Context

This document was developed in partnership between PML Applications, the commercial subsidiary of Plymouth Marine Laboratory (PML) and the Carbon to Sea Initiative, beginning in May 2024. Several versions of this document have been developed through expert review, two in-person workshops, and a public comment period. The public comment period collected and documented comments from the wider community, including 13 reviewers representing OAE projects, regulatory bodies, scientists, and other interested stakeholders.

This document summarizes the feedback received during the open comment period and includes responses as resolutions to each reviewer comment. Line numbers refer to the v6.4 protocol line number corresponding to each comment. Comments are sorted by Reviewer ID.

We are enormously grateful to all participants in the open comment period for their time and valuable input that has been integrated to develop a more thorough and community-driven protocol

Summary of feedback received

Reviewer ID	Line No.	Comment	Resolution
Reviewer 1	219	Table 2 is not labeled.	Change: Corrected Table 9 title to "Example of a safety protocol for a coastal outfall OAE trial (Source: Planetary)" and corrected page number reference in Table of Contents for Table 2.
Reviewer 1	292	Ammonia is toxic, so perhaps '(toxic) free ammonia' is meant	Change: Replaced toxic-free ammonia with "(toxic) free ammonia"
Reviewer 1	483	Euler analysis' is not a typical term for such a diagram.	This diagram figure has been removed from the final document version.
Reviewer 1	516	Identify could be a better word if protective zones are already defined.	Change: Replaced "Establish" with "Identify"
Reviewer 1	580	Given that calcium carbonate is poorly soluble in seawater, I believe it's not a common OAE feedstock used in mCDR.	Feedstock description specifies application in acidic waters. No change.
Reviewer 1	592	Coastal outfall' is the more typical term.	Change: Updated "coast" to "coastal"
Reviewer 1	593	Ideally coastal outfalls would indeed leverage existing infrastructure, but this is not a	Change: Revised language to "This approach uses purpose-built or existing coastal infrastructure [...]"

		necessary condition for coastal outfalls. Especially if gigatonne upscaling is at some point desired, creating new coastal outfall structures may become relevant.	
Reviewer 1	1538	The '(2012)' reference is confusing in case it refers to the 2013 amendment.	Thank you for this correction. Change: Updated reference with the correct year, 2013.
Reviewer 2	1075	The GEOTRACES cookbook provides excellent guidance on hardware and cleaning protocol for trace metal samples. I recommend following their cleaning and handling guidance in sections 7.1.1-7.5. Furthermore, more clarity is needed on the types of metal measurements recommended in this framework. Many freshwater regulators use Total Dissolvable Samples (7.5.1), likely due to abundant total suspended solids, but these measurements are not common in the oceanographic community because they cannot be intercalibrated and struggle to inform absolute concentrations. I recommend collecting Total Dissolved Samples (7.5.2) due to their standardization and relative ease, however, more discussion here may be needed. We typically use Acropak cartridge filters for collecting these samples, however, section 7.10 describes the exact filter holders and filters to use, and I recommend checking these instructions as well because they describe sample processing in coastal waters. Measurement methods will vary between sample types due to their concentrations (porewaters, coastal seawater, open ocean seawater) and should	Change: Added reference and citation to Trace metals row of Table 5 "GEOTRACES Trace Metals Sampling and Sample Handling Protocol"

		probably not be specified beyond use of an ICP-MS. https://www.geotraces.org/wp-content/uploads/2024/10/GEOTRACES-cookbook-v4-2024.pdf	
Reviewer 3	258	I would recommend calling this out explicitly in the text 'principles are referenced in the Aspen mCDR code of conduct', as this isn't the only code of conduct used for mCDR (Planetary lists one on their website, various other mCDR projects have listed codes from time to time).	Change: Added "Aspen Institute's" to specify the author of the mCDR code of conduct.
Reviewer 3	260	This feels out of place, as the aspen covers many more topics than environmental monitoring discussed in this framework. It's not clear if there is a formal link between the two documents, and more importantly, between the two sets of authors, to be able to call his framework as an update to an external citation. I would recommend noting that 'this framework is complementary to existing codes of conduct by offering…'	Change: Revised text to "this framework is complementary to existing codes of conduct by offering […]".
Reviewer 3	268	We would argue that this is a project development process for any given project. That is, these stages aren't just applicable for scaling from 0 to 1000s of tons (moving from stage 1 through 4 as shown in figure 1) but are inherent to developing a project at any given project at stage 2, 3, or 4, which may not scale further. I think some separation between these steps and the scaled stages in Fig 1 would be helpful.	The team agrees these stages are relevant for any project and does not require scaling through all stages. Change: Included text "Progress through these stages may not be linear and will likely involve iterative cycles of planning and testing."
Reviewer 3	268	Is this document intended to reach continuous dosing? This doesn't	This document does not suggest that every project must progress through

		match up with one-off mCDR research projects, like LOC-NESS, that don't move to continuous dosing.	every stage. Instead, it provides an overview of the different scales of research and, where relevant and desired, how projects can responsibly scale up their operations. No change.
Reviewer 3	278	I would simplify this to 'alkalinity distribution.' At this stage in the framework, methods (like olivine addition) haven't been discussed yet. Dissolution is important for all solid/slurry OAE approaches, not just olivine.	Change: Revised language to "[..] the establishment of a baseline (or benchmark) for the relevant environmental variables to support clear understanding of the local hydrodynamics and biogeochemistry, and the predicted impacts and potential risks of an alkalinity addition to aid in the prioritization of a project's ecological and biological monitoring considerations" simplify introduction.
Reviewer 3	293	The executive summary ends before summarizing the implementation side of this framework– a summary of the regulatory chapter and community engagement feels useful here.	The team agrees the executive summary could be expanded for a more clear and comprehensive overview of the document's contents. Change: Added descriptions and internal document links for each section across Part I and II of the framework.
Reviewer 3	403	This could use a rewrite. 'OAE induces carbon uptake by reacting with carbonic acid.' What is reacting with carbonic acid? There's a missing statement before this about adding alkalinity and what chemistry might be released into seawater. This paragraph kind of jumps the gun. I'd say the paragraph beginning at 411 is more clear than the paragraph in 403. These lines are a bit redundant and this section broadly could be clarified.	The team agrees the explanations of seawater carbonate chemistry and the OAE process could be clarified. Change: Restructured and the explanations to describe the paragraph under 4. Background for OAE to have the first paragraph describe the carbonate chemistry reactions governing air-sea gas exchange and carbon speciation and left the second paragraph to explain how OAE works.
Reviewer 3	437	The jump from the overview for section 4 to 4.1 on monitoring is abrupt. We think there should be a simple discussion of various	The team agrees that the transition from discussing the general chemical process of OAE in section 4 to the considerations

		approaches to OAE and resulting chemistry (solid/slurry OAE addition vs. olivine placement vs. aqueous removal of acid) to help clarify what needs to be monitored in section 4.1. Line 458+ touches on feedstocks, but there's some broad feedstock characterization that is missing.	of real-world OAE practices in 4.1 needs more context. Change: Added a bridge paragraph ahead of 4.1 to better preview the next section's content.
Reviewer 3	469	This sentence is bulky and unclear. First, this is the first use of the term 'alkalized water'. This should be defined (or broadened, 'alkalinity-enhanced seawater?') Then, remove 'should spread laterally' to 'should remain in the surface ocean'. Then, 'avoiding high concentrations' doesn't mean anything here and is dependent on feedstock and delivery methods. There is no description of what is considered 'high concentration' which will depend on many perspectives.	The team agrees this sentence could be rephrased for better clarity on the scientific considerations surrounding effective application of OAE. Change: Rephrased to "For OAE to be most effective, the alkalized waters should remain at the surface where it can induce CO2 uptake from the atmosphere, while avoiding thresholds for secondary precipitation and biological impacts."
Reviewer 3	478	This needs a rephrase or clarification. If olivine on the seafloor dissolves in place, concentration will change but position will not, okay. But if brucite is dumped into an outfall, dissolution will change concentration as the particulates are sinking and advecting away. Readers will easily confound these definitions. I'd simplify this sentence to 'dissolution of a particulate changes the concentration of the material…' and then add a line specifically about sinking.	The team agrees the explanation of the processes for alkalinity concentration change could be improved, specifically for dissolution. change: Revised the text to explain the different circumstances in which each process can affect concentration and where. Removed the graphic.
Reviewer 3	502	I'd recommend adding a line here that indicates 'understand dispersion and dilution of alkalinity into receiving waters through	Change: Separated the receiving waters modeling and dye tracer validation into two bullet points.

		models' then turn this bullet into 'validated with dye tracer...'	
Reviewer 3	509	This is a bad bullet. It's completely subjective and lacks meaning because of it.	Change: Revised language to "Release only the minimum volume necessary to achieve the experimental objectives and generate statistically robust data, while avoiding unnecessary environmental perturbation."
Reviewer 3	538	This is problematic where it is placed in the 'regional scale' bullet, implying that OAE project design should include monitoring at the tens to hundreds of kilometers scale. This is extremely unlikely for specific projects, especially at the pilot scale, and could add a massive burden on projects even if this is included with a 'with feasible' asterix.	The team agrees that this level of monitoring is resource intensive. This recommendation is for "very large deployments" where alkaline material can be expected to spread over tens to hundreds of kilometers. In this scenario, regional scale observations would be expected where feasible. No change.
Reviewer 3	545	Overall, this table needs a rework. It confounds OAE methods and OAE deployment types. I would recommend replacing it with a simpler set of 2 tables: One for OAE feedstock types (solid, slurry, aqueous), and another for OAE distribution types (open ocean, coastal outfall, river, coastal placement). These two sets are then taken together to form OAE methods. Breaking it down this way helps clarify what is actually unique, where the current table misses some bullets in some rows and adds them in others.	The team agrees that there are many ways to group OAE pathways. Some TEA analyses have found over 50 different ways to remove acidity or increase alkalinity. In an effort to create a generally accurate overview without introducing too much duplication, we have made some simplifications. No change.
Reviewer 3	562	This is missing industrial products, and aqueous alkalinity (NaOH is neither a mineral nor a rock in the form produced by electrochemical methods). This feedstock section feels like it should come much earlier in this document. Similarly, line 557 - 'pure minerals.. Not always synthetically produced' – I	Change: Recategorized as "Processed or synthetic feedstocks"

		don’t think of steel slag, which has been proposed for OAE, as a mineral or rock.	
Reviewer 3	619	Section 4.2.5 assumes leveraging existing coastal infrastructure.Section 4.1.7 on electrochemical acid removal should be a subclass of 4.1.5 on coastal outfalls. The ‘unique environmental concerns’ here are common to existing coastal infrastructure. This section includes a standalone research pilot as an example– but the intention for the technology is to fit into existing coastal infrastructure, not to always be building new outfalls. The last line here on high volumes of HCl which must be neutralized completely is an oversimplification, and leaves the reader thinking we are always neutralizing HCl as part of the OAE project, which is not the case when we can offload it for other industrial uses, depending on location.	The team agrees that not all coastal outfall applications use existing coastal infrastructure nor do all electrochemical applications neutralize the HCl stream directly. The team acknowledges that some electrochemical acid removal projects are integrated into coastal outfalls however, this methodology is more clearly understood in the field as its own category, as it does not "add" alkalinity. Change: Updated method descriptions in section 4.2.3 to "This approach uses purpose-built or existing coastal infrastructure [...]" and section 4.2.5 to "[...] generates high volumes of hydrochloric acid (HCl), which must be neutralized or diverted for controlled off-site industrial use such that no untreated or partially treated acid is released back into the marine environment." for clarity and comprehensiveness of the different approaches. Added a concluding line to section 4.1.1. to clarify monitoring considerations for multi-method approaches.
Reviewer 3	735	Inert dyes (as exemplified in the LOCNESS project, Dalhousie tracer study, *and Ebb’s Project Macoma*.)'	Change: Updated language to "Ebb's Project Macoma" and hyperlinked the project's blog post about the release.
Reviewer 3	784	This should say, ‘should only be made with appropriate/ required permits, support from community members,...’	Change: "should only be made with appropriate/ required permits, support from community members,..."
Reviewer 3	789	What is this based on?	Change: Text has been adjusted to read Multiple trials "may" be conducted at this stage before moving to Stage 4.

Reviewer 3	793	This seems like a weird callout. What about large storms at sea? Large coastal storms that don't necessarily cause flooding but impact wind and temperature? There isn't a clear link between flooding and OAE.	The team agrees that using "flooding" as an example here could be interpreted as too specific. Change: Include additional context, "Baseline data, whenever possible, should aim to capture significant weather events to understand the extremes of natural variability at the site. Especially events that occur seasonally or annually such as marine heat waves, seasonal flooding, drought, etc. The occurrence of a significant weather event should be noted in the metadata and additional monitoring will depend on the type of weather (i.e. flooding may increase turbidity whereas a heat wave may decrease carbon solubility)."
Reviewer 3	811	5.1.4: Continuous dosing and monitoring. Does this section really just want to address sustained OAE, or also scaled OAE (since it's part of the largest stage gate)? At sea work will be scaled, not continuous.	Change: Distinguished scaled v continuous dosing "As the scale of additions increase or move to continuous dosing..."
Reviewer 3	812	Baseline data collection adjacent to an OAE site, or within the footprint of an OAE project that is small enough that alkaline signals are rapidly diluted, can be used to understand seasonal variability. We don't have to wait until OAE has stopped to be able to say that a baseline is reasonable, especially at current pilot scales.	Change: Added "...or if collected at an adjacent site outside of the alkaline plume."
Reviewer 3	836	Does this mean watchdogs have been involved to date in this stage, or should be per this framework? Will they hold operators accountable? How?	The team agrees it is out of scope for the framework to imply or recommend these specific groups for this long-term planning activity. Change: Cut: "Community watchdogs and conservation groups, which have been heavily engaged in this stage, will help hold operators to account for

			inadequate monitoring frequency and volume. "
Reviewer 3	840	It's odd that this is included in 'stage 4'. For researchers, maybe this is the first time OAE scientists are thinking about scale. But for the OAE industry, we've been on this topic for years now at much smaller scales and earlier stages.	The team agrees that scaling questions should be considered as early as possible. However, continuous dosing may not trigger significant upland or environmental impacts unless very large volumes of alkalinity are being sourced and processed, which is not a requirement for "continuous dosing," but rather an indicator of sector growth more broadly. No change.
Reviewer 3	855	It's important to note that the audience changes from researchers to project operators here. These may not be the same audiences.	The team agrees that researchers and project operators are not interchangeable, and language should be more inclusive of the different audience groups. Change: Replaced "project operators" with "project leaders" make it inclusive of researchers and others
Reviewer 3	1054	I would say it is frequently impossible to identify a suitable control site except under specific conditions (open ocean patches, rivers). In coastal environments, it is entirely unrealistic to find similar control locations given all the varied uses of marine resources, let alone natural variability and hydrodynamics. This section should be strengthened to make it clear that control sites are the exceptions, not a general expectation.	While the team agrees, however, we believe this is sufficiently addressed in the document, which states "Nevertheless, it is not always practical to identify a suitable control site. For example, in coastal OAE projects, two adjacent coves may have similar water chemistry but differ in key processes such as mixing dynamics and sedimentation, resulting in the accumulation of sediments or slower dilution rates." No change.
Reviewer 3	1342	These methods should be cited, especially for commercial techs like FlowCam.	Change: Added the references 115-116: For FlowCAM in the benthic context: "A new method for acquiring images of meiobenthic images using the FlowCAM"

			For IFCB (original paper): "A submersible imaging-in-flow instrument to analyze nano-and microplankton: Imaging FlowCytobot"
Reviewer 3	1345	No citations in this section on benthic monitoring.	The team agrees that adding references would strengthen this section. Change: Added references 86 and 119-126 to the benthic monitoring subsection of section 7.3.
Reviewer 3	1449	But wasn't this section meant for project operators? This includes many professionals who are NOT scientists– engineers, community engagement experts, legal counsel, etc. Would recommend removing the term 'as a scientist'	Change: Removed "as a scientist" from sub-section title.
Reviewer 3	1631	This is uncited. 'Changes in pH' is vague.	Change: Added citation to reference the U.S. Environmental Protection Agency (EPA), National Recommended Water Quality Criteria – Aquatic Life Criteria Table. Updated the terminology to "Changes in pH" to reflect the EPA's description as published.
Reviewer 3	Figure 1	We're not a fan of the images– they don't add much and they don't match up with what we're often seeing in mCDR projects. We don't have dedicated buoys in stage 2 in our coastal process, and we are not envisioning ship work as indicated in stage 3.	These images are illustrative of the scale of each stage and don't necessarily indicate the vessel to be used at this stage. Change: Updated the Stage 2 icon from a buoy to a small boat.
Reviewer 3	Figure 2	I'm not at all a fan of the dropper image. I'd prefer a pipe, an arrow, something that isn't such a leap in scale. I'd also recommend amending the example to something like OH- (instead of Mg(OH)2) to broaden the example across brucite, various industrial alkaline sources, NaOH...	Change: Dropper removed from image.

Reviewer 3	Figure 3	Not a fan of this figure. It is unclear what is aqueous and what is solid (and if it's all assuming we start with solid precipitates, that should be made clear). Sinking is also left off. The transport process could be amended to include both sinking and advection.	Change: The figure has been removed and the text describing the different processes has been revised for clarity.
Reviewer 3	General	Sections skip around in this half– from environmental monitoring in part 1 to part 2: community engagement, monitoring, regulation, OSHA, data sharing. Maybe reorganize to start or end with monitoring suggestions, since that's the goal of this doc? Otherwise Environmental Monitoring is a bit buried in this manuscript.	The team recognizes the reviewer's point. In an effort to be useful for a range of readers, we aim to provide sufficient context throughout the document that may not be necessary for experienced practitioners. No change.
Reviewer 3	General	The jump from regulations to OSHA to data is abrupt. Why not move data handling up to where data collected for environmental monitoring is discussed?	The team appreciates the commenter's suggestion for clarity of information however we believe that data reporting belongs after these sections because it applies to all data collected from the project, potentially including OSHA data if required by regulation. No change.
Reviewer 3	Table 2	If this is a table and not a figure, it doesn't need the little pictures in it.	Thank you for the suggestion, the team agrees that the icons add appropriate visual context for the discussed concepts and aids understanding for those new to OAE. No change.
Reviewer 3	Table 2	This table includes the first time the term 'patch-scale' is used (which should absolutely be defined somewhere if it is included here.'	The team agrees. Change: The term "patch scale" is replaced with "near-field scale".
Reviewer 3	Table 2	The coastal outfall pipe specifies existing outfall pipe– why does it have to be existing? An outfall can be built and permitted for OAE at a	Change: Removed "existing'" from coastal outfall method description in Table 2 and clarified across the document.

		new field site. This is jumping from outfall pipes in general to co-location with other industries, and this row should include both as this document ranges across scales.	
Reviewer 3	Table 2	What does ‘consider adjacent use cases for river water up and downstream’ mean, and why don’t the other rows have to consider adjacent uses?	Rivers have a more uni-directional and directly attributable impact to/from co-located activities. Although all sites should consider adjacent use-cases, the risk is more acute in rivers and thus is highlighted. No change.
Reviewer 3	Table 2	Why is electrochemical acid removal given its own row? This should be included in coastal outfall pipe addition– electrochemical acid removal is just a way to produce aqueous alkalinity. Why are the key monitoring locations here different from the coastal outfall pipe row, which only includes water column and seabed? They should be the same, as electrochemically generated alkalinity is released from an outfall pipe...Why does this row require monitoring for mineral precipitation, but outfall pipe addition does not?	Electrochemical OAE has unique environmental risks not covered in other pathways, for example the ecosystem impacts from acid stream disposal, storage or treatment, impacts from temperature changes and intake of seawater. The team believes these areas are unique enough to justify its own row and that it helps to promote greater understanding of the different pathways. Electrochemical OAE is frequently articulated as a distinct OAE pathway and we believe excluding it would cause more confusion. Change: Added explicit mention to monitoring for mineral precipitation under Coastal Outfall Pipe Alkalinity Addition. Added "For OAE projects that combine more than one method, the focus areas for monitoring should account for all included methods" to the last paragraph of section 4.1.1.
Reviewer 3	Table 3	Recommend standardizing language. For example, Silicates gets ‘potential to introduce biologically impactful elements’ and carbonates gets ‘may contain biologically impactful elements’ and brucite gets ‘may contain impurities’. They can all contain	Change: Standardized the "Description and applicability" column descriptions across all feedstocks. Replaced language use of "impurities" with "elements" for relevant feedstock rows.

		impactful elements, trace metal or otherwise, and should be described the same. As it stands, this table appears biased towards brucite, which only contains impurities.	
Reviewer 3	Table 3	What does ‘effective in acidic waters’ mean under the sodium carbonate row?	Change: Standardized the "Description and applicability" column descriptions across all feedstocks. Replaced "effective" with "highly soluble."
Reviewer 3	Table 3	Why does the NaOH line include ‘low toxicity’ and ‘may induce spawning in molluscs’? Toxicity is not described for any other row, nor are impacts on any given biology.	Change: Standardized the "Description and applicability" column descriptions across all feedstocks. Removed mention of mollusc spawning.
Reviewer 3	Table 3	Why is NaOH under synthetic minerals? If it’s a solid, sure, that fits, but no one thinks of aqueous NaOH as a mineral. The breakdown here is weird.	Change: Recategorized as "Processed or synthetic feedstocks"
Reviewer 3	Table 3	Why does steel slag get ‘low carbon footprint’?	Change: Removed mention of low carbon footprint.
Reviewer 3	Table 3	Overall this table feels biased. This could be easily clarified by standarding language to ensure each feedstock is discussed in the same terms.	The team agrees the table should be more standardized and present a balanced view of each feedstock's considerations, avoiding any appearance of bias toward specific feedstocks. Change: Standardized the 'Description and applicability' text across all feedstocks.
Reviewer 3	Table 3	Similarly, brucite isn’t just found as a natural mineral – it can be produced synthetically. I’d get rid of ‘category’ and try to avoid shoehorning alkaline feedstocks into ‘rocks and minerals’-- just call them alkaline materials and define each row from there.	The team agrees that brucite is both a naturally occurring and synthetically produced alkaline material. However, the categories help serve as general guidelines for understanding feedstock risk and signaling to some audiences that "naturally occurring" does not always mean it is safer. Further, the description lists Brucite as the "natural mineral form of Mg(OH)2" recognizing the synthetically produced counterpart.

			No Change.
Reviewer 3	Table 5	Recommended parameter: 'Plankton.' Plankton... type? Biomass? Community at large? Presence of species? This is fairly vague.	Change: Added "Biomass and Diversity'" specification to Plankton parameter name
Reviewer 3	Table 5	Chlorophyll: Chl-a?	Change: Specified "Chl-a" for Chlorophyll parameter
Reviewer 3	Table 5	Nutrients: Note that this suggests in situ sensors or discrete water samples– but then all subrows for nutrients are bottle samples only.	Change: Removed 'in-situ sensor' from Nutrients method column, and changed 'Discrete water samples" and "Discrete bottle samples" to "Discrete samples" under all relevant parameter methods for clarity and accuracy.
Reviewer 3	Title	The title of this document seems restrictive. The text goes beyond environmental impact monitoring into community engagement and regulation.	While the document encompasses a range of different topics, they all serve to inform environmental monitoring practices. No change.
Reviewer 4	292	Tables 1 & 5: Within "Additional parameters", nutrients are broken into specific sub-parameters (e.g., phosphate, silicate), while the biological and ecological rows (benthic habitat, benthic organisms, and locally important species) remain at a higher level.	The team agrees that the summary table may leave the reader desiring more detailed information on these parameters. Change: Added "Further information on parameter monitoring methods and external reference material is provided in Table 5. Additional considerations for parameter selection and monitoring design is provided in Section 7. Key Parameters for Monitoring." to Table 1 caption.
Reviewer 4	464	Fine-grain sizes of highly alkaline material may also impact sensitive larval stages through gill irritation and ingestion-related tissue damage (e.g., Zhang et al., 2024; Ge et al., 2023; Xiao et al., 2025; Wen et al., 2023), and this biological sensitivity is not fully captured in the current wording	Change: Revised to "[..] operators should ensure that the grain size is appropriate for the field site's physical and biological conditions (including the presence of sensitive early life stages) [..]"

Reviewer 4	571	Table 3. The table notes sodium carbonate (soda ash) but does not highlight its existing use in aquaculture buffering, and sodium bicarbonate (baking soda, NaHCO3), which is also widely used for pH and alkalinity control in aquaculture, is missing.	The team agrees that these uses are important to highlight. Change: We have added a general comment in the preceding paragraph to illustrate a range of use cases for alkaline materials. "Although the table below summarizes feedstocks commonly used in OAE research, alkaline materials have many other use cases such as treating drinking water, wastewater, in foods and beverages and for pH control in aquaculture."
Reviewer 4	651	The statement on coastal protection may overstate this co-benefit. Because the added alkaline material will dissolve and alter grain size over time, any erosion relief is likely temporary and may increase vulnerability if relied upon in place of more durable, nature-based measures (e.g., mangroves, salt marshes, non-dissolving sandbars).	Change: Replaced line "If added on a large enough scale..." with "Research into the co-benefits of this method aims to assess whether it may offer the added benefit of slowing coastal erosion, especially in conjunction with other natural or engineered (e.g. coastal habitat restoration, seawalls, breakwaters, etc)."
Reviewer 4	1004	Since essential parameters are defined as early-warning metrics for ecological impacts, readers may be confused that no explicit ecological parameters appear in the “essential” list.	The team agrees that the "Essential Parameters" category could be refined and clarified to better reflect its role in the development of an environmental monitoring plan. Change: Renamed as the "Essential Parameters" category to "Regulatory Parameters." Updated the parameter description to "These are mostly physico-chemical proxies that provide early warning of potential ecological stress".
Reviewer 4	1050	Tables 1 & 5: Within “Additional parameters”, nutrients are broken into specific sub-parameters (e.g., phosphate, silicate), while the biological and ecological rows (benthic habitat, benthic organisms, and locally important species) remain at a higher level.	The team agrees that the summary table may leave the reader desiring more detailed information on these parameters. Change: Added "Further information on parameter monitoring methods and external reference material is provided in

			Table 5. Additional considerations for parameter selection and monitoring design is provided in Section 7. Key Parameters for Monitoring." to Table 1 caption, and "Additional considerations for parameter selection and monitoring design are provided in Section 7.2 and Section 7.3." to Table 5 caption.
Reviewer 4	1125	The ecotoxicology subsection does not explicitly connect toxicity testing to organism life stage or life history, even though these are critical for understanding vulnerability (e.g., larval shellfish gill sensitivity and turbidity effects on larval feeding behavior).	The team agrees it is helpful to further define ecotoxicology's role in understanding how feedstock material impacts marine organisms, and the different organism conditions that may heighten their vulnerability. Change: Extended the description of how ecotoxicity research is used and defined: "They provide critical data for assessing risks associated with specific aspects of OAE feedstocks, such as trace metal concentrations or resulting turbidity, and at specific organism life stages and behaviors."
Reviewer 4	1405	The current text notes limited understanding of how genetic material responds to real-time changes in seawater chemistry but does not fully capture how environmental conditions affect eDNA detection and interpretation.	The team agrees the text would benefit from additional context on how environmental conditions influence eDNA detection and interpretation. Change: Revised text to "This is an indicator of species diversity and abundance at the trial location, but eDNA detection is strongly influenced by environmental conditions and there is limited understanding of how the genetic material reacts to real-time changes in seawater chemistry." and included the suggested references, 117-118.
Reviewer 4	1459	Readers not closely involved in ocean observing or modelling may not be familiar with the “digital twin” concept, so the term may be unclear to parts of the intended audience.	Change: Added definition "A digital twin is a coupled model-observation system that mirrors the state of an OAE field site in near real time and is used to test scenarios and optimize operations."

Reviewer 4	1879	The example risk register does not explicitly account for hazards that become more prominent in tropical or subtropical settings, such as harmful wildlife and heat-related stressors, even though the framework is intended to be globally applicable.	The team agrees that project sites can pose many unique risks to personnel, and acknowledges this in Table 8's description "A mitigation strategy must be developed according to the unique risk profile of each project." Change: Added mentions of wildlife exposure under occupational risk category and heat and cold stress under operational risk category in Table 8.
Reviewer 5	695	We recommend considering that if the project may have any type of impact on a specific environmental component, the project should not be rejected outright. Instead, we should seek appropriate mitigation measures to prevent any potential damage. If avoiding such impacts is not possible but the majority of the effects of the project are beneficial to the environment, we should identify suitable compensation actions to offset the environmental effects.	The team agrees with this perspective, this is represented in the stage 1 key activity "[...] and design research that mitigates risk" and as decision gate criteria "If the scientific potential is high and the risks are determined to be tolerable, continue to Stage 2." This framework does not suggest that projects will be outright rejected on the basis of potential impact identified in Stage 1. Mitigation is strongly encouraged. More research is needed to make or even suggest decisions on the trade-offs between environmental harms and benefits at different scales. No change.
Reviewer 5	721	“Before release, an impact analysis of the feedstock being deployed is required...“ _ This sentence could be better put at the beginning of the concept (Line 695), to immediately give the operator the context of what is necessary on the feedstock before the deployment.	Change: Rephrased paragraph to "Before release, an impact analysis of the feedstock being deployed is required." and removed this line from the end of the paragraph.
Reviewer 5	737	We would also consider research centers and public entities (if present), to consult in taking information about the most important endemism and other local species. We would include the word “habitats” as sensitive and priority	Change: Replaced text with "Local research centers, public entities, or community resources may be able to provide and help interpret existing data on sensitive or culturally important species and habitats."

		areas to be considered, in addition to species alone; as ecotoxicological studies on individual species alone may prove limiting compared to a more efficient 'habitat approach' (when possible to apply in experiments), going into greater detail for priority habitats listed in international directives, with a view to taking a step forward in the functional observation of the ecosystem.	
Reviewer 5	746	This approach could significantly alter the authorization process depending on the country where the project will be implemented. In some countries, conducting these types of studies requires specific permits (for example, a permit for water discharge), which could complicate the permitting procedure. We could aim to carry out these studies during the operational plant's permitting phase, making the authorization strictly conditional on the completion of the studies and on the results proving to be environmentally harmless.	The team acknowledges that the details and success of a project's permitting efforts are project-specific and subject to all local regulations relevant for the proposed activities. No change.
Reviewer 5	782	Yes, but in doing so, the monitoring plan must interface/align with the requirements of national-international directives and policies which apply in that specific geographical area.	The team agrees. Change: Include reference to regulatory bodies as detailed in section 8.
Reviewer 5	830	Even considering all the required procedures for the FAIR data (referring to chapter 10) – and the external repository better if is specific for the OAE/CDR community (if already available)	The team agrees and we have launched a dedicated home for OAE Field Data, called the OAE Field Data Commons. No change.
Reviewer 5	835	Even considering "a cost-effective" monitoring plan	While the team agrees that cost effectiveness is instrumental to achieving

		that permits to be iterative on the long-term, that makes it more feasible (always in line with all the requirements)	long-term MRV, we do not yet have a definition or recommendation for what constitutes cost-effective and high-quality MRV. A recommendation for a "cost-effective monitoring plan" may be more appropriate for future iterations of this document. No change.
Reviewer 5	886	We suggest considering that it may be also important to explain to the community what “community engagement” is and its limits, as not all communities are familiar with it. This can help raise awareness of the importance of their involvement during public dissemination.	The team agrees with the importance of clarity, but believes the term is sufficiently defined throughout the section. We are wary of defining the "limits" of community engagement as this may be misunderstood. No change.
Reviewer 5	1317	Within the paragraph, we would also consider highlighting the potential role of diatoms and other silicifying phytoplankton in the impacts of OAE, particularly regarding silica uptake, community shifts and carbon export. One potentially under-recognised pathway through which OAEs may influence biogeochemical cycles involves non-calcifying phytoplankton, particularly diatoms. Diatoms construct siliceous frustules using dissolved silicic acid ($Si(OH)_4$), and the extent to which they are silicified strongly affects their sinking velocity and the efficiency with which they export particulate organic carbon (POC). Heavier, more silicified frustules enhance ballasting and increase vertical carbon export to the deep ocean (Abrantes et al., 2016). Recent experimental work indicates that enhancing alkalinity with silicate-bearing materials can	Thank you for providing this valuable input. The team agrees that there are OAE impacts specific to diatoms and other silicifying phytoplankton, however, the explanation provided is too detailed to include in a general framework like the EIMF. We have added a line to allude to a range of impacts beyond calcifying organisms. Change: Added "In addition to calcifying organisms, OAE may also influence non-calcifying phytoplankton such as diatoms, with potential implications for silicification, community composition, and carbon export, though these responses are likely to be highly site-specific."

		increase dissolved silicate and stimulate diatom silica uptake. Mesocosm experiments by Ferderer et al. (2024) showed that, relative to calcium-based or control treatment, silicate-based OAE enhanced diatom silicification. Similarly, Groppelli et al. (2025) reported that diatom silicon uptake increases under moderate alkalinity addition. These findings suggest that OAE could promote diatom-dominated or more heavily silicified communities under certain conditions, potentially strengthening the biological carbon pump. However, these effects are likely to be context-dependent and influenced by factors such as nutrient availability (e.g. the Si:N ratio), seasonal cycles, hydrodynamics and local community composition. Conversely, some studies demonstrate that altered carbonate chemistry can reduce silicification in certain regions (Petrou et al., 2019), highlighting the necessity of site-specific evaluations. Incorporating silicifying plankton alongside calcifying organisms into baseline assessments and long-term monitoring frameworks would provide a more comprehensive understanding of the ecological and biogeochemical impacts of OAEs, including potential benefits for carbon sequestration and possible consequences for community composition. At the end of the paragraph, we would suggest including plankton community metabolic measurements (e.g. gross primary	

		production, respiration and net community production) in the monitoring plan, following the approach adopted in previous marine plankton studies (e.g. Garcia Corral et al., 2017). Including plankton community metabolic rates would enable us to detect meaningful shifts in carbon uptake or release by plankton in response to OA-induced changes. This would complement species-level and community-composition monitoring (calcifiers, diatoms, eDNA, etc.) by providing a functional metric that is directly linked to the ocean's role as a CO_2 sink or source. As plankton metabolism can be easily measured via incubations that track oxygen (or CO_2) fluxes, this optional monitoring module could substantially increase the ecological and biogeochemical relevance of the OAE monitoring programme, particularly for long-term evaluations of carbon cycling and sequestration potential.	
Reviewer 5	1367	When establishing a functional baseline, we would like to add that it is also important to identify keystone benthic calcifying species and evaluate their potential response to alkalinity enhancement. Environments dominated by benthic calcifiers may respond differently to the implementation of OAEs, as these organisms can rapidly draw down added alkalinity through their calcification processes. In such settings, the introduced alkalinity may be consumed more quickly,	The team agrees it is important to note the impact of calcifying organisms on OAE's process. Change: Included the line "Similar to calcifying plankton, benthic calcifiers may reduce the net impact of carbon removal by stimulating biological CO2 release. "

		potentially requiring more frequent or sustained additions to achieve the desired geochemical effect. Furthermore, elevated calcification rates increase biological CO_2 release, which could counteract the intended carbon removal benefits of the treatment. For instance, ongoing mesocosm experiments comparing two benthic bivalve species (Mytilus galloprovincialis and Crassostrea gigas), reared under identical conditions and exposed to the same proportion of alkalinised seawater, indicate through chemical measurements that oysters benefit more from enhanced alkalinity. This necessitates more frequent additions to maintain the experimental alkalinity level. While such dynamics would likely be less pronounced in natural systems, they highlight the importance of understanding the calcifying community present at a monitoring site. This is because the species composition, as well as the relative proportions of these species, could significantly affect the efficacy and maintenance requirements of OAE interventions	
Reviewer 5	1414	"...behavior. Given the complexity added by the intended coupling, it is mandatory to make reasonable and justified assumptions that can allow for a systematic simulation of the environment under study. To do this, scale specific models..."	The team agrees it is important for modelers to clearly state the underlying rationale of their inputs. Change: Included the line "Given the complexity of these coupled systems, it is essential for users to assess whether the model is fit for purpose in an OAE context and for modelers to enable this by clearly documenting and communicating the rationale behind their choice of processes and parameters."

Reviewer 5	1416	... Since high fidelity simulations of injection points can better simulate eventual undesired impacts, given their inherent closer fidelity of the model attainable and the importance of studying such a critical point in which dilution is still low and the influence on the local area is relevant.	The team agrees high-resolution modeling of the injection point warrants an explicit mention given its importance to understanding localized impacts. Change: Added the sentence: "In particular, high-resolution modeling of the injection point or release zone is important, as this is where dilution is lowest and the potential for localized impacts is greatest."
Reviewer 5	1422	...exchange conditions. An important effort should be placed in coastal scale modelling, that can better represent the interaction of OAE interventions with the whole ecosystem in terms of biogeochemistry and chemical effects, using global models as important resources for a downscaling of the results. It is of rising importance to consider impacts of OAE at coastal level, given the site-specificity of the problem and the delicate interplay that the different aspects of ocean environment present.	The team agrees the role of near-field and regional models (e.g. coastal scale modeling) are critical for understanding and planning in accordance to local hydrodynamics and ecosystem interactions. Change: The paragraph has been restructured to better represent the role of near-field, regional and global models.
Reviewer 5	1545	We would also suggest that, in order to link the formal regulatory dimension to the certification and market dimensions, which are both crucial for the credibility and scalability of OAE projects, another element to consider is the role of carbon certification systems. Collaborating with registries in the voluntary carbon market, such as CDR-focused registries like 'Isometric', can help ensure that measurement, monitoring and verification standards go beyond formal regulatory requirements. Integrating these actors increases the project's scientific credibility and transparency, and facilitates	The team agrees that the ultimate goal of OAE is to deliver durable carbon removal, however, the goal of this framework is to provide high level guidance for all field activity leads, whether or not they intend to produce credits. Change: Added a mention of compliant PDDs and structured methodology documents as relevant examples of documentation to share with regulators in Appendix C.

		alignment with emerging removal credit market requirements, thereby strengthening the framework's overall effectiveness. Additionally, creating structured documents such as Methodologies and Project Design Documents (PDDs) that comply with ISO 14064-2 is another best practice. These standardized tools support the definition of baselines, monitoring of results and independent verification, thereby strengthening regulatory compliance and the credibility of projects in the eyes of voluntary registries, as well as scientific and public stakeholders.	
Reviewer 6	744	Baselining - ● Line 744 - It is important to have a robust, seasonal baseline before any dispersal testing begins. ○ This could be a bar that is challenging for project developers to meet. This suggests actively sampling the waters for at least 12 months prior to any dosing, which means substantial investment in the project a few months before that. Project development needs to be able to happen at a reasonable pace.	The team agrees seasonal baselining is most feasible and appropriate as a later stage requirement. Change: Removed requirement of seasonal baseline from stage 2, clarified extension of baselining to include seasonal and interannual variability in Stage 3.
Reviewer 6	1064	Line 1064 - “Without a well characterised baseline, it is impossible to separate an OAE impact from natural variability at the site or to quantify carbon removal.” It's not impossible to separate an OAE impact from natural variability at a site. pH and pCO2 change abruptly near the dosing site, and buoys located 500-2000m away from the	The team agrees. Change: "Without a well-characterised baseline, it is difficult to attribute an OAE-induced environmental impact or create a model that can quantify carbon removal with high certainty."

		dosing site can detect OAE impacts from either backscatter, pH, and pCO2. It's probably correct that a strong baseline is needed to quantify carbon removal, but it's because the model you use needs to be high quality.	
Reviewer 6	1334	Section 7.3 - Planktonic and Benthic Communities Might just be worth mentioning that many of the techniques outlined here are quite intensive to carry out. These are the kinds of activities that project developers are unlikely to be able to undertake without academic collaborations.	The team agrees that some analyses are more practical with ready access to academic research facilities and resources. Change: Added "This section refers to a range of monitoring techniques with varying accessibility levels. Research-grade analyses may be more accessible to projects with academic partnerships, and less practical for project developers working with commercially-available monitoring sensor suites" to conclude the paragraph.
Reviewer 6		I would revisit the 'essential' nature of O2 measurements. Yes, an OAE carbon removal protocol requires it right now, but DO sensors are not common on more affordable probes, and do we really think that alkalinity addition will lead to a measurable change in oxygen levels?	The team agrees that DO is likely to not be impacted by an alkalinity addition, however, it is a parameter that is commonly captured in OAE project monitoring plans. Change: Moved DO parameter to category group "Attribution Parameters"
Reviewer 6		Timelines - Asset 1 would benefit from indicative timelines for each stage and sub-item. For instance, collecting baseline data in Stage 2 is right before conducting dispersion operations test, but how long does that go on for? It's important to just need to be cognizant of how long activities may take. If the suggestion is a year+ of baselining is needed, then 6 months to analyze a 'methods test', THEN a pilot, early-stage	The team agrees that key activities listed within stages can take significant amounts of time. However, we recommend no change at this time because each project is different and the length of baselines and stages should be determined on a case by case basis. For example, some open ocean research trials compare data in and out of the plume as a means of comparison, rather than compare against the previous year's baseline data.

		projects by companies may take too long to generate revenue and will fail. This approach may be more reasonable for a project solely focused on research, but it's important to remember that the volume of 'tonnes dosed' is what leads to revenue that allows a project to scale to Stage 3-4. As I say below, the methods test seems like the first part of a pilot, not an independent activity.	No change.
Reviewer 6		Stage 1: "Map, engage & co-create with impacted parties and decision makers." This feels like a word salad. Identify and consult key stakeholders, sure, but "co-create" the project?	Key activities list impacted parties and decisionmakers who require distinct forms of engagement. There are cases where decisionmakers, including governing bodies and legal entities, act as co-creators to field trials, especially if there is no precedent of the OAE activity proposed. Change: Replaced "Map" with "Identify."
Reviewer 6		Stage 1 - should have a step on compiling existing baseline info from public bodies, academia etc.	Change: Updated concluding paragraphs in section 5.1.1. to include "Project developers at this stage should compile any and all existing baseline data for their site and assess data gaps. Baseline data are critical for defining an impact and measuring additionality."
Reviewer 6		Stage 2 ● The 'methods validation' for Stage 2 seems unnecessary. ○ For serious project developers, it will make more sense for dosing 10's of tons to be the beginning of your 100's of tonnes pilot. You start at lower rates, incrementally increase. "Measur(ing) for predicted impacts and surface additional knowledge gaps" is an obvious central objective of any pilot. ○ "Establish multiple lines of communication with community	The team agrees that baselining work will be a major step in this phase. However we aim to distinguish between very small scale trials that provide valuable learnings on field operations, permitting, monitoring and engineering before scaling up to Stage 3. This stage is important to reflect feedback from communities to "start small" as well as to provide guidance for the field on what is necessary even at smaller scales. This stage offers teams adequate time to establish operational capability and communities and regulators to build confidence in monitoring.

		members”...that’s a planning step, not a ‘methods test’ step ● If you rename Stage 2, “Baselining and Project Establishment”, that makes more sense. Now you’re investing significant $ and time into the project. You're putting equipment on the ground, really hitting the pavement on community, baselining the ocean. Stage 1 looks to be a significant amount of desktop work, with investments are somewhat minimal.	Change: Revised the Stage 2 aim to "To demonstrate and validate dispersal and monitoring methods are working as intended."
Reviewer 6		Stage 3, “Extend baseline to understand seasonal variability”. Obviously for all four seasons this is a year of monitoring data. Ambiguous without more context. Didn’t the framework suggest that baseline data in Stage 2 covers Seasonal Variability? Do you mean interannual variability? Or you mean FURTHER understand seasonal variability?	The team agrees that the baselining activities in Stages 2 and 3 should be clarified, specifically the requirement for achieving temporal variability. Change: Removed requirement of seasonal baseline from stage 2. Expanded definition of baseline activity in Stage 3 to "Extend baseline to understand seasonal and inter-annual variability."
Reviewer 6		Stage 3, “skillful models” - bad phrasing. Suitable models!? Isometric protocols have clear guidance on what a suitable model looks like. This also suggests that the model outputs would be the only determining factor to continuing/reducing/scaling. Much more important than that is successful observational data that determine low risk environmental risk. Model-based assessments of risk are done in Stage 1 or 2.	Change: Revised text to "If the field trial is successful, and observations and suitable models determined low environmental risk to continuous dosing, continue to the next stage."
Reviewer 6		Stage 3 - “Validate models within field observations” - this is extremely hard to do in the context of the field trial, and is unlikely to happen during the early pilot stage, recommending this is	The team agrees that validating models is difficult to do during early pilot stages, but should be a key activity and desired outcome in the field trial stage, before advancing to continuous dosing. Our stages do not indicate preferred or

		removed. Yes you need measurements over longer time periods to ensure the model is accurately representing physics, and to a lesser degree, chemistry. But models don't capture the extreme small-scale variability, particularly in nearshore systems. Your observations near a dosing site will not 'validate' your model's ability to simulate CDR, at least not the way some people will expect when reading this. Maybe on the open shelf in super-calm stratified conditions, but not in an enclosed harbor. Similarly, the text at Line 800 - For example, increased resolution and/or more complex sediment resuspension models....Coupled hydrodynamic-ecosystem-biogeochemistry models can identify complex interactions and aid in developing mitigation strategies. ● Yes, but these kinds of activities/models can not be set up quickly, so it is important to stay grounded in realistic timelines.	necessary timelines, so the teams are free to determine what is "realistic" based on their own projects, budgets, goals and local agreements. No change.
Reviewer 6		Stage 4, stage gate criteria. Who determines the risk level to be manageable? Presumably the project proponent but unclear.	The team agrees that clarity on this point is important. As each project case is unique, we indicate general decision-making and stakeholder groups the project leads should consult with in section 5.1.4. No change.
Reviewer 6		Recommended parameters: turbidity is essential but TSS is recommended? Regulators we speak to would see this the opposite way.	The team agrees. Change: Swap Turbidity and TSS in all relevant sections (Table 1, Table 5 and supporting text)
Reviewer 6		Recommended parameters: I'm yet to be convinced plankton monitoring has any capacity to	The team agrees it is possible plankton will not be affected at smaller scales, and it is appropriate to consider at higher

		inform OAE perturbation in real world trials until at least 1000 tonne+ scale.	scales. The narrative proceeding Table 5 describes that monitoring should reflect the unique risk profile of each project and that strategic integration of parameters across all 3 categories will be required. No change.
Reviewer 6		Recommended parameters: turbidity is essential but TSS is recommended? Regulators we speak to would see this the opposite way. Recommended parameters: I'm yet to be convinced plankton monitoring has any capacity to inform OAE perturbation in real world trials until at least 1000 tonne+ scale.	The team agrees. Change: Swapped Turbidity and TSS in all relevant sections (Table 1, Table 5 and supporting text)
Reviewer 6		Benthic organisms: Monitoring "behaviour" of benthic organisms. What exactly is meant by this and how would it be assessed? Need to be very careful recommending these types of data, as they are Abundance and diversity metrics are typical.	The way the recommendation is written offers practitioners the option to conduct any or all of the suggested measurements as is suitable to their project or target organism. For example, Comeau et al., 2017 showed that three species of bivalve close their valves as a response to both acute and sustained pH, and alkalinity increase. This kind of behaviour would be important to document if it occurred during a field trial. No change.
Reviewer 6		Dissolved oxygen - do we really believe that DO is a suitable metric of overall ecosystem health? There's little/no reason OAE should impact DO to the point that you'd attribute any kind of OAE activity with big changes in DO. Local commercially, ecologically or culturally important species: Definition is very generic, would like to see more specificity on how	The team agrees that DO is likely to not be impacted by an alkalinity addition, however, it is a parameter that is commonly captured in OAE project monitoring plans and "helps assess ecosystem health..." as described in Tables 1 and 5. Change: Moved DO parameter to category group "Attribution Parameters"

		you'd scope this. Otherwise risk monitoring ballooning to unfeasible levels	
Reviewer 6		Local commercially, ecologically or culturally important species: Definition is very generic, would like to see more specificity on how you'd scope this. Otherwise risk monitoring ballooning to unfeasible levels	The team acknowledges the local commercially, ecologically, and/or culturally significant species parameter included in Table 1 and 5 is generic. In section 7.2, there is additional detail on the selection of biological/ecological indicators for monitoring these locally important species. No change.
Reviewer 7	79	Typo	Change: Corrected to "Contributors".
Reviewer 7	177	Ensure consistency with punctuation	Change: Deleted "." from figure titles in table of contents.
Reviewer 7	202	Same as above	Change: Deleted "." from figure titles in table of contents.
Reviewer 7	272	1000 of ton < not consistent with other headers	Change: Replaced "1000s of ton <" with "≥ 1000s of tons"
Reviewer 7	292	Outline of table is not showing up on PDF (border is inconsistent)	Change: Corrected table formatting
Reviewer 7	292	Unclear why phosphate - sulfate are in italics, if this serves a purpose include an asterisk or another marker to clarify	Change: Removed italics from the parameters and added "detail below" to the Nutrient row header to clarify.
Reviewer 7	388	If this document aims to be evergreen, you may consider expanding beyond the 1.5 degree warming mark	The team acknowledges that international targets and climate mitigation strategies are framed around limiting global warming to 1.5-2°C above pre-industrial levels, and agrees the framework should be aligned with that target. Change: Updated text to "To limit global warming to 1.5-2°C [...]"
Reviewer 7	419	Equation 1 marker falls onto two lines	Change: Corrected line break for Equation 1.
Reviewer 7	492	Particulate matter risks described here only focus on the water column, however benthic habitats should be mentioned as well.	Change: Added "[..] and accumulate on the benthic floor which may impact benthic habitats and organisms."

		Changes to benthic habitats (where organisms may feed, reproduce etc) could occur from direct sediment placement or feedstock settling on the seafloor. I believe this risk should be expanded to include these points as it is in other sections of the report.	
Reviewer 7	562	Brucite and steel slag descriptions are not consistent with other definitions. Impurities should be listed (or at least example or most common impurities) as specific elements for ease of reference and consistency.	The team agrees that the brucite and steel slag descriptions should be expanded to be consistent with the level of detail provided for the other feedstocks. Change: Added "such as Fe, Mn, or Zn" for brucite and" and "Si, Mn, Fe,or P" for steel slag.
Reviewer 7	564	No mention of AWL approaches -- they should be included here (described in context of coastal outfalls or CEW, for example), or explained in the introductory materials why they are not included in this framework. See general comment on feedback form.	The team agrees accelerated weathering of limestone (AWL) should be mentioned and its exclusion from the scope of the framework should be explicitly noted. Change: A definition for AWL is introduced at the end of section 4.2.3, with an explanation for why this method is currently out of scope for the EIMF.
Reviewer 7	571	The table description should include that these are environmental impacts to the location of dispersal, not upstream / downstream effects. For many of the feedstocks listed, environmental impacts upstream are significant.	Change: Table description "Characteristics of Commonly considered OAE feedstocks and implications for environmental impact at the addition site"
Reviewer 7	602	A quick explanation of vivianite and struvite affect marine life is needed in this sentence	The team agrees the marine life impact of vivianite and struvite precipitation should be explained. Change: Update the referenced line to "For example, vivianite and struvite precipitates may form during alkalinization of treated wastewater, which can alter nutrient availability and

			generate particulates that may affect benthic or filter-feeding organisms if they accumulate locally."
Reviewer 7	606	The discussion of avoided emissions seems beyond the scope of this document. These short overviews of these methods seem to include pertinent details for the EIMF, yet it is unclear how these avoided emission details are utilized for the EIMF.	The team agrees with the reviewer that emissions reduction is out of scope, and is only briefly mentioned in the document. However, we believe it helps to contextualize the method and its benefits, as people may want to weigh the climate action of avoidance versus removals differently against the environmental risk. No change.
Reviewer 7	735	Missing hyphen in LOC-NESS	Change: Added hyphen to "LOC-NESS"
Reviewer 7	790	Unclear if the suggested extended baseline is meant to be in a control area, or the field site itself. If in the field site itself then it seems like this should be woven into Stage 2. In terms of timing and capital it does not seem reasonable for projects to start stage 3 with the requirements to take an	Stage 2 and Stage 3 projects have limited impacts by the nature of their limited scope, duration and research questions. Some baseline is required, but seasonal and interannual baselines become an essential component as projects consider extending into longer periods and potentially across seasons that have not been adequately studied. Change: Clarified that Stage 3 baseline extension should include "seasonal and, ideally, interannual variability and significant weather events." and added reference to section 7.1 for additional considerations on baselining, including conducting it at the field site or using a control site.
Reviewer 7	798	Legacy bolded parentheses	Change: Un-bolded the parentheses.
Reviewer 7	821	These sentences include phases that are repetitive. Consider modifying some terms to enhance readability. In particular, "operation, operators" and "must make informed...must be monitored"	Change: "Once a robust understanding of the site and operation is established, operators..." and Replace "must" with "will".
Reviewer 7	827	Already have introduced TSS as a term	Change: Replaced "Total Suspended Solids" with "TSS"

Reviewer 7	840	I strongly encourage the authors to consider building in this LCA language [before stage 4] to avoid potential scaling up of approaches that are not sustainable. See applicable studies listed here: https://doi.org/10.1016/j.spc.2019.05.002 https://doi.org/10.3389/fclim.2022.841907 https://doi.org/10.1016/j.rser.2025.116091 (mCDR specific that speaks to the challenges of including LCA's early in the R&D process)	The team agrees that LCAs are an important decision-making tool for field projects in the near- and medium-term. However in Stages 3 and below, the projects are likely working with materials that are still commercially and readily available, without yet triggering significant upstream environmental impacts. Although many projects will be considering their LCAs for crediting purposes, it is not necessary for discrete trials in Stage 3, especially if they are conducted by academic researchers that are not prioritizing research questions about scalability. Change: Added a new citation, reference 76, at the end of the LCA description.
Reviewer 7	863	While the information provided in section 6 is all very meaningful, it seems to relate strongly to the recently released Nawaz and Belotti, 2025 framework. I would like to see this section crosswalked with that framework to ensure consistent information is provided. If there are recommendations that differ it would be more meaningful to explicitly state what that information is and why it diverges. This could be similar to how lines 1168 to 1174 include mention of FEMM.	The team agrees with including additional references to external resources regarding coastal community engagement. Change: Added references 77-78 and the line "When engaging with coastal communities, project leads may benefit from referencing best practice guidelines from specialists such as the recently published Engaging Coastal Communities on OAE and Effective Engagement of the Fishing Community in a mCDR Context."
Reviewer 7	1058	Who determines what "sufficient" information is? Consider defining sufficient a bit more explicitly	The team agrees it is important to clarify what sufficient looks like and according to whom in this statement. Change: Rephrased to "Only once sufficient knowledge has been gained to confidently assess environmental risk and attribute observed impacts, as agreed upon through engagement with regulators, scientific partners and affected stakeholders, may it be

			appropriate to reduce the number of parameters that are measured or the frequency of measurements."
Reviewer 7	1389	Seems to be missing a bullet point	Change: Corrected bullet list formatting.
Reviewer 7	1582	This section uses contractions which is not consistent with other sections of the text.	Change: Expanded the use of contractions for consistency across the document.
Reviewer 7	1601	Add US before EPA per the agency's preference.	Change: Added "U.S." before Environmental Protection Agency.
Reviewer 7	1641	Missing space for "Completed Permitted".	Change: Updated to "Completed and Permitted".
Reviewer 7	1798	Maintain consistency with the UK section with London Convention and London Protocol OR London Convention and Protocol.	Change: Updated all full name references to the LC/LP to "London Convention and the London Protocol"
Reviewer 7	1849	The operation safety section is important and unique. Should this be something operators produce during a stage? Perhaps at Stage 2 or 3. Out of all sections it comes across as simply tacked onto the end of the document rather than integrated, even though it is a useful section.	Change: Added "Create an operational health & safety protocol" as a key activity in Stage 2 and an additional callout at the beginning of section 9 to highlight the importance of operational safety when transitioning to real-world implementation.
Reviewer 7	1966	Somewhere in this section the value of a structured data sharing plan should be underscored and related back to environmental monitoring. This data section has implications for how experimental design and/or concerns should be adapted based on new scientific knowledge. How can that knowledge be easily transferred? How does following these recommended structures increase the flow of information for the field?	The team agrees the section would benefit from further elaboration on how data-sharing and reporting contribute to the field's development, and how it can be achieved. Change: Revised concluding sentence of the section 10' introductory paragraph to: "Data collected as part of OAE field trials and operations "should be well structured and standardized to maximally support intercomparison, accelerate learning across projects, and made openly available for the research and regulatory community."
Reviewer 7	2492	Clarify US EPA	Change: Added "U.S." prior to "EPA" in caption

Reviewer 7	596 (also 1008)	Here, TSS are discussed as the often required measurement for permit compliance. However, Table 1 mentioned Turbidity is usually the parameter required by regulators and TSS is a recommended parameter. Ensure there is consistency with these sections. I believe TSS should be swapped with turbidity in Table 1 as my understanding is that regulators tend to require TSS. However, this should be confirmed.	The team agrees. Change: Swap Turbidity and TSS in all relevant sections (Table 1, Table 5 and supporting text)
Reviewer 7	Figure 8 caption (line # cut off)	Clarify US EPA	Change: Added "U.S." prior to "EPA" in caption
Reviewer 7	General grammar comments	Inconsistent use of hyphens where em dashes should be used	Change: Standardized the use of hyphens and em dashes across the document
Reviewer 7	Table 5	Ensure consistent formatting on table (bold lines throughout)	Change: Formatting updated for consistency
Reviewer 8	260	Do you intend to only include stakeholders, or should Rightsholders also be acknowledged here? This comment can also be carried throughout the document whenever stakeholders is mentioned	In the executive summary, we list "industry stakeholders" as a key target audience for this document. In this context, the term is appropriately used. Elsewhere in the document, we agree it is helpful to enumerate rightsholders as a unique interested party. Change: Included additional reference to "rightsholder" in several places throughout the document, where appropriate, including in the title to section 6.
Reviewer 8	272	I assume the tons for scale is referring to tons of OAE deployed (since at this point it's hard to guarantee the tons removed). This might need to be clarified	Graphic states that the indicative scale refers to tons of alkalinity material No change.

Reviewer 8	288	When referring to the different types of permitting, it might be good to clarify what parts of the world are considered when talking about “comprehensive analysis of recent field trial…” since parameters and requirements differ widely	Change: Added reference to section 8, where specific country and permit information is provided.
Reviewer 8	288	When saying that there are “additional parameters that should be monitored”, it is a bit unclear what “should” means. Is it a prescriptive stance that projects should opt in to monitor these things on their own good will because they might influence the environment? Is it that permits “should” require these things? A bit more clarity in the recommendation or stance might help.	Change: Updated parameter category names and revised introductory language to "Additional parameters- referred to here as Attribution and Context-Specific Parameters support the interpretation of biological impacts and attribution, and their inclusion will depend on the OAE method and receiving ecosystem, as outlined in Table 2 and discussed throughout the framework."
Reviewer 8	307	Is this a typo: “transparently in others”?	Change: Removed "in others."
Reviewer 8	446	It might be nice to add in the consideration of baseline environmental conditions in context with these two considerations to emphasize it is nearly as important as knowing what the alkalinity additions are. I know it talks about it in the next paragraph, but that makes it seem like not one of the top considerations.	This sentence is meant to introduce the pathway-driven considerations of where and what to monitor. The role of baseline data in understanding where and how alkalinity is delivered is discussed in the following paragraph. More detail on baselining is provided in section 7.1. No change.
Reviewer 8	502	It might be nice to add something about understanding potential compounding activities and/or seasonal conditions within the environment. For example, if there is a waste water sewage plant nearby, it is good to know how they may influence the baseline conditions and therefore the	The team agrees that ocean usage impacts and poses potential for compounding environmental impacts Change: Updated list item to read "Time research with seasonal chemical and ecological variability, and existing marine usage in mind."

		environmental impact of your activity	
Reviewer 8	571	This is a bit confusing since it does not address electrochemically produced sources and/or refers to sodium hydroxide as a mineral	Change: Added "Highly soluble alkalinity source, rarely used in solid form." to clarify the description.
Reviewer 8	669	By saying "not all impacts are harmful", this assumes that impact is negative. But impacts are neutral and can be defined as positive or negative. Possibly addressing this would be helpful	Change: Replaced "not all impacts are harmful" with "impacts can be positive, neutral, or negative, and the ..."
Reviewer 8	793	The example of flooding seems to be very specific. Maybe say subject to weather events (i.e. flooding, storms)	The team agrees that using "flooding" as an example here could be interpreted as too specific. Change: Include additional context, "Baseline data, whenever possible, should aim to capture significant weather events to understand the extremes of natural variability at the site. Especially events that occur seasonally or annually such as marine heat waves, seasonal flooding, drought, etc. The occurrence of a significant weather event should be noted in the metadata and additional monitoring will depend on the type of weather (i.e. flooding may increase turbidity whereas a heat wave may decrease carbon solubility)."
Reviewer 8	809	It might be better to use different language than "if the field trial is successful". What type of success? Effective carbon removal? Effective deployment? Effective monitoring?	The language here is intentionally generalized because each field trial has a unique set of research questions and goals. No change.
Reviewer 8	811	In stage 4, it is talking about scaling up to this level. Is it expected that the long-term continuous deployments would be scaling to <1000 tons as stated in Figure 1? It might be good to talk about that when talking about scaling in the text to remind the	Change: Replaced '1000s of ton < 'with '≥ 1000 of tons'

		reader that it is not scaling to commercial scale	
Reviewer 8	1004	It is recognized that the parameters required may vary by jurisdiction - as noted in my suggestions above, it might be nice to indicate where you received these parameters from	Change: Linked to section 8 that describes the countries and regulations consulted.
Reviewer 8	1016	Since this section directly follows engagement, it might be good to note that additional parameters can be informed by community priorities to address important parameters within the region	Change: Added community consideration, "...highly dependent on the project's feedstock, location, dispersal method, predicted impacts, and community priorities."
Reviewer 8	1482	I think an important first step to highlight here would be to know your regulatory landscape. There is a lot of knowledge scientists can gain by learning the regulatory processes and pathways that are currently available and at play in their region.	Change: Added list item "Understand your regulatory landscape: Becoming familiar with the jurisdictions, regulatory officials, and relevant procedures before engagement can help ensure efforts are targeted to the appropriate decision-makers."
Reviewer 9	256	Maintaining a balanced and transparent approach to responsible conduct is critical, particularly given that the updated framework emphasizes benefits for a wide range of stakeholders, including local communities and Indigenous peoples. Section 5.1.1 underscores the importance of relationship building. In this context, referencing additional literature that articulates principles for responsible marine carbon dioxide removal (mCDR) governance would strengthen the discussion. For example, Doney et al. (2025) outline key principles for effective and equitable mCDR development (DOI: 10.69902/84b3a9a8).	The team agrees. Change: Included hyperlinks to "Aspen's mCDR Code of Conduct" reference, and "Principles for responsible and effective marine carbon dioxide removal development and governance" as an additional reference.

		Furthermore, Indigenous perspectives on conduct must be acknowledged, as Traditional Ecological Knowledge (TEK) and Indigenous Knowledge (IK) may inform alternative approaches to stewardship and decision-making. Gardner et al. (2025) provide best-practice guidance for Tribal and Indigenous engagement in mCDR projects, offering a valuable resource for integrating these perspectives into governance frameworks (https://cf.nwf.org/-/media/Documents/PDFs/Climate/Marine-Carbon-Dioxide-Removal-Best-Practices-Tribal-and-Indigenous-Engagement.pdf). Finally, the broken link to the Aspen Institute code of conduct (ref 1) should be updated to ensure access to all referenced guidance documents.	
Reviewer 9	256	Furthermore, Indigenous perspectives on conduct must be acknowledged, as Traditional Ecological Knowledge (TEK) and Indigenous Knowledge (IK) may inform alternative approaches to stewardship and decision-making. Gardner et al. (2025) provide best-practice guidance for Tribal and Indigenous engagement in mCDR projects, offering a valuable resource for integrating these perspectives into governance frameworks (https://cf.nwf.org/-/media/Documents/PDFs/Climate/Marine-Carbon-Dioxide-Removal-Best-Practices-Tribal-and-Indigenous-Engagement.pdf). Finally, the broken link to the Aspen Institute code of conduct (ref 1) should be updated	Change: Expanded on stakeholder mapping and outreach to include information and resource gathering, highlighting Indigenous engagement as an example in section 6.2. Updated link to Aspen's Code of Conduct.

		to ensure access to all referenced guidance documents.	
Reviewer 9	262	In this statement, and often throughout the document, they talk about a phased approach without really describing realistic timelines associated with scalability.	The team agrees that project timelines will vary based on the specific activities undertaken and project circumstances. However, current timeline perspectives are not consistent or readily available enough to provide realistic estimates for each phase/activity. Change: Added text "There is no set duration for each stage, as this depends on the availability of relevant existing information, speed of learning and a range of outside factors."
Reviewer 9	292	Table 1 currently provides justification for essential, recommended, and additional parameters, but supporting references are inconsistent. To strengthen the rationale, references should be included for all parameters. This can be achieved by adding the reference numbers used in Table 5 to the corresponding entries in Table 1.	Change: Added table 5 references to table 1.
Reviewer 9	292	Suggest moving benthic habitat, benthic organisms, and significant species to essential or recommended parameters, as the risk is that these 'additional' parameters may be neglected as though optional	The team agrees that the key parameter category names could be refined to avoid implying relative importance across the categories. A key concept behind the framework is to provide relevant guidance across research scales and the unique environmental risks of each project, so in some cases it may not be possible or relevant to monitor certain parameters. Change: Updated the key parameter categories to "Regulatory Parameters", "Attribution Parameters" and "Context-Specific Parameters."
Reviewer 9	295	Could references be added to the first paragraph of the introduction?	Change: Added reference citations for "State of CDR, 2nd Edition" report and

		This would strengthen the arguments presented. For example, why is OAE more promising in terms of long-lasting benefits, what studies support that claim specifically?	"IPCC Sixth Assessment Report" to the text.
Reviewer 9	362	The analysis of peer-reviewed scientific literature is an important point. However, this field is progressing at an exceptionally fast pace, and new relevant studies may not be included in the current review. A caveat could be added specifying the time frame of the review (e.g., “literature reviewed up to "month, 2025”), so readers understand the scope and limitations.	Change: Revised to "(literature reviewed up to February of 2025)".
Reviewer 9	363	Within these 7 steps, have there been efforts to reach out to Indigenous and other local communities? Step 7 is open to all, but have specific diversity groups been invited to take part? It would be worth mentioning if that is the case. The relationship building mentioned in section 5.1.1 is also important for this document, not just the activities it aims to provide a framework for.	The team agrees. This report has benefited from input provided by over 60 individuals across a range of disciplines and represented groups, including Indigenous representatives, and in a range of formats from in-person workshops to asynchronous reviews, formal and informal feedback, and public comment periods. It will also continue to evolve as the science evolves, with iterations over time. No change.
Reviewer 9	397	Are the references cited here (11–12) appropriate? They seem very narrow in scope, focusing on specific contexts rather than providing a broader conceptual foundation for alkalinity sources in oceanic environments.	Thank you for catching this error on our part. The line was meant to cite reference 13, a review on Ocean Alkalinity, Buffering, and Biogeochemical Processes (2020) by J. Middelburg and colleagues, not the two references that are listed. Change: Corrected to the appropriate reference number.
Reviewer 9	423	Why are the verbs past tense? "Indicated"	Change: Corrected to present tense - "indicates".

Reviewer 9	424	Figure 2. The title should read " Illustrates the processes..." (not single, since two processes are possible as mentioned in the action box).	Change: Replaced "process" with "processes".
Reviewer 9	426	pH could be defined : potential of hydrogen (pH) measures...	Change: Revised to "potential of hydrogen (pH)".
Reviewer 9	434	This phrase should be framed in the context of OAE explicitly (increasing TA from OAE). Natural equilibration with the atmosphere can go both ways (seasonally, regionally, etc), affecting directional trend of pCO2 and pH both ways.	Change: Added "It should be noted that variability in this system does not always result in perfect equilibration and there are regions of the ocean with persistent trends of CO2 absorption or outgassing."
Reviewer 9	440	This section includes “Biogeochemical Changes,” in its title yet biological and ecological aspects receive minimal attention in the first part. To provide clarity and set expectations for the reader, it would be helpful to include a brief reference to the upcoming sections (4.1.1, 7.2, 7.3), which addresses these topics in greater detail. Also a note that no references are provided in this first part of the section, except ref 18 for figure 3 which is a paper about dispersion of pollutants in general.	The team agrees that this section is in need of additional scientific references in support of our statements, as well as guidance to later sections that provide more detail on the specific biological and ecological monitoring considerations. Change: Removed 'Monitoring' from section title. Added additional references 39-45 and linked to sections 7.2 and 7.3.
Reviewer 9	446	The link from reference 17 (Ocean Visions doc) is broken. Could other references be added here?	Change: Corrected "Ocean Visions mCDR Field Trial Database" reference link in References appendix. Added reference for "NASEM 2022 mCDR Research Strategy" report to section 4.1.
Reviewer 9	509	just enough... sounds vague in the context of mitigating risk. Suggest "Release only the minimum volume necessary to achieve the experimental objectives and generate statistically robust data, while avoiding unnecessary environmental perturbation".	Change: Accepted suggested language "Release only the minimum volume necessary to achieve the experimental objectives and generate statistically robust data, while avoiding unnecessary environmental perturbation."

Reviewer 9	514	Ramp up operations gradually: should it be noted that this should use the stage-gated approach so that there is assessment at each point?	Change: Added "through stage-gated approach with assessment criteria"
Reviewer 9	523	RE dispersal, it could be noted that some of the dispersal range might be predicted through physical oceanographic models, or is that already implied?	Change: Added "modeling" to list
Reviewer 9	524	Important statement. Suggest adding "select field sites with good baseline data and/or project timelines to gather good baseline data and operational timelines..."	The availability of baseline data is just one of many factors that go into site selection. Further detail on baselines are provided in section 7.1 No change.
Reviewer 9	524	Important statement. Suggest adding "Dependent on location this may include extended timelines (e.g. not weeks or months for some benthic species but years to decades)"	This section primarily pertains to the physical dispersal of alkaline materials; biological impacts are introduced in subsequent sections. No change.
Reviewer 9	545	Why is 'characterize the composition and consistency of feedstock for impurities' only listed for coastal enhanced weathering, rather than for all of the chemical addition methods in this figure? Perhaps this should be identified in the following text of 4.1.3. and refer to the figure	Change: The team agrees. This bullet has been removed from the table, and included into the section 4.1.3 to broadly apply to all feedstock types.
Reviewer 9	553	Under Open Ocean Alkalinity Addition it says key monitoring locations are the Water Column but should also seabed be added as one of the unique focus areas for monitoring is 'assess risk of secondary precipitation;	It is extremely difficult to attribute sediment changes on the seafloor to alkalinity additions at the surface in an open ocean setting. Secondary precipitation should be mitigated through careful dosing and monitored in the water column based on best available science of precipitation triggers. No change.
Reviewer 9	553	Under coastal outfall pipe and alkalinity addition, it says to assess	The team agrees with this reviewer.

		risk of benthic accumulation - in line with the recommendations for the river alkalinity, this should also include 'Assess sensitivity of pelagic and benthic species to pH changes' OR (in line with the electrochemical acid removal, it could be 'Assess ecosystem impacts from transient pH and alkalinity changes'	Change: Added "Assess ecosystem impacts from transient pH and alkalinity changes." to Coastal Outfall Pipe method
Reviewer 9	571	Is this reference (22) correct in relation to the addition of naturally occurring carbonates ? "An international database for pesticide risk assessments and management"?	Change: Removed reference
Reviewer 9	574	Could references be added to the subsections of this 4.2 OAE methods for clarity and transparency?	Thank you for the suggestion. Change: Added references 44, 57, 59, 61- 67 across the method descriptions, and a concluding section sentence to refer to the OAE best practices guide (2023) where there is a chapter describing OAE approaches in detail.
Reviewer 9	578	Is there a reference that could be added for larger particle settling velocities?	Thanks for the suggestion. We've added a reference; https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2024EF005463
Reviewer 9	611	Dispersal efficiency may also be a function of local topography and oceanography so suggestion that this statement should be revised. Also are there interactions with nitrogen that can lead to outgassing, so should that also be monitored?	Statement refers to the ability for the technology to disperse alkalinity relative to other technologies, not the total dispersal rate or efficiency. No change.
Reviewer 9	628	Is it true that only electrochemical acid removal will lead to community shifts in plankton species? This is listed as unique under this method, but is that not also true of other OAE methods?	This statement is specific to effects of seawater uptake by the electrochemical facility. Broader effects on phytoplankton explored in Section 7.3. No change.

Reviewer 9	638	Does the company need to be identified specifically (proprietary process?) at this point in the document? Or is citing the source sufficient here?	Change: Replaced mention of company name with "One such method"
Reviewer 9	656	Important statements. Suggest adding 'This may resulted in extended timelines for project scalabillity'	This section is about the definition of an impact, not implications for scaling which should be discussed on a case by case basis with the stakeholders and regulators of each project. No change.
Reviewer 9	687	This is critical, absolutely essential. But I think it's not just about understanding the public perception, or appetite for engagement, and assets... I think the idea of "Benchmarks and baselines" should be re-discussed here as well. In some countries, oceanic baseline monitoring of carbonate chemistry already exists through federal or provincial entities, and scientists have been working for decades to build these long-term datasets. Yet, these experts are sometimes not kept informed about OAE projects and activities, which creates serious risks of undermining the integrity of existing monitoring programs. It is essential that these scientists be included in discussions prior to any interventions, both to safeguard continuity of baseline data and to ensure that environmental assessments are grounded in robust, historical context. Failure to engage these stakeholders early could lead to irreversible data gaps and erode trust in the governance of marine CDR initiatives.	The team agrees to highlight the need to establish early relationships with owners of relevant, longitudinal data. Change: Clarified text in section 5.1.1 "Stage 1 Planning & Preparation" to "This will include conversations with regulators, non-profits, civic society, Indigenous communities, fisheries, research organizations and federal, and academic efforts to collect longitudinal data in the area."

		Also that these baselines provide important context on monitoring broader climate change which is important for a range of decision-making processes	
Reviewer 9	708	Just a note that the word Indigenous should always be capitalized	Change: Capitalized "Indigenous" across the document
Reviewer 9	729	Important statements. Suggest adding 'developing these collection plans may be resource intensive - depending on site and scale (e.g. benthic surveys over many kilometers)'	Monitoring plans should reflect the anticipated risk of the proposed project, many of which may be small in scale and not likely to trigger benthic impacts over kilometers. As such, the authors hesitate to add this clarification at this stage. Additional details on baselines and benthic impacts are provided in sections 7.1 and 7.3. No change.
Reviewer 9	729	Defining what constitutes a “baseline collection” in Stage 2 is critical. Are a few measurements sufficient, or must seasonal and interannual variability be accounted for? A robust baseline should capture natural variability across relevant time scales to ensure that observed changes can be attributed to interventions rather than background fluctuations. This is not a trivial point, particularly given the current pressure to accelerate deployments, which risks compromising scientific rigor if baseline requirements are not clearly established. Lines 790–791 in Stage 3 mention “an extended baseline that captures seasonal variability and significant weather events” ... meaning that "normal baseline collection" in stage 2 could omit surveying on these time-scales? Lines 1068 to 1071 mention this: "As such, baseline	The team agrees that baselines are essential and provide additional detail on baseline collection in section 7.1 "Baseline and Control Sites." Change: Removed "seasonal" from the baseline requirement in Stage 2 to better clarify the different requirements between stages.

		data should aim to capture seasonal variability and include data taken in different weather conditions (e.g., after heavy rain, drought, and high wind etc.) as well as across depth gradients. " It should be made clear what "normal" baseline collection entails here or refer to other sections which discuss this more specifically (?).	
Reviewer 9	735	Reference (citation) to Dalhousie tracer study?	Change: Added hyperlink to Dalhousie blog post about the dye tracer study and reference to a 2025 study that describes the dye release in the methods.
Reviewer 9	737	"will be informed by" sounds awkward. Suggestion to rephrase "Locally sensitive or culturally significant species should be identified in collaboration with local communities, ..."	Change: Replaced text with "Local research centers, public entities, or community resources may be able to provide and help interpret existing data on sensitive or culturally important species and habitats."
Reviewer 9	739	hypoxic zones could be added since low O2 (not just the absence of O2 - anoxia) is a stressor	Change: Added "hypoxic/anoxic zones or vulnerability..."
Reviewer 9	742	It would also be helpful to include that species sensitivity assessments should also encompass all organism life stages - ultimately this might define when OAE activities take place to reduce risk	Change: "This will include a combined analysis of all local, lab, mesocosm, and in-situ data, as well as species sensitivity analysis at different life stages to clearly outline the predicted impacts"
Reviewer 9	765	Environmental impact thresholds - who will conduct and set these? Community consensus on levels or just dependent on site and location	Thank you for the clarifying question. In some cases, environmental limits are already established by a regulator. In other cases, new evidence must be developed and findings must be evaluated together with the project proponent, local stakeholders and regulators. This is an area of open science where operational thresholds are slowly starting to come into focus that would avoid triggering biological impacts, but these are highly dependent on

			receiving ocean conditions and more research is needed. No change.
Reviewer 9	774	Ideally - yes. But real-world? Particularly in the deep sea - this may be too resource intensive to obtain this goal.	The team agrees it would be challenging to collect this data in the deep sea. In section 7.2, the framework recommends a process for researchers to identify the concentrated areas where impacts are likely to be felt In the current state of the field, these are in more accessible areas such as coasts or in the upper areas of the surface ocean with open-ocean dispersal pathways as described in Table 2 and section 4.2. No change.
Reviewer 9	795	Suggest sentence revision to 'impacts to socioeconomically or culturally important species'	Change: Added "[..] socioeconomically or [...]".
Reviewer 9	836	While the engagement of community watchdogs and local conservation groups is valuable, operators must be required to implement formal, transparent mechanisms for accountability, including clear reporting protocols, independent oversight, and accessible communication channels. These measures ensure that responsibility for compliance and monitoring remains with those conducting the interventions, rather than being informally delegated to community groups.	Change: Replaced with "Community watchdogs, conservation groups, and regulators..."
Reviewer 9	836	It is more likely to be regional or national governance or management that will 'hold operators to account' through regulations. Perhaps this sentence could be reframed to 'For continued societal acceptance, community watchdogs and local conservation groups...'	Change: Removed mention of these actors in this section as the topic is more comprehensively covered in Section 6.

Reviewer 9	958	Could also established methods of information and dissemination include development of a community of practice? If done correctly, this could be a forum that would be more than passive communication	The team agrees this is valuable to include. Change: Added "Community of Practice" as a public engagement strategy in Table 4.
Reviewer 9	958	To strengthen this table and section 6.3 altogether, consider referencing UNDRIP as a foundational document. It provides internationally recognized principles for Indigenous rights and engagement, including free, prior, and informed consent (FPIC). Linking best practices to UNDRIP would demonstrate alignment with global standards and reinforce the legitimacy of the engagement framework and strategies.	The team agrees UNDRIP provides helpful and relevant considerations on Indigenous rights and engagement for OAE field research. Change: Added to section 6: "The United Nations Declaration on the Rights of Indigenous Peoples serves as a comprehensive international instrument to promote and protect Indigenous people's collective and individual rights. "
Reviewer 9	958	Rightsholders should be also explicitly mentioned alongside stakeholders as they often have independent levels of governance	Change: Rightsholders are referenced throughout the document and added in two additional places.
Reviewer 9	959	It would be good if it was acknowledged that engagement timelines may vary depending on region and also particular communities. As thankfully noted in this document, engagement is a continuous process and for some communities there may need to be years of investment in engagement prior to a proponent developing a larger-scale project	Language about "continuous and evolving practice" assumes variable timelines. No change.
Reviewer 9	1004	Definition of essential parameters - early warning of potential 'stress'. Would that not be 'stress' to organisms rather than to seawater? Or is it that it's meant that 'stress' are levels where biological studies of OAE exposures have indicated that it's stressful?	Change: Clarified stress to ecology "These are mostly physico-chemical proxies that provide early warning of potential ecological stress"

Reviewer 9	1050	The authors may wish to consider including the following in Table 5 for monitoring pH: https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2025JC022575	This methodology was received and reviewed with gratitude. We are aiming to include tried and tested methods for monitoring. As this methodology is more emerging in nature, it may qualify for inclusion in subsequent iterations of this document. No change.
Reviewer 9	1050	Why not designate TA as an essential parameter? OAE is alkalinity perturbation. Without TA, how can dissolution efficiency be assessed or unintended precipitation processes detected? TA is also critical for validating models and ensuring compliance with environmental monitoring frameworks. While TA measurements can be time-consuming and require discrete bottle sampling, they remain a rigorous method for characterizing carbonate system changes. Furthermore, making at least two carbonate-system parameters essential would provide a broader analytical foundation, as other carbonate-derived variables could be retro-calculated from these measurements? Also note that TA is included as an example of a safety protocol trigger for ceasing activity so it seems like it should be an essential variable (see Table 9)	The team agrees with the reviewer that TA is likely to be monitored alongside OAE projects, however it is not yet required by regulators and may not be necessary or possible to detect at smaller project scales. Change: We have recategorized these parameters to better reflect and distinguish between those typically required by regulators, those that help attribute changes in carbonate chemistry and those that are context-specific.
Reviewer 9	1050	A lot of the parameters that are used by managers and regulators of living marine resources are in the 'additional' parameters, such as benthics species or locally commercially, ecologically or culturally important species. This	The team agrees with the reviewer that the Key Parameter groups could be refined. Change: Update the Key Parameter categories to read: Regulatory-Core Parameters, Attribution Parameters and

		would involve fisheries and aquaculture management, marine protected areas and spatial management. Ocean management doesn't manage plankton, but manages those environments and stocks. Whilst it is noted by the authors that these 'additional' parameters may be more important in some circumstances, there is a concern that the classification as 'additional' will mean that they are overlooked. Is there not some way of putting in mention of this in the essential parameter definitions of 'stress' for example?	Context-Specific Parameters. A key concept behind the framework is to provide relevant guidance across research scales and the unique environmental risks of each project. In smaller stages and in some pathways, there may be no anticipated risk to species that are monitored by marine resource managers, though these stakeholders should be carefully consulted early and often.
Reviewer 9	1063	It would be helpful if there was a temporal definition of what might be required to give the reader an idea of investment necessary	The approach to baselines should reflect the natural variability of the site and the scope and design of the experiment. For this reason the team hesitates to provide a recommended "minimum" amount of baseline data collection required. For example, in some cases a monitoring campaign that compares data in and out of an alkalinity plume can provide a sufficiently accurate comparison for a short term, small scale study. No change.
Reviewer 9	1149	Suggest addition to end of sentence that '...can be used in developing monitoring plans, and project-specific species considerations should be included'. Suggesting this as the majority of species in appendix b are not species consumed by people	Neither the examples provided in appendix B nor the paragraph in which this statement is found, apply only to commercially consumed species. The additional language does not add clarity to the use of material in appendix B. No change.
Reviewer 9	1209	Yes - but doesn't detail enough issues with corals	As of yet there is no conclusive evidence on the impacts of OAE on corals specifically. Further, there are no existing or proposed OAE field trials near coral reefs. No change.

Reviewer 9	1216	Stakeholder does not include Indigenous Peoples	Change: Updated text to "stakeholder and Indigenous engagement" to clarify
Reviewer 9	1227	Again not acknowledging length of time for benthic community	Change: Added "Some sites will need to monitor for longer to capture long-lived impacts, such as accumulation of feedstock in sediment, especially in slow-to-recover, benthic species (e.g. corals)."
Reviewer 9	1260	Are references 77 and 78 the best options here? The link to 77 is broken. Could you include an ICES document such as "ICES (2020). ICES and Ecosystem-based management. ICES Convention, policies, and strategy. Report. https://doi.org/10.17895/ices.pub.5466" this provides authoritative guidance on ecosystem-based approaches, which are highly relevant for framing environmental risk assessments in marine contexts.	Thank you for the suggestion and the team agrees. Change: Updated citation links and added reference to the "ICES and Ecosystem-based management" report.
Reviewer 9	1307	Could references be added here to these resources from IUCN and NOAA? Note: think the hyperlinks are broken	The team agrees. Change: Added reference citations to the IUCN and NOAA resources.
Reviewer 9	1310	Section 7.3: This section introduction does not acknowledge that most of the benthic communities of this work (especially given large areas could cover) are deep and likely beyond scuba and/or typical shallow subtidal studies. Addressed later on in the section but does not detail how resource intensive.	The team acknowledges that this may become a risk at megaton scale. However, at current research scales benthic impacts are likely to be very concentrated to areas of release and thus accessible for monitoring as described in section 7.3. No change.
Reviewer 9	1354	This paragraph would benefit from the addition of references	Change: Added references 119-124: "Mesocosm experiments in ocean alkalinity enhancement research"

			"Benthic habitat mapping: A review of three decades of mapping biological patterns on the seafloor" "Potential ecological monitoring indicators and strategies for the Anguniaqvia niqiqyuam Marine Protected Area and a synopsis of available information" "Timescales of Benthic Macrofaunal Response to Diel and Episodic Low Oxygen in a Subtropical Estuary" "Benthic community response to temporal and spatial gradients in physical disturbance within a deep-sea western boundary region" "A year in hypoxia: epibenthic community responses to severe oxygen deficit at a subsea observatory in a coastal inlet"
Reviewer 9	1359	Excellent and realistic sentence.	No change.
Reviewer 9	1362	Proxy and inferences are likely not reasonable for the majority of the sites.	At this time, there is no evidence that the deep sea benthos will be impacted at current or near term research scales. As evidence emerges that this is an area of environmental risk, this framework will require an update with recommended monitoring strategies. No change.
Reviewer 9	1380	The paper referenced (71) is for river restoration (Best Practices for Monitoring and Assessing the Ecological Response to River Restoration), could additional references specific to oceanic environments be added? E.g.: Lisa A Kerr, Jacob P Kritzer, Steven X Cadrin, Strengths and limitations of before–after–control–impact analysis for testing the effects of marine protected areas on managed populations, ICES	Thank you for the suggestion. Change: Added reference and citation to the recommended report "Strengths and limitations of before–after–control–impact analysis for testing the effects of marine protected areas on managed populations".

		Journal of Marine Science, Volume 76, Issue 4, July-August 2019, Pages 1039–1051, https://doi.org/10.1093/icesjms/fsz014	
Reviewer 9	1403	eDNA sampling does not 'identify all organisms present' but rather refers the sequenced DNA to that of reference DNA libraries or databases (and there are some species not sequenced that would be unknowns). Suggest revision of sentence to reflect that, or that or to say that eDNA sequencing could be targeted for known species of interest / protection	Thank you for the suggestion. The team agrees with your suggested language change to clarify the use of eDNA. Change: Revised text to "... genetic barcodes that can identify all known organisms (whose DNA has already been sequenced) or to target known species of interest."
Reviewer 9	1433	Section 7.4 would benefit from more than one reference.	Change: Added citation for Modelling considerations for research on ocean alkalinity enhancement (OAE)
Reviewer 9	1441	Reference to the OAE efficiencies map from carbonplan.org could be used here	The CarbonPlan OAE Efficiency Map is a very useful, but high level tool that does not offer sufficiently high resolution insight for the purposes of environmental monitoring. No change.
Reviewer 9	1505	Add BBNJ	Change: Updated language to include the BBNJ: "[...] the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction Agreement (BBNJ) and the no-harm rule [...]"
Reviewer 9	1535	Note that 'legitimate scientific research' has not yet been defined	Change: Added disclaimer "(which has yet to be defined)"
Reviewer 9	1567	Is there a need to specify "qualitative risk assessment" here? Could it be quantitative in some cases, where the data allows? Removing the specification would allow for either approach to be determined case by case.	Change: Updated language to "project-based risk assessment"
Reviewer 9	1578	"International law is not directly binding on private actors. As a	Thank you for your suggestion. A shorter version of the suggested text has been

		result, the permitting and other regulation of individual projects occurs at the national and sub-national levels. Proactively engaging regulators - often many months ahead of formal applications - lays the foundation for smoother permitting. Most OAE permit decisions hinge on a clear demonstration of environmental risk management, while some permitting authorities also want to see a demonstration of how the project contributes to the region's environmental and climate obligations." Suggestion to add the following at the end of this text: "It is important to take into account all marine protected areas (MPAs) and other conservation measures in the region, noting that MPA regulations may not allow OAE projects within their boundaries. Additionally, regulators involved in marine conservation or spatial planning may have relevant information about where conservation areas may be sited in the future, which could impact an OAE project, and/or information ecologically important species, habitats and features that may require risk assessment and mitigations when designing an OAE project."	included in the conclusion of section 8.2's introduction. Change: Added "Additionally, regulators involved in marine conservation or spatial planning may have relevant information about where conservation areas may be sited in the future and the viability of OAE research projects."
Reviewer 9	1590	Potentially Relevant Regulations for OAE Pilots & Demonstrations	Change: Updated table name to "Potentially Relevant Laws and Regulations for OAE Pilots & Demonstrations".
Reviewer 9	1590	Authorities with relevant jurisdiction or influence in Canada should include	Change: Added Transport Canada to table 7 list. Our team deeply appreciates your recommendations and through our

		- Natural Resource Canada. They lead Canada Carbon Management Strategy. - Innovation, Science and Economic Development Canada - Transport Canada (Canadian Navigable Waters Act) May want to consider distinguishing between those with a regulatory role and others.	process of legal review it was recommended to us that only Transport Canada be added.
Reviewer 9	1590	Additional pieces of legislation that are missing from the table for Canada: - Species at Risk Act (applies from internal waters to EEZ) - Canada National Wildlife Act (particularly in relation to marine national wildlife areas) (applies in internal waters and territorial sea) - Arctic Waters Pollution Prevention Act (internal waters to EEZ or international boundary) - Canada National Marine Conservation Areas Act (applies in internal waters to EEZ)	Our team deeply appreciates your recommendations and through our process of legal review it was recommended not to add these pieces of legislation. No change.
Reviewer 9	1590	Exclusive economic zone/outer continental shelf - the Oceans Act in general applies throughout all Canada's marine estate. This is not limited to MPAs. Integrated ocean management authorities and marine environmental quality measures apply as well.	Change: Added paragraph describing Ocean Act "Notably, the Oceans Act allows for the establishment of marine protected areas (MPAs)... based on the site's conservation objectives which could have implications for potential OAE projects."
Reviewer 9	1598	would be good to include ecologically important species and habitats too	Change: Added "(chemistry, and commercially, culturally or ecologically important species and habitats).
Reviewer 9	1646	Suggest engaging with ECCC regarding the text related to CEPA. There are some important nuances missing. For example, CEPA disposal at sea permits are related to substances listed on Schedule 5 and there is a placement	The team agrees the CEPA description would benefit from expert input to ensure the nuances regarding its relevance to OAE are accurately represented. Change: Engaged legal experts for their review and revised the sentence to be:

		exemption that should be considered.	"CEPA requirements may apply to a subset of OAE activities, as a “disposal at sea”, if the activities include deposition of a substance from a ship, aircraft, platform, or other structure into the ocean. “Disposals at sea” of scheduled substances may be allowed under CEPA pursuant to a permit issued by Environment and Climate Change Canada (ECCC)."
Reviewer 9	1646	Should include a description of the Oceans Act (1996). The Act provides the Minister of Fisheries broad authority to lead ocean governance, lead and facilitate integrated ocean management, establish and manage MPAs, and promote marine environmental quality through regulations, standards, or guidance. Furthermore, Canada has established Federal Marine Protection Standards for federal MPA established after April 2019 (https://www.dfo-mpo.gc.ca/oceans/mpa-zpm/protection-standard-norme-protection-eng.html). Lastly, Canada committed to conserving 30% of their oceans by 2030 through MPAs and OECMs.	Change: Added paragraph describing Ocean Act "Notably, the Oceans Act allows for the establishment of marine protected areas (MPAs)... based on the site’s conservation objectives which could have implications for potential OAE projects."
Reviewer 9	1652	Fisheries and Oceans Canada (DFO) not the Canadian Department of Fisheries and Oceans	Change: Updated the DFO definition to "Fisheries and Oceans Canada" in-line and in Table 10.
Reviewer 9	1662	Suggest there should be an overarching statement about the Fisheries Act in general before getting into section 36 specifically. Additionally, there would be value for proponents if the FFHPP project review and authorization processes for FA sec 34 & 35 and SARA were explained a bit more. For example, the project review	The team agrees that an overarching introduction of the Fisheries Act, excluding the specific section references, would provide a more effective flow for the readers. In regards to the SARA authorization process, the team agrees that this is valuable for teams to understand. However, for consistency in the level of detail provided in each country subsection, we chose not to include this description.

		process does not lead to an authorization. more information can be found: https://www.dfo-mpo.gc.ca/pnw-ppe/ffhpp-ppph-eng.html and https://www.dfo-mpo.gc.ca/pnw-ppe/reviews-revues/request-review-demande-d-examen-001-eng.html	Change: Added "The Canadian Fisheries Act is primarily administered by DFO, although ECCC is responsible for administering and enforcing provisions addressing deposition of deleterious substances." and removed reference to specific sections of the Fisheries Act.
Reviewer 9	1673	This paragraph is confusing, I suggest we pull some pre approved wording about the fish habitat protection and deleterious substance provisions of the Act.	The team agrees the language describing the Fisheries Act would benefit from clarification and expert input. Change: Engaged legal experts for their review and revised the description to "The Canadian Fisheries Act is primarily administered by DFO, although ECCC is responsible for administering and enforcing provisions addressing deposition of deleterious substances. A substance is considered “deleterious” if its addition to water degrades or alters the water's quality to the point that it is deleterious to fish, fish habitat, or the human use of fish. The Fisheries Act aims to protect fish and fish habitat in marine and freshwater environments by prohibiting deposition of “deleterious substances”. Authorization under the Fisheries Act may be required for proposed activities that impact fish or fish habitat, and DFO may impose conditions on such activities if they are authorized. An activity that deposits deleterious substances into water frequented by fish, or under conditions where the deleterious substance may enter such waters, may also be authorized and prescribed specifically by regulation under the Fisheries Act. "
Reviewer 9	1680	This suggests that the Wastewater system effluent regulations would apply to them and I'm not sure if that's true. It may be that the	The team agrees the text should not imply that WSER adherence is automatically the responsibility of the

		operator of the facility is actually the one taking on the responsibility. For the final sentence we may want to suggest they adjust the wording to say further investigation needs to be done to determine how the regs apply in practice	OAE project lead in co-located or integrated projects. Change: Engaged with legal experts for their review and deleted the text: "The WSER prescribes carbonaceous biochemical oxygen-demanding matter, suspended solids, total residual chlorine, and un-ionized ammonia as deleterious substances, but authorises their use in certain conditions. These standards will need to be adhered to if OAE is conducted via effluent outfall from a wastewater system"
Reviewer 9	1685	Suggested insertion for between paragraph above about the Fisheries Act, paragraph below about other federal legislation. "Marine protected and conserved areas may be established under different laws, and may have implications for OAE projects. For example, under the Oceans Act, an MPA may be established in an area of the sea in Canada's internal waters, territorial sea, or EEZ, in order to conserve and protect species, habitats and their ecosystems. Oceans Act MPA regulations specify what activities are allowed and prohibited within each site, based on the site's conservation objectives. Therefore, an Oceans Act MPA's regulations may not allow OAE projects. Marine protected and conserved areas, as well as other areas of conservation significance need to be considered when identifying sites for OAE."	The team agrees that the Ocean Act's MPA regulations and their role in project site selection is relevant and helpful to include. Change: Added language after 'other federal legislation' paragraph that reads "Notably, the Oceans Act allows for the establishment of marine protected areas (MPAs) in Canada's internal waters, territorial sea, or EEZ, to conserve and protect species, habitats and their ecosystems. Oceans Act MPA regulations specify permissible and prohibited activities, based on the site's conservation objectives which could have implications for potential OAE projects."
Reviewer 9	1733	Suggestion to rephrase sentence (which says stand twice) and to add the word provincial into the permit description so that now that	Change: Accepted suggested language and updated text to "Standalone provincial permit issued by the Nova Scotia Department of Environment and

		sentence would read 'Standalone provincial permit issued by the Nova Scotia Department of Environment and Climate Change (NS-ECC)'. Also the link to the Planetary project website seems to be broken.	Climate Change (NS-ECC)". Updated links to ensure they are active and added citations to links throughout the document.
Reviewer 9	2158	This is still a draft; however, it's difficult to assess the relevance of references (x5) such as "Document. GOOS" without additional context.	Thank you for noting this. The team agrees that these references should direct to the specific documents cited from GOOS. Change: Updated the references to include the authors and titles of each referenced specification sheet.
Reviewer 9	2329	Table 10: DFO (Canadian Department of Fisheries and Oceans)	Change: Corrected description name for DFO to "Canadian Department of Fisheries and Oceans" and across documents.
Reviewer 9	2329	Key terms and definitions (Table 10) does not include work, undertaking or activity (WUA), which should be included in the high-level checklist for regulators assessing OAE field trials. WUA are considered by regulators during review. Suggest adding WUA to Table 10, and referring to it in Appendix C	Appendix C is a checklist for all users regardless of country. As WUA is the precise terminology for Canada but is not readily used elsewhere, it is not included in the checklist, but the checklist has been revised to include it at a high level. Change: Added "Description of proposed works, necessary infrastructure, undertaking and activities (where applicable, as defined in relevant regulatory frameworks)" to Appendix C.
Reviewer 9	2433	Project scope, site and regulatory context - some additions could be helpful for regulators	Thank you for your suggestions. Change: Added "Description of proposed works, necessary infrastructure, undertaking and activities (where applicable, as defined in relevant regulatory frameworks)" to Appendix C.
Reviewer 9	2447	Environmental Risk Assessment - update some of the terms	Change: Updated to "Summary of a project-based risk assessment" and added "mitigation strategies described in Table 8" to the checklist to provide further examples.

Reviewer 9	2447	Environmental Risk Assessment - suggest more clarity on some terms	This section is intended as a high-level checklist to be used in conjunction with the guidance in the framework's main text. Additional detail on environmental risk assessment is provided in Table 11 and Section 7.2. No change.
Reviewer 9	2451	Is there a need to specify "qualitative risk assessment" here? Could it be quantitative in some cases, where the data allows? Removing the specification would allow for either approach to be determined case by case.	Change: Updated to "Summary of a project-based risk assessment"
Reviewer 9	2458	Monitoring and Reporting Plan - what does 'regulator access mechanisms' mean?	Change: Updated to "[..] and mechanisms for regulators to access or request project monitoring data"
Reviewer 9	2464	This line seems to be the only one speaking of (non-disaster) mitigations related to environmental protection. It would be better to expand it.	The team agrees species protection is an essential component to mitigation measures; non-disaster mitigation of environmental impacts is a guiding principle of this document. The document identifies this risk in the topic in Section 4 and addresses it in a mitigation step: "Identify protective zones or time periods where sensitive or culturally important organisms are present that may be at risk of OAE impacts." No Change.
Reviewer 9	2466	Suggest rephrasing to be more inclusive of different types of governance and engagement approaches.	Change: Rephrased to "Plans for engaging and/or involving Indigenous and local communities, and other implicated parties"
Reviewer 9	2471	Post-project Stewardship - suggest clarifying 'habitat restoration' and why needed. Is this referring to offsetting? Obligations by who and for what?	The team agrees this could use more clarity. Change: Included clarifying language to reflect regulatory direction "If warranted and required by regulators, plans and/or obligations for site decommissioning or habitat restoration."

Reviewer 9	2474	Table 11 - suggest adding temporal aspect to Row 5, Composition, Abundance, and age structure of fish fauna	This is a direct reference from the Water Framework Directive (2000) and we do not want to mispresent the reference. No change.
Reviewer 9	General	While the framework outlines a phased and gated approach for OAE, it remains unclear what the communication mechanism will be and who holds the authority to determine when it is safe to advance from one phase to the next. Specifically, there is ambiguity around who evaluates whether risks are tolerable and what criteria guide these decisions. Table 7 is very informative; however, it also highlights the numerous jurisdictions involved in each country, which could further complicate decision-making and coordination across phases.	The team agrees there is ambiguity on how the stages will be communicated and to which interested party and authority. As each project is a unique case, project leads will need to establish appropriate reporting relationships with the relevant authorities that they identify, and demonstrate their case as they seek support for scaling up their research. No change.
Reviewer 10	235	Add Part I	Change: Added section header "Part I: Environmental Impact Monitoring Framework".
Reviewer 10	240	Here it says field trials, but the scope per line 269 includes continuous dosing & monitoring	To clarify, 'Continuous Dosing & Monitoring' is one stage of a field trial, this sentence refers to any stage of field trial. No change.
Reviewer 10	655	The coastal enhanced weathering section doesn't mention the potential metal toxicity issue, so is less forthcoming than writeups on other methods.	Change: Added "However, because the placement of materials is irrevocable, feedstocks should be thoroughly characterized and tested for dissolution rate and predicted levels of trace metal or nutrient release, in the effort to mitigate related environmental impacts"
Reviewer 10	709	Add the private sector	Change: Added "the local private sector" to this list
Reviewer 10	964	These formal tools don't seem to be captured in Table 4. Add?	Change: Added a row to Table 4 to include "Public input mechanisms such

			as surveys, comment forms, or public review periods"
Reviewer 10	976	Parameters aren't usually "required by local regulators" (if this means local governments), but by national and state/provincial governments.	Change: Deleted "local".
Reviewer 10	1004	Suggest classifying carbonate parameters like DIC and TA as de facto essential because they are important for documenting positive impacts, although they might not be required by domestic regulators.	The team agrees that the Key Parameter groups could be refined to better reflect the framework's goal of providing relevant guidance that should be applied in accordance with the unique environmental risks and benefits of each OAE project. Change: Renamed the Key Parameter categories to "Regulatory Parameters", "Attribution Parameters" and "Context-Specific Parameters".
Reviewer 10	1100	Quite a few of these will be defined in regulatory requirements.	The team agrees. No change.
Reviewer 10	1480	Not quite accurate to say that international treaties, norms and laws "form the legal foundations upon which national frameworks are built". Often, domestic laws drive the development of international treaties, which then drive modifications to domestic laws to comply, etc. Iterative.	The team acknowledges that this sentence may misrepresent the iterative relationship between international and domestic law creation. Change: Deleted the sentence "These form the legal foundations upon which national frameworks are built."
Reviewer 10	1558	Add "...and regulatory requirements"	Change: Added "[...] and regulatory requirements" under "Project Scope, Site, & Regulatory Context" list item.
Reviewer 10	1641	For these examples, present project dates in a more consistent format, in keeping with what the permit says.	The project examples have varying levels of details available on their project dates and conditions, and we aimed to represent each project as accurately as possible.
Reviewer 10	1741	The 2nd person voice doesn't match the other sections: "you may consider..."	Change: Updated to "The following UK government resources provide information on permitting and licensing requirements for projects: environmental permit or marine license."

Reviewer 10	1944	Suggest change to: "it might be difficult..."	Change: Updated to "[...] it may be difficult [..]".
Reviewer 10	several spots	It's surprising that ocean acidification isn't discussed somewhere as a potential benefit, e.g., in Background on OAE, 5.1.4 Stage 4: continuous dosing and monitoring, and/or Section 7.2: Ecological / Biological Considerations. A missed opportunity?	While the team agrees that mitigation of ocean acidification is an exciting opportunity to demonstrate co-benefits of OAE, the research on the actual mitigation potential is still inconclusive. As the research evolves this topic may be featured more prominently in future iterations. No Change.
Reviewer 11	272	> Even though the purpose of this stage-gated approach is to upscale the project responsibly, we think it would be beneficial to add a fifth stage: Job Closure Monitoring. This addition would provide a complete view of all environmental monitoring requirements throughout the entire lifecycle, from planning and preparation to post-deployment.	The team agrees that it is important for projects to document and share the relevant environmental impacts, research and operational learnings from a project site at its closure. Change: Included closing paragraph in section 5.1.4 titled "Project Closing and Conclusion" to describe the necessary steps a project should take to its closure.
Reviewer 11	272	> We recommend removing the amount of tons per year because this might not apply to all OAE methods. For instance, detecting a clear OAE signal from only 10s of tons per year at coastal sites is likely to be challenging.	The team agrees that detecting a clear OAE signal from 10's of tons will be challenging. Stage 3 is intended to capture dosing levels that can generate "CDR relevant processes." While we agree that OAE project methods vary, the "indicative scale" is meant to illustrate ramp up at a high level. No change.
Reviewer 11	538	The paragraph introduces the concept of method-specific monitoring focus areas without addressing multi-method OAE deployment (e.g., a project might generate alkalinity from seawater using electrodialysis, and disperse it using an existing outfall pipe)	The team agrees that there are alkalinity enhancement approaches that use a combination of the methods described in section 4.1, and the monitoring considerations for these multi-method approaches should be clarified. Change: Added "For OAE projects that combine more than one method, the focus areas for monitoring should

			account for all included methods" to the last paragraph of section 4.1.1.
Reviewer 11	607	One could argue that the CO2 dissolved will end up in the ocean and thus, capturing this dissolved CO2 is net CDR.	The team agrees some may argue this. We believe this consideration is addressed in the line "Alkalinization will thereby result in emission avoidance in the first instance before CDR is achieved." No change.
Reviewer 12	97	Line 97 and in 1795. It is Environment Agency (not Environmental)	Change: Replaced "Environmental" with "Environment" in both instances.
Reviewer 12	1589	Table 7 -- in the UK section, the Water Environmental Regulations do not apply as far out as the EEZ / OCS so you can remove them form that row	Change: Removed "Water Environment Regulations" from the EEZ / OCS row for the UK.
Reviewer 12	1742	The links haven't been activated	Change: Updated links to ensure they are active, and added citations to links throughout the document.
Reviewer 12	1748	It should be one nautical mile for good ecological status, not 3 nautical miles. Figure 6 also needs to be updated to reflect that.	Change: Updated Figure 5 (previously Figure 6) reference of "good ecological status" from "3 nautical miles'" to "1 nautical mile"
Reviewer 12	1788	Says "consultations to earn novel permits may take as long as 1-2 years". Suggest amending to "applications for permits or licences for novel activities may take as long as 1-2 years". This is because consultation may not be required, and in any case the consultation part wouldn't take that long. It is usually the iterative process overall that takes the time.	Change: Replaced "consultations to earn novel permits may take as long as 1-2 years" with "applications for permits or licenses for novel activities may take as long as 1-2 years."
Reviewer 12	1795	It's the SEA LIFE Weymouth Aquarium. Also, I'm not aware that it is a "renewable licence", because it covered a defined trial – suggest removal of that part from the date row in the table	Change: Replaced "Sea Life Aquarium" with "SEA LIFE Weymouth Aquarium" and removed "renewable license" from date row for clarity of permit conditions.

Reviewer 13	1591	Global Affairs Canada administers foreign marine research applications in EEZ	Our team deeply appreciates your recommendations and through our process of legal review it was recommended not to include this. No change.
Reviewer 13	1663	DFO administers Fisheries act s34 and s35	Change: Removed references to specific sections of the Fisheries Act to simplify legislation overview and provide a level of detail consistent with the other regulatory sections.
Reviewer 13	1667	ECCC administers and enforces the sections that prohibits depositing harmful deleterious substances in waters frequented by fish, with possible exemptions depending on project details. Project plans may be submitted to DFO for review to determine if further authorization or mitigation is needed. Everyone in Canada must ensure that their activities are managed to prevent the deposit of deleterious substances into waters frequented by fish. A deposit of a deleterious substance is only authorized pursuant to, and in a manner consistent with, a Fisheries Act regulation or by a regulation under other federal legislation. ECCC does not have the same mechanisms to review project plans or provide feedback or guidance to project proponents. It is important to note that there is no mechanism that would allow ECCC to issue statements on regulatory certainty regarding any project proponent's activities, or issue statements around a proponent's compliance with federal environmental legislation (see https://www.canada.ca/en/environment-climate-change/services/ma	Change: Updated language after an external legal review to: "The Canadian Fisheries Act is primarily administered by DFO, although ECCC is responsible for administering and enforcing provisions addressing deposition of deleterious substances. A substance is considered "deleterious" if its addition to water degrades or alters the water's quality to the point that it is deleterious to fish, fish habitat, or the human use of fish. The Fisheries Act aims to protect fish and fish habitat in marine and freshwater environments by prohibiting deposition of "deleterious substances". Authorization under the Fisheries Act may be required for proposed activities that impact fish or fish habitat, and DFO may impose conditions on such activities if they are authorized. An activity that deposits deleterious substances into water frequented by fish, or under conditions where the deleterious substance may enter such waters, may also be authorized and prescribed specifically by regulation under the Fisheries Act."

		naging-pollution/fisheries-act-registry/frequently-asked-questions.html)	