Considering Blue Carbon in Marine Developments, Planning and Policy

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Executive Summary

Benthic marine sediments — particularly fine-grained muds and silts — represent the largest long-term store of organic carbon in UK seas and play a critical role in climate regulation. Shelf seas around the UK contain globally significant sedimentary carbon stocks, accumulated over millennia and largely protected from remineralisation when undisturbed.

Despite their importance, research into carbon stores below the surface 10cm of sediment remains limited. These deeper layers may contain older, less reactive and more permanent carbon stores, yet they are increasingly threatened by activities that penetrate well below the surface layer, including cable trenching, offshore wind foundations and anchoring systems. The scale of potential emissions from disturbance of these deeper stores remains largely unquantified.

Marine sedimentary carbon stores cannot currently be actively restored at meaningful scales, making avoidance of impact the only effective mechanism for protecting these climate assets. However, sedimentary carbon currently receives little explicit recognition or protection within UK planning, consenting or carbon accounting frameworks. Even where carbon-rich benthic habitats are protected within Marine Protected Areas, carbon storage itself is not assessed as a feature of condition or integrity.

The report identifies a significant misalignment between climate policy and marine planning. Offshore wind and other marine infrastructure are routinely justified on the basis of carbon reduction, yet emissions arising from seabed disturbance are not included within project-level greenhouse gas assessments. As a result, the true climate impact of major marine developments is systematically underestimated. Recent developments in policy and case law, including expanded scope 3 greenhouse gas assessment requirements, provide a clear opportunity to address this gap within existing Environmental Impact Assessment processes.

Current marine plans and strategic energy frameworks make frequent reference to “low carbon” development and carbon capture, but fail to recognise marine sediments as the final long-term sink for carbon absorbed by the ocean. This may be changing, with the UK Marine Strategy 2025 making reference to the importance of protecting habitats with high carbon sequestration ability as part of its benthic feature health assessment. Terrestrial frameworks, such as the Land Use, Land Use Change and Forestry reports offer a strategy that may be transferable to the marine space to assess carbon impacts.

The report concludes that requiring the inclusion of sedimentary carbon disturbance within greenhouse gas assessments offers the most immediate and system-wide route to recognising blue carbon within UK planning. This approach would enable comparison of alternatives, support avoidance and minimisation through the mitigation hierarchy, and align marine development with the UK's climate objectives.

In parallel, the report highlights the need for recognition of carbon-rich sediments and an avoidance-first approach for marine project planning, targeted protection of the most carbon-rich sediments as recognised features within Marine Protected Areas, restoration of vegetated habitats as an active measure to increase natural carbon stores, and investment in research to improve understanding of deep sediment carbon and remineralisation rates. Together, these measures would reposition marine sediments as part of the UK's natural climate infrastructure, ensuring that efforts to decarbonise the economy do not inadvertently undermine one of the country's most important carbon stores.

The formation and state of UK blue carbon stores

25% of global CO2 emissions enter the oceans (Ford et al. 2024), with an average flux of 0.01-0.02 grams of carbon per square metre of ocean surface per day. For an area the size of the UKs exclusive economic zone and continental shelf, this results in a daily absorption of 8,850-17,700 tonnes of CO2 per day (using area figures from JNCC, 2024). Colder water and higher windspeeds correlate with a higher carbon flux (Ford et al. 2024) and so the UK waters are likely on the higher side of this range.

Carbon dioxide dissolved in the water column is absorbed by photosynthetic organisms and converted into organic carbon (OC) molecules. These molecules flow through the marine food chain as photosynthetic organisms are consumed by grazers and, in turn, predators. OC molecules deposited on the marine sediment surface originate from faeces, detritus and mortality of organisms from marine, freshwater and terrestrial environments (with river systems transporting OC into the UK seas). They form part of the total carbon content of a sediment, which also includes inorganic forms of carbon (mainly calcium carbonate found in shells).

Marine sediments are the largest pool of OC on the planet (Sala et al. 2021), with an estimated 2322GT in the top 1m of marine sediment globally (Woodward-Rowe et al. 2025) and global deposition rates exceeding 2.5GT of OC per year (APOC 2025). Deposition rates are greatest in shallow shelf seas (e.g. North Sea and Irish Sea) and in river mouth areas (Middelburg 2018, APOC 2025). Despite only occupying 7-10% of the ocean floor, shelf seas contribute around 80% of organic carbon storage globally (Bauer et al. 2023). The surface layers (10cm) of UK marine sediments hold an estimated 240MT of OC (Burrows et al. 2024). The North Sea alone contains an estimated 230MT (Diesing et al. 2021) of organic carbon in the top 10cm of sediment alone, Burrows et al. (2024) estimates that the English North Sea contains around 37.5Mt of OC in these surface layers. This is despite years of intensive bottom trawling which will have degraded this stock (Sala et al. 2021).

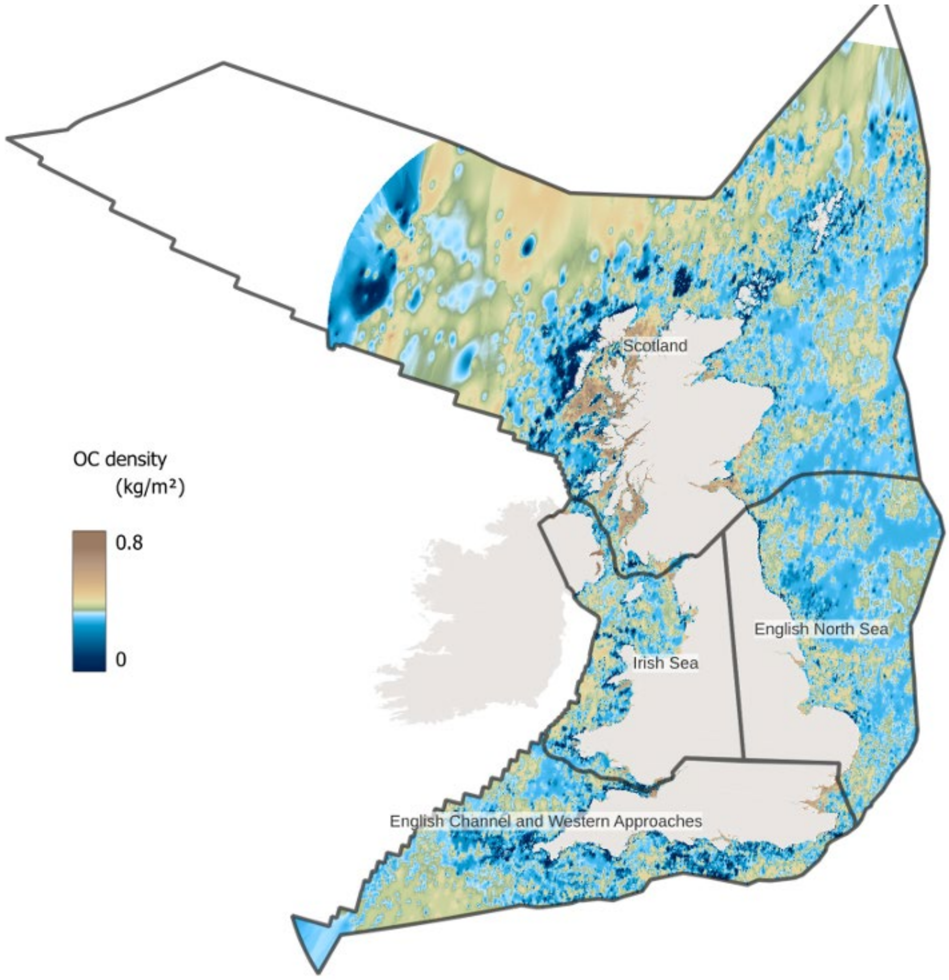

Figure 1. Organic Carbon (OC) density in the surface (10cm depth) seabed sediments across the UK's Exclusive Economic Zone (Smeaton et al. 2021).

Not all carbon deposited on sediment surfaces will be sequestered (incorporated into long term carbon stores) within the sediment. Many forms of carbon will react to oxygenated waters while exposed in surface sediment layers and so can be deemed short lived (Tiano et al. 2024). In high sedimentation environments, these carbon stores move down into anoxic sediment layers where they are less likely to remineralise and so contribute to longer term carbon storage. Most models assume that deeper sediment is dominated by less reactive forms of OC. Cefas (2026) estimated a sequestration rate of 0.424Mt per year in UK marine surface sediments. An estimated 1.4Mt are sequestered annually (APOC 2025) across the North Sea, with 0.039Mt in the English North Sea (Cefas 2026). For perspective, the UK's ambition for Carbon Capture and Underwater Storage (CCUS) projects in all UK waters is to store 20-30Mt per year by 2030.

The ecosystem within the sediment will also play a key part in moving surface OC to deeper, more permanent stores. This is a process known as bioturbation. In UK waters, such burrowing assemblages are dominated by worms and molluscs.

Sediment grain size has a high correlation with carbon sequestration rates. Oxygen from the water column penetrates less into finer grained sediment such as mud and silt, resulting in a shallower reactive surface layer (APOC 2025). Finer particles in these sediments, such as clay, will adsorb carbon molecules onto their surface. This protects the carbon from microbial degradation and reduces the overall reactivity, encouraging sequestration to deeper layers (Mayer 1994). The basins around the UK contain vast areas of fine sediments (see figure 2.). Once under the active layer, carbon can remain unmineralized for millennia to eons if undisturbed (LaRowe et al. 2020).

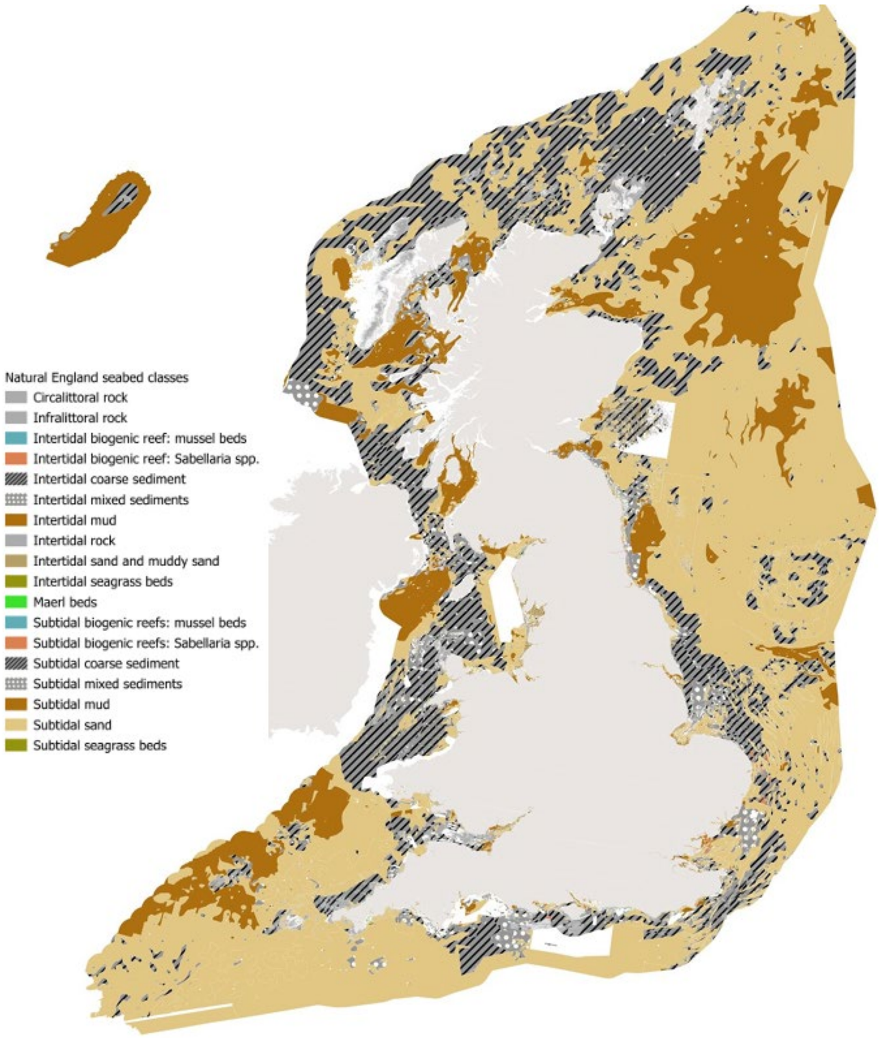

Figure 2. Seabed sediment types from Natural England Marine Habitats and Species Open Data. Showing the major sediment classes. OC accumulation broadly is highest in mud habitats and lowest in rock habitats.

Table 1. Showing the extent (km2) of mud habitats in the UK, using data and regions from Burrows et al. 2024. Note that mud and silt are also present in various habitats identified as 'mixed' which are not included in this table. Littoral mud occurs within the tidal range of coastal zones. Sublittoral mud is found below low tide, whereas it is deemed deep mud below 20-30m (JNCC, 2008).

Habitat type	*Littoral mud*	*Sublittoral mud*	*Deep mud*
English North Sea	*147*	*5,444*	*0*
English Channel and Western Approaches	*390*	*9,300*	*363*
Irish Sea	*233*	*6,594*	*0*
Scotland	*0*	*59,575*	*223,922*
Total	*770*	*80,913*	*224,155*

As well as finer sediments, vegetated coastal habitats (saltmarshes, seagrass beds, kelp beds and macroalgae) are stores of organic carbon. These habitats store both short-term carbon within their biomass and longer-term sedimentary stores. The vegetation in these habitats reduces current flow and encourages deposition of carbon onto the seabed, with saltmarsh storing more OC in its soils from a terrestrial origin coming from riverine sources. Although coastal vegetated blue carbon habitats represent only 1.0% of the total area of UK seas, they contain 1.7% of the total organic carbon stores, and account for 3.8% of annual accumulated organic carbon in those stores (Burrows et al. 2024). Interlinkages between habitats are also important in the marine carbon cycle. For example, detritus from coastal vegetated habitats support filter feeding assemblages and eventually contribute to the sedimentary carbon store.

Human impacts on blue carbon stores

The table below outlines the range of pathways in which human activities are disturbing OC deposits in marine sediments around the UK. For a more detailed review of these impacts, see Appendix 1.

Table 2. Outlining the range of pathways for human activities to disturb sedimentary OC deposits.

Human activity	Impact pathway	Magnitude/Spatial footprint	Notes
Dredging	Removal and resuspension of fine, OC-rich sediments.	High local impact; repeated in estuaries and ports. Estuaries are high OC sediment areas.	
Bottom trawling	Mechanical disturbance of surface sediments (~top 10cm). Removal of bioturbating organisms which encourage OC sequestration to deeper layers.	Largest global footprint of marine disturbance. 1-2 orders of magnitude greater than dredging. Estimated 4.67Mt CO2 emission equivalent in UK waters (Cefas 2026) from sediment disturbance.	Otter boards are the most damaging gear type, with deeper sediment penetration up to 15cm.
Offshore wind	OC exposure through drilling/screwing of turbine foundations. Infrastructure induced hydrodynamic drag and turbulence alter sediment transport patterns.	Up to 122T of OC exposed per drilled foundation (Smeaton et al. 2021). Localised gains around arrays. Large scale basin changes to sediment (and OC) distribution.	Based on figures from Seaton et al. 2021. The mud content of all North Sea surface sediment is being altered by 0.1% per year because of current

	Slack or surface laid cables continually disturb surface sediments. Ecological halo/ reef effects increasing OC flux to the seafloor Redistribution of fishing effort into deeper, more OC rich areas. Disturbance associated with inter-array and export cables. Decommissioning activities leading to resuspension of sediment and reimposition of local hydrodynamic regime.	Small scale permanent disturbance. Increased organic matter flux to seabed locally (tens of metres) Modelled increase of 0.35% of UK blue carbon emissions. As with other cable issues (see below)	OWF infrastructure (Chen et al. 2025).
Cables	Exposure of deeper, potentially older OC; partial remineralisation Pre-grapnel runs and sand wave levelling sweeps.	Trenches of 1-5m in width and 1.5-3.2m in depth. Up to 128kg of OC disturbed per metre of cable trench. Impacting primarily surface layers. Deeper impacts for larger sand-waves.	Water jetting creates deeper trenches than a metal plough.

	Cable protection and associated hydrodynamic effects. Decommissioning activities leading to resuspension of sediment and reimposition of local hydrodynamic regime.	Likely to contribute to the same effects pathway as turbine infrastructure. Larger effects expected in shallower, high current areas.	

Table 2 references:

Smeaton, C. et al. (2021) Marine sedimentary carbon stocks of the United Kingdom's Exclusive Economic Zone. Frontiers in Earth Science 9, 593324.

Chen, J., Christiansen, N., Porz L. et al. (2025) Sediment transport pathways and organic carbon burial impacted by offshore wind farms in shelf seas, 30 October 2025, PREPRINT (Version 1) available at Research Square [https://doi.org/10.21203/rs.3.rs-7742330/v1]

Cefas (2026) The role of English seabed sediments in carbon storage, impact of human activities, environmental pressures and potential management options: Evidence review.

Current carbon emissions and seabed health targets and protections

Protecting natural carbon stores

UK legislation and policy increasingly recognise the role of nature in capturing and storing carbon, including in marine and coastal environments, but this recognition remains lacking any fixed targets. The Environment Act 2021 and the subsequent Environmental Improvement Plan (EIP) acknowledge the importance of preserving and enhancing nature's capacity to store carbon, explicitly identifying coastal habitats such as saltmarsh and seagrass as important carbon stores. In parallel, marine-specific frameworks - including the Marine Strategy Regulations - identify the value of protecting and recovering seabed habitats that underpin marine carbon storage. However, while some habitat restoration targets exist (for example for saltmarsh and seagrass extent within the EIP), no UK legislation currently sets specific, quantitative targets for the protection or enhancement of marine sediment carbon stores, and blue carbon is not yet systematically embedded within planning, consenting, or carbon accounting frameworks.

Environmental Improvement Plan 2025. Goal 1 (13). By 2043, increase saltmarsh by 15% compared to 2009 levels, seagrass by 15% compared to 2024 levels, and create functional oyster reef habitat at ecosystem scales in 5 to 8 suitable English water bodies

Net zero targets and the carbon budget

The UK became the first government to commit to a legally binding target of Net Zero by 2050. The Climate Change Act 2008 allowed the UK's framework of setting carbon budgets to be implemented. This framework is unchanged to this day, with the 7th carbon budget released in 2025.

The UK's carbon budget 7 sets a target of total electricity supply emissions of 1Mt by 2050. A number of studies have tried to assess the life cycle of carbon outputs (how much carbon emissions the construction and operation of the structures can be assumed to 'cost') of offshore wind, with results varying from 7.8-25.5 grams of CO2 per kWh (Bonou et al. 2016 and Yang et al. 2018 respectively) while a recent study of FLOW estimates a carbon output of 31g of CO2 per kWh (Brussa et al. 2023). With estimates for UK offshore wind generation exceeding 100GW by 2050, these carbon output estimates generate a range of 6.84-22.35Mt of CO2 per year. None of the sources used in this estimate consider sedimentary blue carbon emissions as part of their life cycle assessments, and so the true figure will be higher than that stated above.

The carbon budget itself makes no mention of the fishing industry at all, which is a significant activity for blue carbon emissions (see Appendix 1). Though recently introduced measures to ban bottom trawling in Marine Protected Areas may reduce the blue carbon emissions of the industry, many of these areas were not exposed to bottom trawling pressure anyway and the total seabed impact of bottom trawling may remain unchanged as fishers move to other areas (though any change in overall fishing activity will have corresponding effects on the seabed carbon stores).

The National Policy Statement (NPS) for Energy (2023) and associated NPS for Renewable Energy (2023) set out the UK government's commitments for meeting net zero targets specifically by reforming the energy sector. Offshore wind is referred to in these documents as vital for the decarbonisation of the network. In order to facilitate the rollout of the huge amount of turbines needed to meet the 50Gw target, the NPS sets out measures to safeguard the environment through the implementation of the Offshore Wind Environmental Improvement Package (OWEIP).

The OWEIP includes:

- The Collaboration on Offshore Wind Strategic Compensation (COWSC) programme, to identify and deliver strategic environmental compensation.
- Revision of the Habitats Regulations and Marine Conservation Zone assessment processes for offshore wind. To facilitate offshore wind delivery whilst "maintaining valued protection for wildlife".
- Implementation of an industry-funded Marine Recovery Fund (MRF) into which developers can contribute to meet their environmental compensation obligations.

These measures, though welcomed by The Wildlife Trusts, focus entirely on biological indicators (protected habitats and species) when considering environmental impacts. The justification of the commitments to the large offshore wind targets within the NPSs are entirely focused on carbon emissions and their reduction. To not focus on ways in which the implementation of these projects can minimise emissions in their construction phase (through avoidance of high carbon sediments) seems therefore to be a drastic oversight.

The government is also committed to reforming the UK's energy transmission network. The National Energy System Operator (NESO) recently unveiled its strategic spatial energy plan (SSEP) which is optimised for "environmental, societal and other spatial interests". Carbon emissions reductions are clearly a target of this plan and can be argued to be both an environmental and societal interest. Throughout the scoping report for the SSEP, climate change mitigation is repeatedly referred to as including the development of offshore wind. The ocean's capacity to absorb carbon dioxide is acknowledged in the SSEP, where it is referred to as a carbon sink. Nowhere in the report, however, is there the link made between CO2 absorbed by the oceans and its final place of long-term storage – the sediment. Potential blue carbon impacts of any proposed developments are not acknowledged anywhere in the SSEP. The Wildlife Trusts argue that while decarbonising the energy sector is a worthwhile goal, it is irresponsible to approach this in a way where the carbon impacts of the implementation of this action are not considered to minimise as much as possible.

Terrestrial projects may also release carbon emissions through disturbance of soil or destruction of vegetation. Though, as with marine, there is no specific protection on the grounds of carbon storage. Terrestrial planning teams with The Wildlife Trusts nonetheless make arguments to the value of this store. Smith et al. (2013) is referenced to show that wind farms on undegraded peatland are unlikely to reduce future carbon emissions; similar research is severely lacking for marine habitats. Natural carbon sequestration is also referred to in terrestrial local plans (see table 2), which are referred back to by The Wildlife Trusts' planning teams. Similar focusses are lacking in marine regional plans:

- The East Marine Plan makes nine references to 'Low Carbon', 34 references to (artificial) 'Carbon Capture' and four references to 'Carbon Reduction'. Sedimentary OC stores are not mentioned in the plan.
- The North East Marine Plan makes four references to 'Low Carbon' and 15 references to (artificial) 'Carbon Capture'. Sedimentary OC stores are not mentioned in the plan.
- The North West Marine Plan makes four references to 'Low Carbon' and 11 references to (artificial) 'Carbon Capture'. Sedimentary OC stores are not mentioned in the plan.

Table 3. Recognition of sedimentary carbon stores and commitments to their protection in terrestrial planning frameworks.

Terrestrial planning framework	Reference to carbon stores
Greater Cambridge Local Plan	Contains '**Policy CC/CS: Supporting land-based carbon sequestration and carbon sinks'**. This contains requirements that: - When proposals are on peat, evaluation of the soil content is completed and a soil management plan is submitted. - There will be a presumption in favour of preservation of peat in situ. - Any potential harm to peat soils associated with a development proposal must be reduced to the minimum possible level. - Removed peat soils must be temporarily stored and used in a way that will minimise carbon loss to the atmosphere. - Proposals to enhance peat soils and protect its qualities will be supported
Broads Authority Local Plan	Contains '**Policy POSP3: Soils'** which states that proposals shall: - Principally, leave soils that are carbon sinks in situ The justification for this document also recognises soils "as a store for carbon" with particular reference to peat.
Yorkshire Dales National Park Local Plan 2025-40	- Acknowledges peat and blanket bog habitat as an important carbon store. - Aims to store more carbon than it produces by 2040.

Though not a part of the EIA process for individual terrestrial projects, carbon emissions from terrestrial land disturbance have been reported on through the 'Land Use, Land Use Change and Forestry' (LULUCF) prepared in accordance with the reporting requirements of the United Nations Framework Convention on Climate Change (UNFCCC). A similar report is not produced for marine emissions.

Marine Protected Areas

The government has set out targets for MPA condition under the Environment Targets Regulations (ETR) 2023 and for the wider marine environment with its UK Marine Strategy (last revised 2025) and Environmental Improvement Plan (EIP) 2025. The ETR requires at least 70% of protected features in MPAs to be in favourable condition by the end of 2042, while the EIP targets 49% of features favourable (and 46% recovering) by 2030. Though no UK MPA currently has its blue carbon stores as a protected feature, some benthic habitats rich in OC are protected features in some MPAs, namely intertidal/subtidal mud and mixed sediments as well as intertidal vegetated habitats. The EIP 2025 commits to a review of MPA locations and protections, with a stated goal of 'improving climate change resilience'.

Within the existing UK marine protected area network, subtidal mud is a protected feature at 25 sites covering a total of 11,234km^2 (DEFRA 2024) while mixed sediments are a protected feature of 40 marine sites. As marine mud sediment is not an Annex 1 habitat under the Habitats and Species Regulations, it may only become a designated feature of an MCZ if it represents a nationally significant example (as outlined in the Marine and Coastal Access Act 2009). Of the 230-244Mt of carbon stored in the UK's (and Isle of Man) marine surface sediments, 105Mt currently resides within areas designated for marine protection - that is Marine Conservation Zones (MCZs), Special Protection Areas (SPAs), Marine Nature Reserves (MNRs) and Special Areas of Conservation (SACs).

Under section 28 of the Offshore Marine Conservation Regulations, a project or plan may not be agreed upon if it is deemed to adversely effect the integrity of any protected marine site (established the publication and scrutiny of an environmental statement). The NSIP projects however are given the power to pursue development within these sites due to overriding public interest. Any project which is deemed to impact the integrity of a protected site must utilise compensatory measures in order to maintain the coherence of the national sites network (Natura 2000).

Legislative hooks

In this section we look at the current state of legislature in the UK regarding marine planning and greenhouse gas emissions, with specific reference to potential avenues to pursue for better recognition of blue carbon emissions and protection of existing sources.

Greenhouse Gas Assessments

Under the Infrastructure Planning (Environmental Impact Assessments) Act 2017 (EIA regs), projects requiring an EIA are required to publish reports of their effects on the environment resulting from their project. This includes greenhouse gas emissions:

"Schedule 4. ***5.*** *[Reports must include] A description of the likely significant effects of the development on the environment resulting from… the impact of the project on climate (for example the nature and magnitude of greenhouse gas emissions) and the vulnerability of the project to climate change."*

Projects listed as NSIPs must undertake an EIA in line with the EIA regs, as per the Planning Act 2008. However, a separate EIA legislation exists to cover potential marine elements not covered in the EIA regs. This Marine Works (Environmental Impact Assessment) Regulations 2007 also mentions greenhouse gas emission reporting, but the only statement is a carbon copy of that used in the EIA regs.

This results in Greenhouse Gas Assessments (GHGA) produced for all projects for which an EIA is required. Though the Act quoted above does not go into detail about specific activities which should be scoped into a GHGA, guidance from The Department for Energy Security and Net Zero (DESNZ) refers to:

Direct emissions ("Scope 1") — emissions from fuel combustion, on-site installations, plant, machinery, vehicles or operations that are owned or controlled by the project operator.

Indirect energy emissions ("Scope 2") — emissions associated with purchased or imported energy (e.g. electricity, heating, steam, cooling) consumed by the project.

The Department for Energy Security and Net Zero (DESNZ) published supplementary guidance (2025) on how to assess downstream ("scope 3") GHG emissions in EIAs for offshore oil and gas developments, following a recent landmark decision by the UK Supreme Court in Finch v Surrey County Council (2024). These scope 3 emissions include the future burning of hydrocarbons extracted from O&G sites. As such, the umbrella for activities to be included in GHGA is expanding.

UK Marine Strategy

The latest UK Marine Strategy: Part One (2025) refers to carbon sequestration by marine habitats as a benefit to users of the marine environment and acknowledges that the European shelf seas act as a carbon sink. Some specific habitats (intertidal sediment, subtidal benthic and pelagic) are acknowledged in this report as playing a role in regulating atmospheric carbon. In part one of the 2025 report, protection of benthic carbon stores is specifically referred to:

"The natural carbon storage and sequestration capacity of some benthic habitats highlights their important role in the context of climate change and the importance of protecting relevant areas of seabed from pressures that degrade this capacity." (UK Marine Strategy part one 2025)

The impacts of 'offshore structures and other activities' is listed as an indicator for benthic habitat health. The reference to human benefits from carbon sequestration may also be of some use, as the Office for Environmental Protection (OEP) has obligations to 'protect people from the effects of human activity on the natural environment'. Under the Marine Strategy Regulations 2010, the government is required to take action to achieve and maintain good environmental status in our seas. If carbon storage of benthic habitats and the risks posed to these habitats by offshore structures are listed in the Marine Strategy, the government is legally obliged to take action.

A Cefas report (2026) lists the confidence in the current evidence of hard structure impacts on OC as low. It highlights the lack of knowledge of deeper OC stocks within marine sediments as a significant knowledge gap, as well as a general lack of research/evidence into how installation activities can affect OC sequestration and storage. The report recommends monitoring of OC change across the life cycle of projects.

DEFRAs response to the consultation on the UK Marine Strategy Part One 2025 highlights the recognition that "…Blue carbon habitats are important nature-based solutions to climate change". The UK has established the UK Blue Carbon Evidence Partnership to progress the evidence base on blue carbon habitats. This reflects growing national recognition of the importance of marine carbon stores, while also highlighting the significant evidence gaps that currently limit their integration into planning and carbon accounting frameworks.

Environmental Improvement Plan

Goal 7 of the Environmental Improvement Plan provides a helpful but limited legislative hook for advocating the protection of blue carbon habitats. Its explicit commitment to "preserving and enhancing nature's potential to capture and store carbon" and its recognition of coastal and marine habitats such as saltmarshes and seagrasses as important carbon stores marks a significant step forward in acknowledging the climate function of the marine environment within national policy. This framing supports the argument that blue carbon habitats should be treated as strategic climate assets, rather than solely as biodiversity features.

The strength of this hook is constrained by the absence of binding, habitat-specific carbon protection requirements or explicit delivery mechanisms within planning and consenting regimes. The commitment is at a high, strategic level and does not yet translate into clear obligations for infrastructure developers or decision-makers to avoid, minimise or compensate for impacts on marine carbon stores. As a result, while Goal 7 provides a strong policy rationale for integrating blue carbon into environmental assessment and planning decisions, further regulatory clarification and targets are needed.

Goal 7: Climate change. We will reduce greenhouse gas emissions to accelerate to net zero and work to prepare the natural environment for the effects of climate change. [Commits to] Preserving and enhancing nature's potential to capture and store carbon and reduce greenhouse gas emissions... Coastal and marine habitats like saltmarshes and seagrasses are important carbon stores.

MPA legislation

Section 13 of the Habitats Regulations 2017 sets out the priorities for designating special areas of conservation (SACs) in the UK. These are as follows:

1. To maintain or restore an Annex 1 habitat or Annex 2 species as specified in the Habitats Directive.
2. To maintain coherence of the national sites network.
3. To protect against threats of degradation and destruction to which the site is exposed.

The Marine and Coastal Access Act (MACAA) 2009 sets out the grounds for designation of an MCZ. This includes:

1. The conservation of marine flora or fauna.
2. The conservation of marine habitats.
3. The conservation of features of geological or geomorphological interest.

Current marine protected sites are designated for one or several 'protected features' which they contain. Though the presence of any Annex 1 habitat or Annex 2 species within the boundaries of a protected site does not automatically grant the status of 'protected feature'. Rather, features are protected upon establishment of the protected sites often if they are deemed to represent a nationally important example of this feature. The UK is committed, via the MACAA (section 132), to the formation of a network of MCZs to conserve and improve the marine environment.

If blue carbon stores are to be protected under existing or newly proposed sites, then there appear to be two avenues to make this argument in existing literature. This could be under the third point of the Habitats Regulations criteria, which could be utilised to protect fine-grained seafloor habitat from destructive activities such as trawling and construction works. 'Mud habitats in deep water' are also regarded as a priority habitat in the UK Biodiversity Action Plan. Additionally blue carbon may be classified as a valued geological feature, especially when referring to the richest and oldest (below the surface layer) blue carbon stores. Natural England is responsible for publishing protected site strategies to oversee the management, protection and recovery of the designated features within a protected site (though the MMO must also be consulted for offshore sites).

Developments within or affecting MPAs

Under the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (as amended), NSIP developers (non NSIP projects are unlikely to be granted permission without overriding public interest) are required to undertake an Environmental Impact Assessment where a project is likely to have significant effects on the environment. For offshore and coastal developments, this requirement is almost always triggered.

As part of the EIA process, developers must:

- Prepare an Environmental Statement (ES) describing the likely significant environmental effects of the proposed development.
- Establish baseline environmental conditions, typically including physical seabed characteristics, benthic habitats, designated sites, and species.
- Assess direct, indirect, cumulative and in-combination effects during construction, operation and decommissioning.
- Apply the mitigation hierarchy (avoidance, mitigation, compensation) to reduce adverse effects.
- Demonstrate how environmental impacts have informed site selection, design choices and alternatives.

While EIA legislation requires assessment of sediment disturbance and habitat impacts, it does not explicitly require developers to assess impacts on marine sediment carbon stores. As a result, marine sediments are treated primarily as physical or ecological receptors, rather than as critical climate assets. Carbon impacts are typically addressed only in relation to operational emissions, vessel use, or embodied carbon in materials.

This represents a misalignment between Habitats Regulation, EIA and climate policy. A regulatory gap is present here in which projects may be deemed acceptable despite causing long-term loss or degradation of blue carbon stores, provided that conventional ecological compensation is proposed. This gap presents a clear opportunity to strengthen EIA and

Habitats Regulations processes by explicitly recognising marine sediment carbon as a material planning consideration, and by requiring developers to avoid, minimise and compensate for blue carbon loss alongside biodiversity impacts.

Conclusion

Of the options to pursue listed above, the GHG assessment route appears to offer the likeliest chance of significant change. EIAs are already mandatory for offshore NSIPs and many marine developments, and GHG impacts are explicitly required to be assessed. This lowers the level of change, and therefore resistance to it, that we are asking for.

The EIA Regulations, alongside the Marine Works (EIA) Regulations, clearly establish climate impacts and greenhouse gas emissions as mandatory components of environmental reporting. Recent developments in policy and case law — notably the expansion of greenhouse gas assessments to include scope 3 emissions following *Finch v Surrey County Council* and subsequent DESNZ guidance — indicate a clear trajectory towards more comprehensive and causally inclusive climate assessments. Within this expanding scope, emissions arising from the disturbance of carbon-rich marine sediments can reasonably be framed as indirect project-related emissions, particularly where seabed disturbance is an integral component of offshore development.

The exclusion of blue carbon disturbance from project-level greenhouse gas assessments does not imply the absence of emissions but rather reflects limitations in current greenhouse gas accounting frameworks, including the absence of agreed methodologies, uncertainty in causal attribution, and the lack of an internationally recognised inventory for marine sediments. Though the solution need not necessarily be the development of an international system.

The 'Mapping greenhouse gas emissions and removals for the land-use, land-use change and forestry sector' (LULUCF) report published by DESNZ (2025) offers a potential framework for how a marine carbon inventory would look. In this report, terrestrial land is assigned into seven categories based on their usage and habitat type. Standardised values of carbon storage are assigned to each category to allow the modelling of land-use-change to estimate the overall carbon emissions. Under such a framework, the seabed could be classified into a limited number of carbon-relevant categories, including sediment type, depth, and known disturbance regimes such as bottom trawling intensity. For each category, indicative values for surface sediment OC density could be assigned using existing national datasets (e.g. Smeaton et al. 2021; Burrows et al. 2024), in the same way that default carbon stock values are used for different terrestrial land classes within LULUCF reporting. Impact assessment would then be based on change in state, rather than absolute carbon storage.

For a given activity — such as cable trenching, foundation installation, or dredging — the spatial footprint, depth of disturbance, and duration of impact are already routinely assessed within EIAs. These parameters could be combined with sediment carbon density values to estimate the quantity of organic carbon exposed or mobilised by the activity.

Though the UK Marine Strategy explicitly recognises benthic carbon storage and risks posed to it, this is a strategic level document, not directly related to the consenting of individual projects. It is therefore difficult to leverage this for change of EIA processes, though it does present a strong supporting argument that failure to make changes may undermine statutory duties under the Marine Strategy Regulations.

The Wildlife Trusts will continue to advocate for the recognition of OC stores within MPAs and future MPAs and push to categorise these as protected features where possible. There is room for interpretation in the Habitats Regulations that could cover OC stores and once in place this would offer strong protection to the feature. However, only the most nationally significant examples of OC stores would be likely to gain protection, leaving the resulting benefits severely spatially limited. It does not solve the problem of system wide disregard of blue carbon emissions. The process would also be a slow one, and gains would be made on a case-by-case basis.

Recommendations

Protecting blue carbon stores from further degradation and allowing the process of carbon sequestration to rebuild sediment carbon stocks should be seen as a key tool in the fight against climate change. Carbon sequestration to marine sediments operates on an immense scale and requires no money or effort from humanity, only our absence. The following recommendations are set out in order of practical impact and achievability within existing UK planning and regulatory frameworks. For each recommendation, specific advocacy actions are identified to indicate how The Wildlife Trusts can realistically pursue change through their existing planning, policy and partnership roles.

Secure the inclusion of sedimentary blue carbon emissions within Greenhouse Gas Assessments (GHGAs)
Greenhouse Gas Assessments produced as part of Environmental Impact Assessments for Nationally Significant Infrastructure Projects and other marine developments should explicitly include emissions arising from the disturbance of carbon-rich marine sediments.

EIA legislation already requires assessment of the likely significant effects of projects on climate, including the nature and magnitude of greenhouse gas emissions. Recent legal and policy developments — including the expansion of scope 3 emissions following *Finch v Surrey County Council* and subsequent DESNZ guidance — demonstrate a clear trajectory towards more comprehensive and causally inclusive climate assessments. Within this context, emissions resulting from seabed disturbance can reasonably be treated as indirect project-related emissions where sediment disruption is an integral component of development.

The Wildlife Trusts will:

- Consistently request the inclusion of sedimentary carbon emissions within GHGAs during EIA scoping consultations for offshore wind, cables and other marine developments.
- Submit representations at examination stage arguing that failure to consider blue carbon disturbance leads to a systematic underestimation of project climate impacts.
- Advocate to DESNZ, Defra and PINS for supplementary guidance clarifying that sediment disturbance emissions should be considered within marine GHGAs, analogous to recent scope 3 guidance for oil and gas.

Embed an avoidance-first approach to blue carbon within project design and site selection

Marine sedimentary carbon stores cannot currently be actively restored at meaningful scales, and natural recovery following disturbance is slow and uncertain. Avoidance of disturbance must therefore be prioritised within the mitigation hierarchy already embedded in EIA and Habitats Regulations processes.

Carbon-rich sediment types — particularly fine-grained muds and silts — should be explicitly recognised as sensitive climate assets during option appraisal and design, alongside ecological receptors.

The Wildlife Trusts will:

- Use existing sediment and organic carbon mapping to identify high-risk areas and present these as constraints during early-stage consultations.
- Challenge project site selection and cable routing where carbon-rich sediments are affected but alternatives have not been adequately explored.
- Advocate for blue carbon sensitivity to be incorporated into EIA baseline characterisation and alternatives assessments.

Secure recognition of sedimentary carbon as an indicator of seabed condition within Marine Protected Areas

Though the recent consultation to ban bottom trawling within 41 offshore MPAs with seabed features has the potential to benefit the recovery of sedimentary carbon stocks if implemented, bottom trawling continues elsewhere in UK waters across carbon-rich sediment types. While some MPAs protect carbon-rich benthic habitats, the carbon stored within sediments is not recognised as a component of feature condition. This limits the ability to restrict damaging activities on climate grounds.

Sedimentary carbon should be recognised as part of seabed health within existing and future MPAs, particularly where fine-grained sediments represent nationally significant stores. Even outside of protected MPAs, guidance should be issued to avoid where possible the use of sediment disturbing activities over sediment types deemed to be 'carbon rich'.

The Wildlife Trusts will:

- Advocate to Natural England, JNCC and the MMO for the inclusion of sedimentary carbon considerations within protected site strategies and condition assessments.
- Advocate for whole site management where possible which will protect all habitats within the MPA boundary from damaging activities, including sedimentary carbon.
- Use evidence of carbon loss or disturbance to support objections to damaging activities within MPAs, alongside ecological arguments.
- Promote the interpretation of existing designation criteria (e.g. degradation and resilience) as encompassing the protection of climate-regulating functions.
- Support the identification of the most carbon-rich sediment sites as candidates for enhanced protection within future MPA reviews.

Drive recognition of blue carbon within strategic spatial planning and coordinated infrastructure delivery

Poor coordination of offshore infrastructure leads to cumulative and unnecessary disturbance of marine sediments. The NPS for Energy (2023) states that greater coordination of offshore energy transmission infrastructure is likely to reduce the cumulative impacts on the environment by installing fewer, larger, transmission cables. Though the environment in this instance focuses on habitats and species, similar benefits would also be seen for impacts on blue carbon, as every buried cable deemed unnecessary through coordination of infrastructure could represent millions of square metres of sediment left undisturbed.

Recent examples include the North Falls and Five Estuaries OWFs, and the Lion Link and Nautilus Interconnectors. Both of which, with strong overhead planning, could have had coordinated infrastructure to reduce their impacts. This represents a continued failing of the current system to meet the expectations laid out in the NPS for Energy.

The Wildlife Trusts will:

- Challenge missed coordination opportunities in project examinations by evidencing avoidable seabed disturbance and associated carbon loss.
- Work with partner NGOs to position blue carbon as a shared interest linking nature recovery and climate mitigation in strategic planning debates.

Build the evidence base needed to underpin long-term policy change
Data gaps relating to deep sediment carbon distribution, remineralisation rates and large-scale sediment redistribution currently limit the robustness of carbon accounting in marine planning. Addressing these gaps is essential to support defensible decision-making and regulatory change.

It is vital to build a detailed picture of deeper blue carbon stores as deeper penetrating activities continue to proliferate across UK seafloors. It is irresponsible to continue these activities blindly when the environmental impacts remain unknown. As a matter of course, deep sediment sampling efforts should be commissioned across the UK to develop our two-dimensional surface view into a three-dimensional map of the upper 5m of sediment. This could be funded as part of the Crown Estates programme of research projects. Cefas (2026) also identifies the need to fill the knowledge gap of deeper OC content in order to assess the full UK carbon stock.

It is also vital that we gain a better understanding of the proportion of resuspended OC which is remineralised from a single disturbance event. Specifically, these studies should focus on disturbance events in environmental and hydrological conditions found in the UKs waters. This would allow for more accurate carbon budgeting and modelling of the impact on (and recovery of) the UK's blue carbon stores.

The current literature suggests that the placement of OWFs may have large scale effects on the redistribution of OC across the entire UK basin due to in-combination wake effects. The area localised around the OWFs themselves are expected to increase their OC sediment load. While this may sound like a positive, OC deposition is only being re-organised, with deposits elsewhere likely to receive less OC in turn. This also has implications for the decommissioning of OWFs. Modelling should be carried out to establish the fate of any accumulated carbon stores should the infrastructure be removed.

The Wildlife Trusts will:

- Advocate for targeted research funding through Crown Estate, Defra and UKRI programmes to address priority blue carbon knowledge gaps.
- Actively engage with and help shape the priorities of the UK Blue Carbon Evidence Partnership to ensure that research outputs are aligned with planning and regulatory

needs, particularly around sediment disturbance and carbon accounting methodologies.

- Support the inclusion of sediment carbon monitoring requirements within marine licence conditions and post-consent monitoring.

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Appendix 1: Human impacts on blue carbon expanded.

Human activities that disturb the seafloor can cause the remineralisation of sedimentary carbon stocks through a number of processes. Resuspended sediment is now exposed to oxygenated water, allowing mineralisation of organic carbon molecules. The turning and mixing of sediment also allows oxygen to penetrate deeper into sediments, remineralising organic carbon in deeper layers than the natural surface active layer (Tiano et al 2024). The fraction of resuspended and exposed OC which remineralises will depend on local conditions, the remaining OC may return to its original store or be deposited elsewhere. When sediment is resuspended into the water column, the finest sediments will be carried away from the disturbance site by prevailing currents, while heavier sediments settle faster (Linders et al. 2017). This causes a decrease in the carbon carrying capacity of a disturbed site through the degradation of the finest sediments.

Organic carbon in deeper anoxic layers may still be degraded into methane (LaRowe et al. 2020, Bradshaw et al. 2021) which is a significantly stronger greenhouse gas than CO2. The resuspension of sediment (along with the direct damage of activities) will have a negative impact on the photosynthetic output, and therefore the carbon uptake, of the local biological community (APOC 2025). Though these effects are likely short term and potentially balanced by increased photosynthetic output following the resuspension of sedimentary N and P (Atwood et al. 2024). Atwood et al. 2024 found that 55-60% of carbon released into the water column from bottom trawling is released into the atmosphere within ~9 years of the event, similar rates should be expected for all disturbance activities. Additionally, the oxidation of organic carbon results in a lowering of pH. This in turn increases the rate of inorganic carbon dissolution both within the sediment and within living organisms (LaRowe et al. 2020, Burrows et al. 2024).

Finally, the footprint of any manmade structure installed within an area of soft sediment may provide a permanent disruption to any OC deposition and sequestration within that area. Either by direct obstruction of an area of seafloor (such as turbine foundation structures or oil & gas platforms) or through constant disturbance of the surface layers (through the movement of unburied cables or mooring lines). There may be localised increased in OC deposition due to colonisation of the structures, but further research is required as to the overall effect of OC stores surrounding the structure throughout its life.

Dredging

Dredging is a high impact activity for OC stores as it almost exclusively targets finer estuarine sediments which are higher in OC. Porz et al (2025) suggests that dredging impacts may be 1-2 magnitudes lower than bottom trawling (the most impactful human activity) while being 1-2 magnitudes greater than construction related activities. As dredging for ports and vessel navigation is a constant process with little alternative, it will not be the focus of this report.

Bottom Trawling

Most research into quantifying the effect of seafloor disturbance focus on bottom trawling as this is the largest footprint of any human marine activity. Most fishing pressure only impacts the top few centimetres of sediment (Tiano et al. 2024) and, due to the many natural and anthropogenic impacts on this surface layer, this is the most vulnerable store of carbon to remineralisation (Burrows et al. 2024). Repeated intensive trawling events will significantly degrade the sediments carbon stock, with decreasing carbon emissions from each trawl over an intensely impacted site (Sala et al. 2021). The removal of bioturbating organisms within the surface layer also reduces the rate of sequestration of OC to deeper layers. Sala et al. 2021 estimates the global emissions from bottom trawling to be 1.47Gt, almost 4% of global emissions. Though following studies suggest consideration of local environmental conditions could significantly lower this estimate (Tiano et al. 2024, Atwood et al. 2024) down to 0.02Gt (Kalapurakkal et al. *2025*).

Bottom trawling typically refers to beam trawls or otter trawls. Beam trawl nets are held open by a solid beam on the upper lip of the net. This heavy beam keeps the mouth of the net on the seafloor as the net is towed. Otter boards meanwhile, are placed at the left and right ends of a trawl net and angled to pull the net open as the trawler moves forwards. These otter boards also dig down into the seafloor up to 15cm. As such, otter boards are the most disruptive gear type with regards to blue carbon stores. Existing gear options which reduce seabed impacts include the use of static fishing gear or the use of electrical stimulation of the seafloor rather than mechanical (Sala et al. 2023). However, there are implications with both these alternatives and switching effort away from bottom trawling to other methods requires extensive consultation and consideration of wider impacts and possible unintended consequences.

Cable installations

It is anticipated that there will be around 5,000 km of array cables for offshore wind farms (OWFs) installed in the UK between 2019 and 2029 and 4,000 km of export cables in the same period. This is nearly enough cabling to stretch between London and Tokyo and only to meet the 2030 target of 50GW of offshore wind by 2030, with over 140GW expected by 2050. On top of this, offshore transmission cables and interconnectors between nations are becoming increasingly utilised. as international energy grids emerge. Cabling, like offshore wind, favours shallow waters due to lower costs of maintenance and installation. These installations, though smaller in overall footprint, penetrate significantly deeper into the sediment than bottom trawling. Thus these activities have the potential to remineralise older carbon deposits that were previously untouched by bottom trawling. It must be recognized that research into carbon stores below the surface layer represent a knowledge gap, with most studies focussing on the top 10cm of sediment. As such, the true scale of emissions from disturbance of these older carbon stores remains unknown.

Traditionally cables are buried 1-2m below the seabed to protect them from damage e.g. from anchors or fishing equipment. Though softer sediments will require a deeper burial to prevent the cable becoming un-buried due to cable disturbance or sediment movement (either natural or through disturbance from other human activities). The width of the trench will depend on the tools used and the sediment composition, with softer sediments producing wider trenches. Standard ranges of trenches are 1-5m in width for ploughs, while water jets produce narrower and deeper trenches (Muneez et al. 2018). Water jetting tools have been an increasingly popular alternative to ploughs since the 1980s. These tools use high pressure water jets to ‘dig’ a trench to depths of up to 3.2m depending on the sediment (Subtrench, 2007).

Carbon impact estimate

Smeaton et al. 2021, considering only the surface 10cm, estimates densities of OC as high as 0.8kg/m^2 for marine sediments. Using this figure as a maximum OC yield at all sediment depths, Eastern Green Link 2 cables (the UKs longest marine cable project at 505km, linking Scottish energy suppliers to English consumers) could expose up to 40,400 tonnes of OC.

This is a rough estimate, as it should be stressed again that the evidence base for OC profiles below the surface layer are severely lacking. It could be that the North Sea surface layer is depleted in OC through decades of intensive bottom trawling activity (Sala et al. 2021) and the deeper layers contain richer, undisturbed OC stores. If this were the case the blue carbon emissions from cable emissions could be higher than this estimate. It is also important to note that such projects as EGL2 will not be installed through rich mud sediment across their entire length (indeed over hard substrate, cables are often not buried at all), lowering the overall blue carbon emission.

The total amount of resuspended OC will not be remineralised into the water column. Estimates of the fraction of this OC remineralised are hard to estimate as research into carbon stores below the surface layer is lacking. Kalapurakkai et al. (2025) suggests that the fraction is small, and that deeper stores of carbon would be less reactive than stores in surface layers. Henatz & Sheffold (2023) assumes a flat remineralisation of 22.5% in their model (though acknowledging that the fraction remineralised could be significantly different and that OC profiles below 10cm are a data gap), which would equate to 9,090 tonnes of OC remineralised in this estimation of the Eastern Green Link 2 impact. It is assumed in these models that the remaining unmineralized OC will settle back on the seafloor and return to the sediment carbon store, as the unmineralized fraction will largely be less reactive forms of OC. Sanches et al. (2021) however, identifies a priming effect when more reactive and more persistent forms of OC are mixed (as they would upon resettlement on the sediment surface) leading to an average increase of 53.7% in the mineralisation rate of the more persistent forms. Though research into this effect is in its infancy, without rapid transport to deeper sediment layers, settled OC may still remineralise before it can rejoin the sediment carbon store.

Offshore wind turbines

Offshore wind generation is committed to expanding from 15GW of capacity in 2023 to 40GW by 2030 (Net Zero Strategy 2021) and estimates 88GW of capacity by 2040 (UK Carbon Budget 7). Offshore wind farms in the UK are typically fixed turbines (due to the availability of shallower waters), with each windmill stood on a concrete foundation which is hammered deep into the seabed through a process called piling. Floating offshore wind is an emerging technology allowing wind farms to expand into deep waters. Floating offshore wind (FLOW) usus multiple mooring lines anchored into the seafloor to maintain the positions of its floating turbines.

Though the foundations and anchors of wind farms will disturb the sediment, the largest footprint of disturbance are again the associated cables. Each wind farm typically has a large export cable which travels to shore and delivers the generated electricity. These cables are typically buried where they can be to prevent damage and so create the same problems as other transmission cables and interconnectors. To allow a large field of turbines to export energy via a single cable, inter-array cables run from each individual cable to converge at a converter platform. In a large wind farm of hundreds of turbines, these inter-array cables can easily span in the thousands of km (Brussa et al. 2023) and though they are not buried, this web of cables will drift with the current and disturb the surrounding surface layer permanently through the life of the installation.

Shallower waters utilised for fixed offshore wind tend to have higher wave energies, leading to a dynamic seafloor dominated by sand and gravel beds. These sediments are typically lower in OC content as they are continually disturbed and oxidated. FLOW specifically addresses the challenges of deep waters encountered by fixed offshore wind, and in so opens the impacts to deeper, more sheltered mud and clay habitats which are richer in OC. The anchor points for FLOW are piled into the seafloor and the associated mooring lines and inter-array cables may continually disturb the surface layers of sediment if slack.

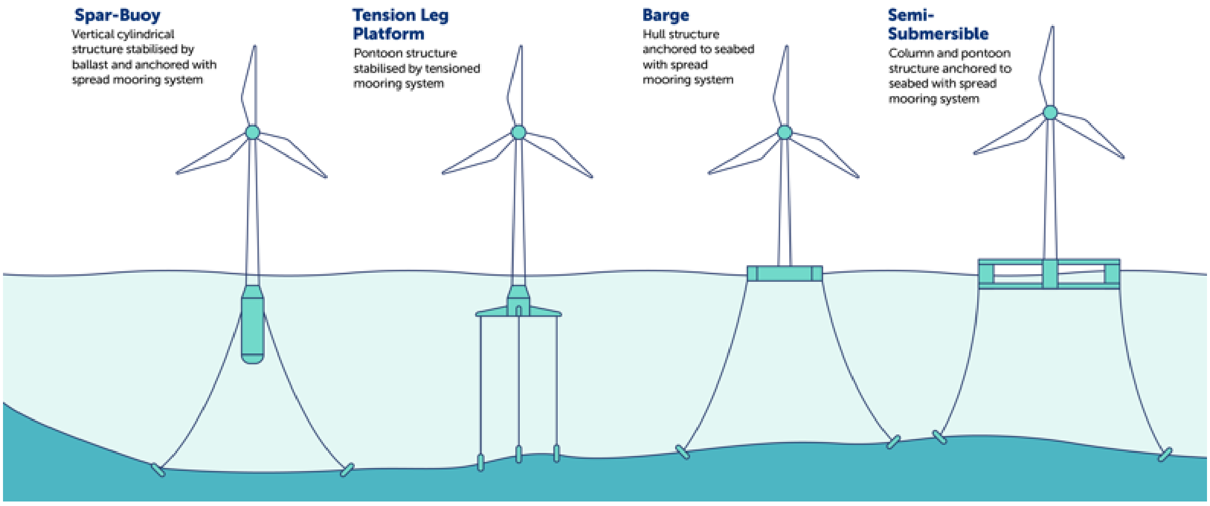

Figure 3. Showing various designs for FLOW with mooring lines in tension or with some slack.

The installation of turbine foundations themselves will also expose OC stores to be remineralised. Though the piling of a foundation into soft sediment may be more likely to displace sediment horizontally, in firmer sediment foundations are often drilled into the seafloor. This drilling of foundations is accounted for in application documents. A wind farm on Dogger Bank gives a worst-case scenario of 50% of all turbines to be installed in this manner, with 15,270m^3 of sediment released into the water. This is potentially up to 122T of OC exposed per drilled foundation (using OC density from Smeaton et al. 2021).

Offshore wind also has important indirect anthropogenic effects on Blue Carbon through its interactions with the fishing industry. As bottom trawling is often restricted between turbine arrays to protect cables, this pushes fishing efforts into other areas. Potentially increasing the trawling impact on areas deemed unsuitable for offshore wind, including deeper carbon rich sediments. Donald et al. 2025 modelled the impact from planned offshore windfarm increased blue carbon disturbance in the UK waters by 0.35 % through the shifting of fishing effort.

Recent studies have looked into the effect off massed turbines on hydrodynamic and atmospheric regimes. Chen et al. 2025, modelling the current assemblage of North Sea turbines, found synergistic effects of neighbouring OWFs which led to significant changes to current flow and sediment distribution. On average, the mud content of all North Sea surface sediment was being altered by 0.1% per year as the new hydrodynamic regime imposes itself. As large assemblages of turbines impose drag on the water column, OC settlement increases in the immediate vicinity of the OWF. This has been modelled to equate to an overall net gain in OC around the OWF over the lifetime of the project (Henatz & Scheffold 2023), though this has further implications for decommissioning, where removal of the infrastructure may lead to a reversal of the hydrodynamic regime and a scouring of the built-up OC.

This effect of OWFs acting as OC hotspots is also compounded by the reef effect, by which colonising organisms increase the organic flow to the seafloor through mortality and excretion. This ecological halo effect has been measured on long-standing structures such as oil and gas platforms and associated with OC increases in surface sediments up to 50m from the structure (Woodward-Rowe et al. 2025).