5	Section 3.7.1 & 3.7.4 & 3.7.5 – If Puro expands beyond HNLC zones, the way the AOI is defined in this section may not work well for other depositional settings (especially along continental margins and/or interiors) – such as where OUR COMPANY operates	Thank you for your comment. The MCFS methodology is currently limited to HNLC to ensure distinct additionality, as well as a stable set of eligibility, safety, quantification and monitoring criteria. However, the scope may be expanded in the future updates of the methodology to incorporate additional deployment areas. Requirements would then be adjusted accordingly.	No change
36	Section 3.7.3	Section 3.7.3 - should be removed as many of the world's most efficient carbon removal localities are located within 12 miles of a coastline. This would make it impossible for OUR COMPANY to utilize this method if it is not removed.	Thank you for your comment. A key aspect of the MCFS methodology is to ensure that the removed carbon sinks to a depth suitable for durable storage of at least 200 years. For a conservative estimate, it is assumed that 100% of the carbon exported the deep ocean by an MCFS project will remain dissolved in the deep waters, entering the global deep-water circulation patterns. The durability claim is therefore assessed based on the ventilation timescales of the deep waters which the carbon enters. While there are regions with deep water within 12 nautical moles from the shore, many regions are generally shallow, and the exported carbon would not enter the water masses with a long-enough ventilation timescale.	No change
37	Section 3.7.7c	Section 3.7.7c – technically the entire ocean is impacted by humans. Recommend tightening this up to emphasize should not occur where substantial impact to carbon delivery occurs (e.g., no dredging) – but many of the areas with highest carbon export have some form of human impact (this would substantially reduce where OUR COMPANY would be able to operate).	Thank you for your comment. It is true that the majority of the oceans are impacted by human activities in one way or another. This rule, however, is speficially limiting operations at regions where human activities may have a major negative influence on the carbon storage, and includes examples of such activities. The CO2 Removal Supplier must in their project desciption identify any potential disturbances, which may include some not listed here. However, not all human activites negatively impact the safety of the storage, and therefore this rule specifically mentions "disturbances".	No change.
38	Section 3.7.9	Section 3.7.9 – this size of extent for data monitoring really only applicable to HNLC regions. Recommend revision to subdivide into smaller volumes of water in different depositional environments to be more representative of other project sites – like in deltas and where the water depth is deep enough for moderate to high carbon removal with high burial efficiencies. Points about the thermocline, etc. only in reference to HNLC regions.	Thank you for your comment. The scope of the MCFS methodology is currently limited to HNLC regions only. The decision was based on ensuring distinct additionality, as well as a stable set of eligibility, safety, quantification and monitoring criteria. However, the scope may be expanded in the future updates of the methodology.	No change
39	Section 3.7.12 & 3.8.2	Section 3.7.12 & 3.8.2 – why limit to just to modeling when in situ measurements can be taken in some regions?	Thank you for your comment. While the MCFS methodology is limited to HNLC regions, it is not meant to be applied only to a very specific region - on the contrary, the requirements are designed to ensure that any region that fulfils the eligibility criteria could be used. While for some reasons, direct measurement data is readily available and in-situ measurements are easier to conduct, this might not always be the case. Although in-situ monitoring is required during the operations (see section 9.6.), for the site characterisation and understanding the ocean dynamics within the Area of Interest or an individual sinking locations, it is essential that the CO2 Removal Supplier is able to model the expected outcomes of their deployment. The requirements in sections 3.7. and 3.8. are prequisite criteria the CO2 Removal Supplier must comply with before they can proceed to the deployment-phase. The model outputs provide the likely outcomes of a specific deployment in a specific region, and guides the operations during the deployment, fixation and sinking phases. Furthermore, the DIC-depleted plume constantly evolves during the fixation phase, and is dynamic in both temporal and spatial dimensions. In situ measurements are essential to validate the used models, but cannot accurately depict the evolving plume. Therefore, the models are utilised to assess the dynamic evolution of the substrate plume.	
40	3.7.4	"The CO2 Removal Supplier shall demonstrate that the sinking occurs in a region where deep ocean circulation will maintain that the sunken carbon will remain out of contact with the atmosphere for at least 200 years." How is this demonstrated? Can this be linked to elsewhere in the methodology where the method of demonstration out of contact for >200 years is described?	Thank you for your comment. The CO2 Removal Supplier must show that the captured carbon reaches water masses which do not have contact with the atmosphere for at least 200 years. The durability is assessed based on the deep-water ventilation timescales, and the requirements for these models are described in section 9.5. Furthermore, section 6.3 describes how to assess for carbon losses during the 200-year period. These clarifications have been added to the rule.	Rule clarified to include details on the model requirements and carbon loss assessment: Further requirements on assessing the deep-water circulation are described in section 9.5., and the assessment of the carbon losses due to deep-water ventilation are described in section 6.3.
41	3.7.5	Are thee nutrient threshold values supposed to be assessed based on an annual mean or long term climatological mean baseline? Or any particular data source? Or is this requirement just for the area immediately before the time of the activity?	Thank you for your comment. This section describes the eligibility criteria for selecting an Area of Interest and deployment and sinking sites. Initially, the CO2 Removal Supplier should characterise the region based on peer-reviewed scientific literature and/or databases. The assessment must include monthly averages from multile years, and be assessed for the relevant season of the planned operation. The initial assessment is then verified by the measurements taken at the deployment and sinking site during the baseline assessment. We have revised the rule to add more information and cross referenced the relevant rules in the methodology.	Rule revised to include further details on the assessment and the baseline verification.
42	3.7.6	"The data from scientific literature or databases shall in all cases include measured data." The meaning of this sentence is a bit unclear and I'm not sure it's a useful distinction to make. Is this saying ocean modeling or reanalysis products (e.g. GLORYS) can't be referenced for this site characterization? If a model assimilates measured data or is forced by measured data, can it be used?	Thank you for your comment. The full sentence states "When based on information obtained from databases or literature only, the assessment shall always include reanalyzed data based on direct measurements, which may be supplemented with assimilations from satellite observations and processed with numerical models." This specifically allows for the use of ocean modeling and renalysis products, but those products need in all cases be based on direct measurements or observational data. For example, models which have not been verified with observational data would not be considered eligible.	No change

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43	3.7.9	"given that the data is accessible." What if the data is not accessable/available for at least 5 consecutive years? Or is this an initial site requirement?	Thank you for your comment. This section describes the eligibility criteria for selecting an Area of Intetest and deployment and sinking sites, and therefore must be fulfilled prior to operations. The intent of this requirement is to allow for the CO2 Removal Supplier to use pre-existing data from the region to supplement in-situ measurements conducted by the Supplier. We have removed the note for "given that the data is accessible", as in any case, the data used for the site characterization must be presented by the CO2 Removal Supplier in their project description, which is verified by the Auditor. Initially it was refereincing to open-access data, which is not a strict requirements pending that the data used is sourced from relevant peer-revieved datasets or scientific publications, some of which may not be openly accessible. In those cases, the CO2 Removal Supplier must have access to that data in other means, and the data must be available for third-party auditing.	Removed "given that the data is accessible".
44	3.7.9	" The data shall include the best available spatial resolution consisting of at least 50 depth layers and portray any intra-seasonal variations at minimum on a monthly resolution". Why only spatially gridded data and at least 50 depth layers, this seems like an oddly specific requirement. This requirement largely only allows mapped/interpolated data products or reanalyses and excludes many in situ datasets (e.g. shipboard niskin bottle samples, moorings).	Thank you for your comment. To ensure extensive site characterization prior to the operations, a reanalysed database approach was selected. Each Area of Interest may be large and include multiple deployment and sinking sites. It would not be possible to only conduct field measurements from the entire AOI to sufficiently understand the site characteristics. However, section 9.6. (specifically rule 9.6.6.) includes the requirements for in-situ sampling prior to operations at each specific deployment and sinking site.	No change
45	3.7.9	General comment on this characterization, I think it's likely there are very few sites globally that can meet this full criteria, if the data here are from measurements alone. Interpolated data products or reanlyses with BGC models could, although inclusion of all the micronutrients (Fe and Mn) is rare, so I think this criteria either needs further clarification or needs to be made significantly less strict.	Thank you for your comment. This rule does not strictly require the data to be based on measurements only. The end of this requiremets states "The CO2 Removal Supplier shall assess and evaluate the above-mentioned characteristics utilizing data produced and distributed by the Copernicus Marine Service or other relevant databases and relevant peer-reviewed scientific literature. When based on information obtained from databases or literature only, the assessment shall always include reanalyzed data based on direct measurements, which may be supplemented with assimilations from satellite observations and processed with numerical models. When possible, the CO2 Removal Supplier should supplement the data with in-situ measurements. The evidence shall be made available for the Auditor and verified during the baseline characterization."	No change
46	3.7.9	"Assessment of horizontal and vertical seawater velocities maps at key depths in the water column". Note: in situ measurements of vertical velocities are very difficult to obtain, these would almost always be only available from reanalysis or derived estimates from other observations.	Thank you for your comment. You are correct, and the rule has been edited accordingly.	Rule 3.7.9.b edited: removed "vertical".
47	3.7.9	"identification of downwelling regions " how should these be identified?	Thank you for your comment. The CO2 Removal Supplier must comprehensively assess the oceanographical characteristics of the area they operate in. The physical oceanographical model for the AOI must characterize regional water mass movement, including vertical transport, which will identify whether or not the study region is a downwelling region. Water mass movement will also be validated through in situ measurements for temperature and salinity.	Subrule separated into new rule (3.7.10) and reference to AOI physical oceanographic model added
48	3.7.9	"processed with numerical models" Does this imply only explicit data assimilation (e.g. 4Dvar) within models? Vs models forced with boundary/initial conditions from in situ data, or validated against in situ data. I think clarification is needed.	Thank you for your comment. To clarify the application of the numerical models, the subrules in 3.7.9 regarding numerical model products have been separated into its own rule, now 3.7.10. References to the specific numerical models have been added and detailed in Section 9.5.	Subrule separated into new rule (3.7.10) and references to the AOI physical oceanographic model and global ventilation model added
49	3.7.11	Similar to previous comment, what does 'ample' mean here? This is not scientifically actionable for the Auditor	Thank you for the comment. Please also see the response for comment no. 28. This section describes the eligibility criteria for the Area of Interest and the deployment and sinking sites. As discussed in the response for comment no. 25, the methodology does not set a lower boundary for an eligible air-sea gas exchange flux. The CO2 Removal Suppliers can only claim credit for removals that are modeled to be replaced from the atmosphere within 10 years. This is described in section 6.1.9. While this is not a strict eligibility criterion, the need to fully account for air-sea gas exchange will limit the areas where it is practical and efficient to operate. For clarification, we have revised the rule.	Revised rule 3.7.12. (numbering has changed: "The CO2 Removal Supplier shall demonstrate that the project activity takes place in an area where ocean circulation patterns enable the carbon-depleted surface waters to remain at the surface and in contact with the atmosphere for long enough to allow for sufficient air-sea gas exchange prior to downwelling of the surface water masses to ensure net-negativity."
50	3.8.1.- a.	"... or retained below the surface of the water without sinking." | On the surface is a misnomer which suggests that the substrate floats and is partly in water and partly in air, which reduces the effectiveness of the method.	Thank you for your comment. We have revised the text to clarify, that the substrates are floating on the near-surface ocean waters, not directly on the surface.	Clarified the text: "Duration of the period when the Substrate floats in the near-surface ocean water."
51	3.8.2. – a.	"... unless methods are used to retain the substrate and limit dispersion." | Example: The substrate can be strung like beads on a thread.	Thank you for your comment. Limiting dispersion of the substrates may potentially be beneficial to monitor the substrate bloom during the fixation period, but may pose issues when they sink to the seafloor. For example, the piling of the substrates on the seafloor could induce anoxia, which is a considered a major negative environmental impact. To ensure that the approach minimises or mitigates this, the substrates should instead disperse into wider areas, allowing the oxygen exchange at the water-sediment interface.	No change.

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52	4.2.2., 9.8.1., 9.8.2.	Public engagement expectations: it is not clear how these expectations will be defined or accomplished for open ocean interventions with long durations and far-reaching impacts. In Section 9.8, the ongoing feedback and grievance mechanism is very helpful. For communities impacted by open ocean interventions, a portfolio approach could help projects engage with stakeholders who do not have access to a computer, like adding an in-person town hall or regular meetings that review the grievances and feedback.	Thank you for your comment. The core requirements for stakeholder engagement are common across all methodologies, and are set in the Puro Standard General rules and Puro Stakeholder Engagement Requirements. All CO2 Removal Suppliers operating under any of Puro Standard methodology must also comply with these requirements as well as all other Puro Standard requirements. For further information on the stakeholder engagement requirements, see the Puro Standard Stakeholder Engagament Requirements as well as the Stakeholder Engagement Report (both available at the Puro Standard document library). These documents are also referred to in the methodology, e.g. in rule 4.2.2. a, rule 9.8.1 and rule 9.8.2 b. Section 2 of the Puro Standard Stakeholder Requirements includes criteria which the CO2 Removal Supplier must comply with, describing the relevant stakeholders, planned and executed communication strategies, the issues raised and how the Supplier resolves the those issues. It addresses the need to ensure that stakeholders without e.g. internet access are considered when sending invitations, and which groups to at least include in the consultation. The criteria does not explicitly require a certain approach for communications, and indeed the the Supplier must consider relevant communications approaches for the potentially diverse groups of stakeholders. In the Stakeholder Engagament Report template, we ask the Supplier to specifically identify all potential stakeholders, and list the various stakeholder consultation activities and the feedback received. This includes, but is not limited to the ongoing grievance mechanism. The CO2 Removal Suppliers must report the applicable stakeholder engagement measures for each Audit, even if there has been no feedback since the last report.	No change
53	4.3.1	Explain what actions are taken after assessment if it has been determined there is a high risk of reversal	Thank you for your comment. The reversal risks shall be assessed based on the requirements described in section 4.2., which is referenced in rule 4.3.1. The CO2 Removal Supplier shall use the risk matrix provided to assess th eseverity and likelihood of each risk. If the risk is at an undesirable or untolerable level (see rule 4.2.2), the CO2 Removal Supplier must either eliminate the risk or reduce the risk to a safe and acceptable level. If elimination or reduction of the risk is not possible, the project is not eligible for the issuance or CORCs.	No change.
54	Section 4.3	Section 4.3 – why limit to just the deep ocean? Why not continental shelves, etc.? And, if the method expands monitoring to include in situ direct measurements, a lot of the reversal risk will become much better constrained and known. Without direct measurements, 'reversal' is a big unknown.	Thank you for your comment. The MCFS is limited to deep ocean sites due to permanence. Elibigle deep ocean sites provide conditions (long ventilation time frames) that allow for a 200-year durability of carbon dioxide removal. The proposed MCFS methodology focuses on exporting the organic matter into deep water masses, rather than sediment burial. Even though some of the deployed substrates and attached microalgae will end up in the sediments, there is no accurate way to quantify this fraction. Additionally, the organic matter is generally remineralized within a short time frame, and the objective is therefore to ensure that the organic material reaches a water mass which has a ventilation period of at least 200 years. The CO2 Removal Supplier must evaluate the deep-water trajectory and estimate the ventilation time as described in section 3.7. Regarding the reversal risk and measurements: Due to ocean dynamics, direct measurements do not adequately capture the resolution and 4D evolution of the deep water masses in which the carbon is stored. This can be achieved by modelling approaches which are supported by direct measurements used for model supplement and calibration.	No change
55	Section 4.4.5	Section 4.4.5 – shouldn't be just harmful chemicals but also harmful algae.	Thank you for your comment. Harmful algal blooms are considered one of the key environmental risks, which must be accounted for as addressed in section 4.5. The referenced rule addresses environmental, health and safety issues for which harmful algae are not relevant.	No change.
56	4.5.	"... provided there is no current." | In places where there is a current there can be no EXHAUSTION.	Thank you for the comment. Unfortunately, the information and context provided in the comment are insufficient to clearly identify the section of text which the comment addresses.	No change
57	Section 4.5	Section 4.5 is well written and thorough	Thank you for the supportive feedback.	No change
58	Section 4.5.2	Section 4.5.2 – can be supplemented with direct in situ measurements. Does not need to be only calculation-based.	Thank you for your comment. We added a subrule that allows for a measurement approach as an alternative to the modeling approach.	Added subrule 4.5.2(a) which allows for measurement instead of modeling of phytoplankton growth rater after deployment.
59	Section 4.5.6	Section 4.5.6 – many depositional environments can measure DO directly, does not need to be so poorly constrained. This calculation in my mind is overly simplified and likely won't be directly related to actual DO concentrations, even in the deep ocean.	In the deep ocean depositional scenario that this methodology is focused on, we would argue that the box model required by rule 4.5.6. to assess bottom-water oxygen depletion along with the vertical DO sensor profile measurements required pre- and post-deployment (see section 9.6.) is appropriate and the focus on modeling may even have advantages over more emphasis on direct measurements. First, the model is based on bottom-water oxygen measurements (subrule a). Second, the model's organic-matter component is informed by output from the Lagrangian model (subrule d), which implies that the most appropriate location (i.e., where most substrate reaches the bottom water) can be modeled; it is not realistic to expect that a near-optimum location for oxygen measurements could be determined in real time. Note that vertical profiles (including deep water) of dissolved oxygen concentration measurements are required at all stages of deployment (table 9.3); this is now explicitly mentioned also in chapter 4.5. (rule 4.5.6.).	Cross-reference to the direct measurements required (table 9.3.) added to the rule to clarify the requirement for in-situ measurements for the full water column.
60	p. 53	Table 4.2. What thresholds of decreased macronutrients would constitute a significant nutrient robbing risk here? What level of nutrient depletion would 'inform reasonable substrate application rates'? This isn't clearly actionable or auditable without establishing specific thresholds based on existing literature or project research prior to deployment.	Thank you for this comment. We agree that nutrient robbing is an important and difficult topic. Table 4.2. merely provides an overview of the rules that are part of section 4.5., which constitute the actionable and auditable items. Specifically, the relevant actionable/auditable thresholds for this are defined in rule 4.5.1. (local nutrient depletion) with the intra-seasonal minimum used as a locally relevant limit. Indeed, this does assume a level of pre-deployment research either done by the supplier or available in public sources (scientific literature, public monitoring programs), as required by the eligibility criteria (section 3.7).	No change

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61	p. 53	Table 4.2. "Potential adsorption of seawater anions, especially phosphate, to metal oxides in the substrate, possibly contributing to phosphate removal from ocean surface water." Is there any existing data/references indicating the risk of this? Or can lab data be collected in advance of deployment to develop clear thresholds for monitoring?	Thanks for this comment. In our assessment, the potential for anion adsorption - while likely small compared to biological uptake of e.g., phosphate - is difficult to generalize based on existing scientific knowledge and data. This partially due to the proprietory nature of the Substrate but even more so because the inorganic nutrients loaded onto the Substrate can change from deployment to deployment depending on the locally limiting nutrient(s). Geochemical modeling or experiments can be used, however, to determine the sorption properties of each Substrate "recipe" and we now added a rule recommending such assessments to inform operational decisions and understand the importance of the non-biological component of anion drawdown which, again, is likely small.	Added rule 4.5.11 recommending geochemical modeling or experimentation to characterize the potential of phosphate (and other anion) sorption to the Substrate.
62	4.5.1	"avoids local reduction of macronutrients below levels exceeding AOI intra-seasonal variability". How Is intra-seasonal variability defined? 'Intra-seasonal' just means sub-seasonal so it's not clear what timescale is relevant for this minimum.	We added a footnote to the document to define intra-seasonal variations: 'Intra-seasonal variability' across this document refers to the variability within the relevant season of operation (e.g., October to December for southern-hemisphere spring season) as determined by measurements over several years during this season.	Footnote added to define "intra-seasonal variability"
63	4.5.2	"using the Redfield ratio (C:N:P = 106:16:1)". Can regionally varying Redfield ratio be used rather than the standard global value?	Thank you for this useful remark. We added a footnote that allows the use of regional Redfield ratios.	Footnote allowing regional Redfield Ratio to be used was added to rule 4.5.2
64	Figure 5.1	In the equation it doesn't appear that the crucial second step air-sea CO2 uptake is taken into account, C_stored is defined as gross amount stored Bia increased carbon fixation and sinking efficiency. Does this appear in C_stored or C_loss? I know these are defined in more detail later but I think it's notably absent from the description here.	Thank you for the comment. Section 5 introduces the overall CORC equation, and the individual components of each of the variables in the main equation are further described in sections 6, 7 and 8. The air-asea gas exchange is included in the term C_stored, and those requirements can be found in section 6.1.	No change
65	Section 6.1	The quantification of fixed carbon does not accurately account for the potential variability of sinking times of the substrates. In its current form, it is based on the assumption that all substrates sink simultaneusly.	Thank you for your feedback. We agree, and have revised the method for quantifying the fixed carbon. The revised equation now takes into account the variability of the sinking times as well as the accumulation of organic carbon. The requirements for assessing the sinking variability have also been revised (section 9.6.).	The equation for C_fixed revised to account for variability in the sinking time and carbon accumulation.
66	6.1.7	The integration for the sinking efficiency does not yield the correct units and includes two depth variables. The limits of integration over depth should only apply to the remineralization rate and not over the full exponential term.	The previously written sinking efficiency equation integrated over the wrong equation. The sinking efficiency equation has been corrected to reflect the ratio of carbon flux that makes it to the appropriate depth horizon (z_n) relative to the carbon flux out of the euphotic zone. The equation has been updated as a discretized summation because this more closely reflects the project implementation.	Changed the integration of the sinking efficiency equation.
67	6.1.9	"Global ocean models are necessary for quantifying AS ". Global models aren't actually necessary. Only models that cover the region where equilibration takes place (which is typically basin scale but not always this large). And theoretically a project could use a model with a domain that does not capture all of the potential equilibration, and just use a lower efficiency value.	Thank you for your comment. Although it is possible to use regional models to quantify the equilibriation timescales of air-sea gas exchange, we use a 10 year horizon to account for the temporal variability in equilibration timescales that arise from basin to basin. To simplify the complexity associated with modeling air-sea gas exchange for both the CO2 removal supplier as well as for the auditor, we require the use of the Direct Ocean Capture (DOR) tool from Zhou et al. 2025 which can be accessed online from CarbonPlan. It is possible that in the future this requirement for the DOR tool will be adjusted as more tools to quantify air-sea gas exchange come online.	No change
68	6.1.9	Remark on the air-sea gas exchange: in addition to the large uncertainty associated with coarse resolution and lack of inter annual variability, the application of the DIC perturbation over a large geographic polygon, vs a specific site point location, also has a substantial impact on the efficiency as the deficit is distributed over a region with varied circulation and mixing processes that can affect subduction and air-sea gas exchange timescales.	Thank you for the comment. We undertand this concern and have considered the effects of this requirement. As mentioned in the remark box, we understand the limitations and caveats the use of the DOR framework developd by [C]Worthy and CarbonPlan introduces. Regardless, we consider the framework to be the best possible solutition to ensure robust assessment of the air-sea gas exchange for any project seeking to issue CORCs under the MCFS methodology. Rapid advances are under way to improve our understanding of the air-sea gas exchange and the regional variabilities, but to date, there is no approach which would better suit the need to be able to assess the uptake efficiency using a third-party, open access framework with a conservative-enough approach. We support the development of other approaches and are willing consider expanding the options for air-sea gas exhange assessment when the methodology is updated. Such new approaches would need to be based on peer-reviewed, widely-accepted scientific frameworks and may potentially allow for a higher resolution spatial resolution in the future. Large-scale biogeochemical models are also resource and time intensive, and therefore, instead of requiring each CO2 Removal Supplier to build such a model for each individidual deployment site or Area of Interest would likely not be feasible. Puro is open to discuss other options for assessing the air-sea gas exchange and consider changing or modifying the requirements when the methodology is updated in the future.	No change
69	6.1.9	Even though I appreciate the remark on caveats on the air-sea gas exchange, I think the inclusion of the DOR efficiency tool is premature. Given the level of detail and rigor in measurements/monitoring required for other aspects of the methodology, I think it is reasonable to expect a similar level for AS gas exchange. Without clear quantification of the systemic uncertainties from this model estimate (e.g. due to unresolved mixing processes, broad application of DIC perturbation at the surface not realistic etc), I think it's reasonable to require projects to run experiments specifically for their project site to quantify AS at this stage. This would be in line with other community developed methodologies for other mCDR pathways (e.g. the Isometric OAE from coastal outfalls protocol), which all have the air-sea CO2 uptake component in common.	Thank you for the comment. Please also see the response above for comment no. 61. We understand that the DOR framework has limitations and caveats when applied to the MCFS approach, as it was not specifically designed to be used for such a purpose. However, the possibility for the CO2 Removal Supplier to determine their own experiment to conduct measurements and model approaches for the air-sea gas exchange flux may also prove to be problematic, as without a clear framework, the approaches selected by different projects would not be comparable. Additionally, measuring the parameters required for air-sea gas exchange efficiency is very difficult on smaller scale deployments, and overall, direct measurements are not straightforward. However, we are open to discuss other options to assess the air-sea gas exchnage efficiency and consider changing or modifying the requirements when the methodology is updated.	No change

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70	6.2.8	"local dynamics models". This is vague, and needs to be clarified more. In fact 'oceanographic models', 'global models' and similar phrases are mentioned at various points but it's important that these are defined. I think what is being referred to in these cases are circulation models that discretize the equations of motion on a three-dimensional grid (with or without biogeochemistry depending on the application), and not simplified 1-D mixing models or advection-diffusion models etc, but in some cases (like assessing the deep ocean storage >200 years) may be referring to inverse box models of the ocean circulation. I think it's worth defining these terms clearly in all cases.	Thank you for your comment. The language in section 6.2.8 has been revised to include a more explicit connection to the environmental risks section 4.5.1 and 4.5.2 which outline the requirements for quantifying the risk of changes in nutrients. Additional requirements for an inverse circulation model or other appropriate 3D global circulation model have also been added.	Specification of "The CO2 Removal Supplier may use an inverse circulation model such as the model presented in DeVries and Holtzer et al. 2019 or any other peer reviewed model which can accurately resolve 3D global circulation to identify this watermass connectivity." was added.A connection to environmental risks section 4.5.1 and 4.5.2 was also added.
71	Section 6.2	Quantification and monitoring - The monitoring requirements for MCFS span significant spatial, vertical, and temporal scales. While important progress is being made, further work is needed to improve the accuracy and reliability of carbon export flux measurements and pCO_2 deficit assessments. With regards to Section 6.2, we support comparing satellite data to baseline measurements (like those from the Argo fleets). Using satellite data alone to estimate Net Primary Productivity will risk under-estimation due to the coarseness of satellite data.	Thank you for your comment. Additional language has been added to section 6.2.6 which requires the validation of satallite estimates of transport efficiency (TE) with field measurements, validated models, or published and peer reviewed datasets. Section 9.5 regarding the use of various models to aid the carbon quantification and monitoring has been restructured to provide clarity and details for each of the models presented in the methodology. Model details such as its purpose, model specs (e.g. resolution, represented processes), forcing data products, model outputs, and validation requirements have been added as needed. Nevertheless, no model is perfect. Model requirements shall be updated as the science evolves. And wherever possible, real-time in-situ measurements are required, especially in quantifying the carbon export flux.	Rule 6.2.6. revised to explicitly require validation of the estimated transfer efficiency by field measurements, datasets or validated models.
72	6.3.4	These are largely commercial modeling softwares that are suggested here for 'far-field' modeling, there are many other open source model software tools that can do this (Oceanigans, ROMS, MITgcm etc). When 'within kilometers' of the deployment site is mentioned, it would be very helpful to indicate what kind of resolution (or at least representation of what processes) is expected here, and how large a domain. As written this is a heavy lift for a project but without much clear guidance on requirements, and also not easily auditable.	Thank you for your comment. This rule was edited and additional far-field modeling requirement for assessing ocean ventilation was removed. Instead, the particle dispersion model will be used to assess the bounds of the subtrate deposition as this is already a requirement to inform other areas of monitoring and verification. The particle dispersion model shall be forced with transport operators from a mesoscale physical oceanographic model, which does not have specific modeling software requirements.	Rule revised: reference to far-field modeling sofware removed and replaced with reference to particle tracking model.
73	7.4.4e	Section 7.4.4e – variables appear to be for on land and not in the marine environment (see table). Do these need to be changed to be in the marine realm?	Thank you for your feedback. Project emissions take into consideration emissions across the whole Activity Boundary of a specific MCFS project. While the deployment and carbon storage of the MCFS approach occur in the ocean, an MCFS project may also include operations on land, for example, for the substrate manufacturing and processing stages. For example, suppose the CO2 Removal Supplier builds a new manufacturing facility. In that case, they will then need to assess whether the land on which the facility was built was previously used for agricultural or forestry purposes for construction. Rule 7.4.4. states the requirements in those cases, accounting for the direct land-use conversion (dLUC). Therefore, the variables are correct.	No change
74	p.101	Local environmental regulations vary significantly in rigour. Defined Puro.earth regulations for MRV protocols would strengthen the durability and reliability of these carbon removals.	Thank you for your feedback. Section 9.1. provides a general introduction to the monitoring requirements, which are further defined in the following subsections. For many of the parameters that require monitoring, a consensus already exists for applicable and reliable protocols. In case there is a specific protocol required, we have provided more details in the methodology (e.g. rule 9.4.3. for substrate testing). For some parameters, there are multiple eligible and reliable protocols; in such cases, the CO2 Removal Supplier must justify the use of a specific protocol for a given parameter. All protocols must be selected based on established scientific protocols, described in internationally recognised global ocean observing programs or other applicable peer-reviewed scientific publications (see rule 9.6.4). The selected protocols and methods will be evaluated and approved by the independent third-party Auditor. In addition to the requirements listed in the methodology, robust environmental regulations are necessary for a successful MCFS deployment. Many of the requirements set in the methodology may also be required for the environmental permit, while some may not. Conversely, local environmental authorities may require specific analyses that the Puro Standard does not. In those cases, the CO2 Removal Supplier must always comply with the stricter requirement. As science evolves, we will update the methodology accordingly, which may include edits to the monitoring requirements as well.	No change
75	Section 9.2	Section 9.2 – monitoring plan as written makes sense.	Thank you for the supportive feedback.	No change
76	Table 9.2	"Surface water retention time" and "Deep water trajectory". These aren't standardized oceanographic parameters, how should this be calculated?	Thank you for your comment. These parameters are determined based on the model outputs, which are described in section 9.5. To clarify this, the information has been added to the description of the purpose for these parameters in table 9.2.	Added "based on the modeled outputs following the requirements determined in section 9.5." to the purpose column for the two parameters.
77	Table 9.2	Might be useful to include a column for units in this table if it's possible	Thank you for your comment. We added a column for the units in Table 9.2.	Column "Unit" added to table 9.2., adding unit information for each parameter.

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78	Section 9.4	Entirety of Section 9.4 is overly tied to Gigablue specific substrate – other phytoplankton biomass sinking companies will not be able to utilize any of this. Many of these calculations to be done in a lab are not at all related to the natural environment and in my opinion are highly controversial. Measurements should instead be performed in the natural world/environment to ensure sinking and removal is actually taking place – instead of a model and are in measurements that are not representative of the world we live in.	Thank you for your feedback. The current version of the MCFS methodology requires the use of a substrate material, on which the phytoplankton grows. One purpose of the substrate is to ensure the rapid and efficient sinking of the additionally grown phytoplankton. This technique sets MCFS apart from OIF or microalgal ballasting, or even artificial downwelling. Given the criticality of the sinking mechanism, at this point the methodology does not include free or otherwise sinking phytoplankton. Section 9.4. includes the necessary requirements for laboratory testing and section 9.5. for modeling, both of which include requirements on assessing the substrate material prior to deployment. The laboratory experiments and model outputs are used to initially assess the potential outcomes of the field deployments, and field sampling is used to both verify the laboratory results as described in requirements for the field sampling in section 9.6. For the purposes of carbon quantification, in-situ sampling and measurements are required in all cases. The parameters measured in laboratory setting serve two purposes: prividing a baseline (as blank) for the in-situ measurements and provide the statistical variance of the pristine substrates introduced to the ocean. During the operations, the CO2 Removal must collect samples of the free-floating substrates. We have revised section 9.6. to include more robust requirements for controlled platform deployments, which will serve to monitor the sinking variability and may in certain cases be used for measuerement of organic carbon accumulation on the substrates. The use of these platforms allows for increased understanding of the substrate performance in the open ocean conditions.	No change
79	Section 9.5	Section 9.5 – although parameters outlined in this section make sense, the uncertainty of the modeling is not well constrained – the 95% CI as to how much carbon actually gets removed may end up being far different than the modeling outcome of any approach using this exact modeling approach.	Thank you for your comment. We understand that there are several possible modelling approaches described in this section. However, these models serve to account for the components of the CORC equation (5.1). Consequently, the methodology requires the CO2 Removal Supplier to select modelling approaches that meet the particular requirements, of e.g. carbon capture or carbon loss, follow the data collection reporting procedures outlined in Section 10.2, and determine the corresponding measurement uncertainty of the parameter based on the data source (measured, estimated, or calculated). This provides the basis for calculating the uncertainty of measurement of the model (if not already provided by peer-reviewed literature for parameters or the model). Following these steps, it should be possible to constrain potential sources of uncertainty. However, addional language has been added to the local models outlined in section 9.5 which explicitly requires the validation of local models with in situ sampling taken during the deployment.	Language added strenghtening the requirement for the validation of models with in situ sampling taken during the substrate deployment. Requirements on the platform deployments added to section 9.6.
80	Section 9.5	Modeling - there are big challenges with effective modeling of impacts, particularly beyond the immediate intervention site. For example, does the Lagrangian model consider how particle speed may change as it sinks through the water column? Chajwa et al. (2024) showed how accumulating mucus on marine snow slows the rate at which particles sink, which could risk under-estimation of sinking speed if it's not considered by traditional models. Is this being addressed, and how? It relates to other sections (e.g., 5, 9) when it comes to quantification and modeling. This could be addressed in pre-deployment modeling exercises for simulating substrate trajectory during the export phase so that there is a simulation of how phytoplankton recruitment and substrate mass sinks and any changes in sinking speed across time and depth, but the language is not clear.	Thank you for your comment. Although we expect that due to the minimum sinking speed threshold of 20 m/hr there will be minimal accumulation of mucus upon the sinking substrate, we require in field sinking speed measurements to validate this. The in-situ sinking rate shall be calculated from the acoustic signal of the sinking Substrates detected by echosounders or tracking the sinking particles with ROV or equivalent validated scientific equipment available at the time of operation, pending approval by the Issuing Body (rules 9.6.14 and 9.6.15). Additionally, the Lagrangian model outlined in section 9.5. is designed to simulate the release and behavior of the sinking particles which can further be used to understand any impacts that changes in sinking speed might have upon fraction of carbon that is sequestred below the 200 years threshold.	Section 9.6. revised to include further details on the assessment of sinking rates.
81	9.5.1	High resolution' is arbitrary, clearer definitions of resolution, or if not resolution processes that need to be resolved in different situations (e.g. tides, turbulent mixing, first Rossby radius of deformation….)	Thank you for your feedback. A table has been added to section 9.5 which details the applicable processes that need to be resolved for each model. Additionally, section 9.5 has been restructured to include details of the purpose of each model in order to further clarify how the resolution requirements might vary from model to model. This rule was removed from the "General Modeling Principles" and incorporated into the model specific subrules below.	Table 9.3. added to clarify the details of each applicable model. Section 9.5. restructured to include clarity on requirements for specific models, dividing between local and global scale.
82	9.5.2	I think this is saying that the model outputs need to validated with comparison to observations using datasets (with Copernicus as an example). The working of this is unclear, and there needs to be some guidance on model validation requirements (or at minimum some references to examples in publications). Otherwise it's very difficult for a third party to verify this if there aren't any clear requirements or criteria.	Thank you for your feedback. We have restructured Section 9.5 so that any specifications for model validation, as needed, is now detailed for each type of model that is presented in this methodology. This rule was subsequently removed from the "General Modeling Principles".	Section 9.5 restructured and rules under "General Model Principles" edited and moved to fit specifc model requirements.
83	9.5.4	I think this is indicating that all models need to be run as forecasts? This isn't really practical in most cases, it's somewhat rare for large scale ocean only models to be run in forecast modes, and not necessary for nearfield/regional high resolution modeling of a site (an ensemble of handcarts to capture inter annual variability is sufficient). More guidance needed here.	Thank you for your feedback. We agree that this rule was unclear and should not apply to all models equally. We have restructured Section 9.5 such that each model presented in this methodology is given a numbered rule, and applicable rules under "General Model Principles" have been edited and moved to fit the specific requirements for each model. This rule was subsequently removed from the "General Modeling Principles".	Section 9.5 restructured. Rule was removed from "General Model Principles". Rule was edited and added as subrules to fit specifc model requirements.
84	9.5.6	What about atmospheric forcing and boundary condition/initial condition datasets? Realistically these are all typically from gridded data products/reanalyses (e.g. atmospheric reanalysis products determined from satellite winds), and in situ measurements are limited to certain input forcing (e.g. river fluxes, DIC forcing), or direct data assimilation (however using data assimilative models for all circumstances is challenging given their cost and are not available for all circumstances).	Thank you for your feedback. This rule was too generalized. Section 9.5 has been restructured and details regarding the appropriate datasets for model forcing, data assimilation, and model validation for each model is provided individually as needed. This rule was subsequently removed from the "General Modeling Principles".	Section 9.5 restructured. Rule was removed from "General Model Principles". Rule was edited and added as subrules to fit specifc model requirements.
85	9.5.7	The open source requirement conflicts with earlier suggestion to use proprietary models such as Delft3D. " Any computer code and datasets behind the simulation shall, to the extent possible, also be available in repositories." This could be further clarified. Does this mean all the model configuration and specific experiment code? Also analysis of the outputs? Pre-processing of forcing data etc?	Thank you for your feedback. We have clarified the rule to indicate that all details of the model simulation required for reproducibility and evaluation of simulation results shall be provided to the auditor. Due to the restructuring in Section 9.5, this rule now appears as 9.5.1.	Edited rule 9.5.7 (now 9.5.1) for clarity.

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86	9.5.9	This says just a physical oceanographic model is required, but interaction of sinking material with the circulation/vertical transport involves particle dynamics, and typically a BGC model or particle model would be coupled. It should be clarified which tracers/processes are required for this model, and what scales of physical processes should be represented (none are defined here), so that this is actionable and auditable.	Thank you for your feedback. Additional details regarding model forcing datasets, represented processes, outputs, validation, and spatial and temporal resolution has been added. Due to the restructuring in Section 9.5, this rule now appears as 9.5.4.	Details added to rule 9.5.9 (now 9.5.4)
87	9.5.11	It is unclear in what context the regional and global models would be coupled. 6.3.5 is referenced here but that rule doesn't exist. The models referenced in the tire sea gas exchange and permanence rules are outputs from the models, and in fact derived mapped data products that were determined from those model outputs. Actually running those models with coupling isn't really the intention of those model products/model set ups and is not necessarily practical/feasible for projects without direct collaboration with the developers of those models.	Thank you for your comment. The rule number was referenced incorrectly here. It should have been rule 6.3.4. Further, upon further examination of the modeling requirements for ocean ventilation and air-sea gas exchange, we agree that this rule is not applicable in this context. Because our motivation for prescribing the use of specific model products for ocean ventilation and air-sea gas exchange is to set a standard metric across all MCFS projects, it would not make sense to have the project developers re-run the prescribed models with various regional models. This rule has been removed.	Remove rule 9.5.11 and restructure modeling section. Ocean ventilation and air-sea gas exchange models now appear under "Global-scale models" as 9.5.8 and 9.5.9.
88	9.5.11	" taking care to properly adjust the regional model output resolution to match the global model resolution to limit discontinuities across the two models". It's unclear what this means. Unless the two model grid resolutions and vertical gridding are actually the same (which is very unlikely the case because the global models are practically run at much lower resolution), then there will be some level of implicit upscaling as the input to the global model can only be applied at the grid resolution. I think what would be helpful to clarify here, is that the vertical profile of output from the regional model should be preserved as inputs to the global model as much as is possible.	Please see the response to comment no 78 above.	Remove rule 9.5.11 and restructure modeling section. Ocean ventilation and air-sea gas exchange models now appear under "Global-scale models" as 9.5.8 and 9.5.9.
89	9.5.12	Without clearer guidance here on minimum requirements for parameters modeled, possibly a minimum resolution requirement, or at the very least a description of which processes should be represented, it's very difficult for an independent third party to verify this, and risks being very subjective depending on who the verifier is.	Thank you for your feedback. In order to improve clarity, section 9.5 has been restructured into two sections, local models and global models, with explicit directions for the purpose of each model. The section now includes the details of the purpose of each model in order to further clarify how th resolution requirements might vary from model to model, with clearer connections between each required model and its purpose. Additional language has also been added to clarify the processes that each model must include. Finally, table 9.3. has been added, detailing the applicable processes that need to be resolved for each model.	Table 9.3. added to clarify the details of each applicable model. Section 9.5. restructured to include clarity on requirements for specific models, dividing between local and global scale.
90	9.5.13	Is this referring to the earlier Nowicki et al. 2024 dataset specifically? Or any peer reviewed data on durability/deep sea circulation/residence times.	Thank you for your comment on the use of Nowicki et al. 2024 to calculate durability. Currently this methodology requires the specific use of the Nowicki et al. 2024 data set for the quntification of durability due to its coupled assessment of air-sea gas exchange, carbonate chemistry, and large scale circulation patterns. In the future the methodology may be updated to include a wider range of peer review work on the topic to reflect the evolving state of the field.	Explicit reference to Nowicki et al. 2024 dataset for determing durability added and consolidated into rule 9.5.8 under "Global-scale models" subsection
91	9.5.14	"The model shall integrate both hindcast and forecast oceanographic data and include physical forcing parameters such as currents, wind, and surface waves, based on validated data products (e.g., Copernicus Marine Service or equivalent)". Is it possible to be more specific here of which processes need to be represented? e.g. stokes drift, or windage?	Thank you for your comment. More details have been added regarding how the offline particle tracking model is forced. Modeled data products of horizontal and vertical current velocities and surface wave parameters from the physical oceanographic model (described in 9.5.4) and wind products from validated data products shall be used. The processes represented in the physical oceanographic model are further detailed in rule 9.5.4 and explicitly linked to the particle tracking model. Note that the rule referenced here has changed to rule 9.5.5 after section 9.5 was restructured.	Details added to rule 9.5.14 (now 9.5.5) and direct reference to physical oceanographi model added for clarity.
92	9.5.14	"The model shall couple physical oceanographic models with Lagrangian particle tracking to simulate three-dimensional transport, dispersion, and vertical settling of the substrate." Does the term 'coupling' here imply that the particle tracking needs to be done online in the model? Or is offline particle tracking software (e.g. Parcels) applicable here using model velocity outputs or velocity reanalysis/data products? And at what temporal and spatial frequency should the velocity fields used for the particle tracking be?	Thank you for your feedback. We agree that this was unclear. The language in this rule has been clarified to state that particle tracking will be done offline. The particle tracking model will be forced by the physical oceanographic model velocity fields, and thus the spatial and temporal resolution shall depend on that of the physical oceanographic model (detailed in rule 9.5.4). Note that the rule referenced here has changed to rule 9.5.5 after section 9.5 was restructured.	Clarified language in rule 9.5.14 (now 9.5.5).
93	9.5.14	It's not clear from this description if a 3-dimensional ocean circulation model needs to be used for this or not. I think there is a fair argument that because the particles are buoyant and if the sinking is very rapid (which it is required to be), that using 2-D surface velocity field data (e.g. satellite-derived or from a model output like HYCOM) would be sufficient to represent the dispersal, likely with the inclusion of windage and stokes drift. In this case, high resolution regional and global velocity data products are available that could be use to advect particles offline, and a separate physical model does not need to be run. It really needs to be clarified if a regional circulation model is required to be run for this or not (and just particle tracking with existing velocity fields instead).	Thank you for your feedback. The particle tracking model is run offline using the 3D current velocities taken from the AOI physical oceanographic model. Therefore, the particle tracking model will also be a 3D model, but no additional circulation models will be required. This has been clarified. Note that the rule referenced here has changed to rule 9.5.5 after section 9.5 was restructured.	Clarified language and added explicit link to the AOI physical oceanographic model in rule 9.5.14 (now 9.5.5).
94	9.5.16	There are many formulations for biogeochemical models, and NPZD is just one framework, and doesn't inherently include carbonate chemistry (although 'DIC-POC-N-P mass balance module' is mentioned, I really can't interpret what this is referring to (is it a specific model)? It would be helpful here to instead have a minimum set of parameters that should ideally be represented, and mention some specific biogeochemical models. Also, these biogeochemical models are in most cases run coupled to a circulation model, it sounds here like this is suggesting a simple 1D mixing layer NPZD model, but its unclear if this should be coupled to physics or the mixing layer, density etc is just prescribed. A 1D NPZD model like this is not 'standard' or standardized in any way, so the most useful thing here would be to include a reference or some example models.	Thank you for your feedback. We agree that not only would an NPZD model be inappropriate for the application of undersating local dynamics related to biogeochemical processes within the area of interest, the current modeling procedures would be insufficent to validate an NPZD model. To better support the goal of understanding the biogeochemistry at the site of substrate deployment, we have removed the specific requirement for an NPZD model. Site biogeochemical characterization is conducted through in-situ measurements and historical records using published data products.	The requirement for an NPZD model was removed.
95	9.5.16	"The model shall incorporate biogeochemistry of the applicable micronutrients, reflecting the best scientific understanding of the influence of micronutrient cycling to local productivity." Can you be specific about which micronutrients? NPZD models don't typically include micronutrients, complex biogeochemical/ecosystem models like PISCES, MARBL, COBALT etc, and typically only iron (although Pisces can now include Cu, Zn, Co and Mn).	Please see response to comment 85.	Requirements on NPZD model removed.

Comment no.	Rule or section	Comment	Response	Action
96	9.6.4	Is there an order of preference for use of these protocols or is it the choice of the CO2 removal supplier? This should be explained.	The CO2 Removal Supplier must describe and justify each protocol used in their project description, and the selected approaches are verified by an independent third party auditor. For many of the parameters, multiple applicable protocols exist, some of which may suit a specific situation or analysis better than others. Puro may also request a Supplier to use another protocol, in case one selected by the Supplier is deemed unsuitable, as stated in rule 9.6.4.	No change
97	Section 9.6	Section 9.6 for in situ measurements can definitely be expanded upon greatly as the entirety of the water column can be measured (not just surficial conditions at the point of sinking). In fact, without measuring at deeper depths, a lot of the preservation of the phytoplankton will be unknown or poorly constrained. Just having the input prior to sinking will give overall higher carbon estimates than what monitoring deeper in the column will provide. Then, in settings in which muds or underlying sediments can be taken, even better constrained carbon fluxes can be directly measured.	Thank you for the comment. Parameters such as temperature, salinity, DO, turbidity, inorganic macronutrients, carbonate system parameters (DIC, TA and/or pH), microphytoplankton abundance, bacterial abundance, and microbial community composition will be measured throughout the entire water column during both baseline and verification phases. Primary producer-related parameters will be quantified exclusively within the photic zone. Efficient open ocean monitoring, especially considering the fast sinking rate of substrates, necessitates a significant focus on substrate sampling during the sinking phase (rule 9.6.11, MOCNESS sampling). This primarily serves to confirm that substrates reach deep water. This methodology emphasizes the export of organic matter into deep-water masses (those above the sediments) rather than sediment burial, meaning phytoplankton biomass is typically not preserved in its organic form. Rapid remineralization of phytoplankton and other labile organic matter into dissolved inorganic carbon (DIC) occurs quickly upon reaching the sediment, with the DIC then stored in the deep water. The main objective is to achieve a deep-water layer retention time exceeding 200 years, thereby preventing water parcel ventilation.	Minor revision to the sampling requirements in section 9.6.
98	Section 9.6.11	Section 9.6.11 – in shallower settings where organic carbon flux is more prominent, depths should not be so deep – should be tied to the depth range of the environment being worked.	Thank you for the comment. Each project must assess the depth of each sinking site as determined in section 3.7. While the methodology does not strictly include a minimum depth, under the current scope of the methodology practically all sites are located in regions where the water depths exceeds 800 meters. The sinking site depth is determined on a case-by-case basis for each site (see rule 3.7.10.), pending approval by Puro based on the evidence that ensures the sequestration timescales of at least 200 years. If a site with a depth under 800 meters is considered eligible, the sampling increments are adjusted to represent the applicable strata.	No change
99	Section 10	Section 10 is fine and can be strengthened without being as necessary should many of these other comments be worked into the documentation of this methodology.	Thank you for your supporting comment. In our view, the changes based on the received comments have improved this methodology, and we invite you to review the changes to the other sections.	No change
100	11.1.5.	Additionally, 11.1.5 currently requires records of stakeholder engagement in the event of ongoing feedback and grievance and any documentation on environmental and social impacts that may have occurred during the monitoring period; after each report, the methodology requests documentation on how the CO2 supplier proposes to resolve a grievance or outstanding issue. This may communicate a "checking the box" approach to meaningful engagement or engagement conditional on whether negative impacts are affecting impacted environments and communities. Revisions to request reporting of co-benefits, and other transparent stakeholder engagement efforts that fall outside of grievance-reporting mechanisms would be beneficial. For example, a qualitative report could complement the existing requirements, but we don't know how feasible this is for open ocean interventions versus coastal interventions.	Thank you for your comment. Please note that further stakeholder engagement requirements are set elsewhere in the Puro Standard General Rules and Stakeholder Engagement Requirements. For further information, please also see the response for comment no. 52 above.	No change