# Work Package 7(f): Direct impacts of oil and gas development – Impacts on Blue Carbon

# Introduction

The importance of the role of the ocean in mitigating climate change is increasingly being recognised1. It is estimated that the marine environment sequesters over 2.5 billion tonnes of carbon per year which equates to approximately 22% of anthropogenic CO2 emissions2. Blue carbon is the carbon stored naturally in marine and coastal systems. The term blue carbon first came into wide use with the publication of an IUCN report on coastal blue carbon in 20093. Since then, research, practice and policy has expanded rapidly4 and there have been numerous calls for wider application of the concept in marine management and climate policy5–7. Whilst there are constraints on the level of ambition possible for natural carbon sequestration on land8, in terms of capacity to plant trees and restore peatland for example, the capacity to increase carbon sequestration in the marine environment is thought to be much more extensive9 and is now the focus of increasing research effort10.

Research into the capacity for increasing blue carbon is still developing and there are many unanswered questions about the potential for blue carbon to contribute to climate change mitigation but it is widely acknowledged that urgent protection is needed for those blue carbon stocks already identified11. However, many actions that restore and protect blue carbon also protect and enhance biodiversity and other ecosystem services (such as fisheries production and nutrient protection), and so work to increase blue carbon will not only bring climate benefits but wider environmental positives too.

Practical assessments of current carbon stored in marine systems are becoming more widespread, for example extensive work has been done on Scottish blue carbon and it was recently estimated that 1,515 ± 252 million tonnes (Mt) of carbon is stored in the top 10cm of Scottish waters (the full extent of the Exclusive Economic Zone)12. A study of the English North Sea estimated the total carbon stock to be 37.4 million tonnes (Mt), with 98% occurring in sublittoral mud and sand/mud seabed sediments and just 2% in coastal habitats including seagrass meadows and saltmarshes12.

Blue carbon refers to a number of forms of natural marine carbon capture and storage including:

1. The capacity of a habitat for long-term locking down of carbon in the associated sediment.
2. The capacity for a habitat to increase the carbon stored, by sequestering further carbon in the associated sediment.
3. The capacity for a habitat to store in the long-term carbon in the plants or animals that make up the habitat.
4. The capacity for a habitat to increase the carbon stored, by sequestering further carbon in the plants and animals that make up that habitat.
5. The capacity for animals or plants to sequester carbon in the long term in deep sea environments after their death.

In recent years there has been extensive research into carbon sequestration by marine habitats. It has been found that seagrass, a marine flowering plant with a root system that is found from the polar regions to the tropics, has a remarkable capacity for sequestration. For example, a hectare of the Mediterranean seagrass *Posidonia* can store up to 15 times as much carbon per year as a tropical rainforest13 and between 10 and 15% of all marine organic carbon is thought to be stored in seagrass meadows14. Whilst coastal and marine vegetation like seagrass and mangroves are estimated to account for around 0.2% of the seabed, they store 50% of the stored marine sediment15. Their capacity to sequester carbon can continue to increase indefinitely and they lock down the carbon over timescales of millennia16.

There are many facets to blue carbon beyond seagrass beds though. Large marine animals which sink to the bottom of the deep sea become carbon sinks, and whilst each one stores away a relatively small amount of carbon, collectively large whales and fish are an important part of the marine carbon cycle. A recent study advocated for allowing more large fish to sink to the bottom of the deep ocean to enhance carbon storage in marine systems, estimating that since 1950 global fisheries have released 0.73 billion metric tonnes of carbon17.

The potential for the ocean to sequester more carbon must be considered alongside the increasingly better understood capacity for the release of carbon associated with the degradation of marine habitats18. In the last few years research has begun to focus on the emissions associated with marine habitat damage and the negative impact of some methods of fishing is also becoming clearer. In 2021 a high-profile paper highlighted the importance of effective marine protection for biodiversity, food supply and climate change19. The paper covered a wide range of issues associated with ocean conservation and climate change, but what was highlighted in extensive press coverage was that the paper estimated that the emissions associations with fishing disturbance of benthic habitats could be equivalent to the emissions from global aviation emission (approximately 1 billion tonnes of carbon dioxide per annum). The article highlighted the impacts of bottom trawling in particular and the scope for that fishing methods to be releasing vast quantities of carbon. Perhaps because of the high level of media coverage and some challenges to the estimates made, this paper has been controversial, particularly because of the negative perspective on fisheries.

Building local and global networks of Marine Protected Areas can help ensure that long-term blue carbon stores are preserved and enhanced20. Within fishing areas, an increasing focus on science-based fisheries management will allow fishers to increase their efficiency and reduce the impact of their fishing activity on seabed habitats, and therefore blue carbon.

Management also needs to be underpinned with the understanding of how climate change the efficacy of our marine management measures21.

# Global policy on blue carbon

The Intergovernmental Panel on Climate Change (IPCC) recommends actions that will keep global warming under 1.5℃ to avoid catastrophic consequences to people and biodiversity22 and the Paris Agreement requires countries to do this23. The urgency to increase global efforts to limit temperature increase to 1.5℃ was recently re-iterated in the Sharm el-Sheikh Implementation Plan, one of the key outputs of the annual United Nations Framework Convention on Climate Change (UNFCCC) 27th Conference of Parties (COP26) held in Egypt in November 202224. The major global action required to achieve this is to reduce emissions to net zero by 2050. Net zero means reducing all greenhouse gas emissions by as much as possible and balancing the remaining emissions through methods to remove carbon from the atmosphere25. This can be done by artificial carbon capture and storage or through the natural removal of carbon from the atmosphere by carbon sequestration by habitats. Technological carbon capture and storage is still developing and is constrained by cost and by the availability of suitable sites26. Enhancing natural carbon storage within ecosystems, when done effectively, can bring a wide range of additional co-benefits, enhancing other ecosystem services, enhancing biodiversity and contributing to climate adaptation and resilience27. Reliance on future carbon capture and storage is risky and it is important that carbon offsets are used carefully and alongside the necessarily large cuts to greenhouse gas emissions28.

It has widely been reported that nature-based solutions could contribution up to a third of the required emissions reductions needed to reach net zero greenhouse gas emissions by 2050 and although it remains difficult to quantify the overall importance, natural carbon sequestration is now widely accepted as one of the leading tools for reducing global emissions. But caution is required around nature based solutions29. They are not a substitute for radical emissions reductions or for biodiversity-focussed nature restoration and protection30. Although there has been slow progress to see the full embedding of nature-based solutions in climate action, particularly going beyond tree planting, the close relationship between healthy ecosystems and biodiversity and reducing emissions has now been established and is widely discussed as a key part of the solution. For example, the Glasgow Pact, agreed at the UNFCCC Conference of Parties in Glasgow (COP26) included this in Section IV31:

“38. Emphasizes the importance of protecting, conserving and restoring nature and ecosystems to achieve the Paris Agreement temperature goal, including through forests and other terrestrial and marine ecosystems acting as sinks and reservoirs of greenhouse gases and by protecting biodiversity, while ensuring social and environmental safeguards;”

However, one barrier to the wider acceptance of the role of blue carbon in climate change mitigation has been its absence from national inventories. Until recently national greenhouse gas inventories only included terrestrial carbon sequestration and there was no opportunity to formally quantify blue carbon. In terms of setting national climate change policies and leveraging funding, alignment with reductions in reported greenhouse gas emissions has been key, and therefore the absence of blue carbon in inventories has delayed the wider acceptance and implementation of blue carbon management as a form of climate action. However, this is beginning to change. In 2013 (updated in 2014) the IPCC published the Wetlands Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories32 to enable countries to include wetlands, including specifically coastal and marine wetlands, namely mangroves, seagrass beds and tidal marshes, in their national greenhouse gas inventories. Some countries now include these habitats in their national inventories and NDCs (including Australia, Belize and Costa Rica).33. However, many countries have yet to include blue carbon in their national greenhouse gas reporting.

Consequently, many countries now include some aspect of marine management and blue carbon in the climate change plans and policies but work is still ongoing to fully integrate nature based solutions and ocean climate solutions into solutions and plans34.

# What is the current UK policy position on blue carbon?

The importance of nature-based solutions in climate action is acknowledged in UK policy advice. In 2020 the Natural Capital Committee (now defunct and much of its function transferred to the new Office for Environmental Protection) produced advice on using nature-based solutions to reach net zero by 2050 which emphasised the need for a more holistic and co-ordinated approach to net zero and wider environmental protection, including to the use of the sea35 . In 2022 the UK Climate Change Committee recommended that “The UK Government and Devolved Administrations should continue to strengthen protection and restoration in marine areas, and support efforts to sustainably manage marine and coastal ecosystems, giving due consideration to their carbon value.”36. Protecting and enhancing blue carbon is increasingly being integrated into marine management. Carbon sequestration capacity is now being considered as part of some Marine Protected Area selection and management, for example in the English Highly Protected Marine Areas consultation the blue carbon value of the candidate sites is highlighted37 and blue carbon is a key function in the draft selection criteria for Scottish Highly Protected Marine Areas38. This still has a long way to go though and in June 2022 the Office of Environmental Protection (OEP) included in a letter giving advice on DEFRA environmental targets their concerns that there are no targets which direct attention towards the important role of marine environments in sequestering carbon and its vulnerability to climate impacts39.

The inclusion of blue carbon in saltmarsh and seagrass meadows in the UK national greenhouse gas emissions inventory is currently under consideration in the UK40 and subject to some further investigations, blue carbon is likely to be added in the near future41.

However, it must be acknowledged that there are still challenges around integrating wider environmental protection with climate action. Whilst work is underway to include blue carbon in the national inventory and integrate it into Marine Protected Area management, marine developments are still being approved which have wide ranging impacts on marine ecosystems and blue carbon which is of great concern.

# How oil and gas licensing threatens UK blue carbon

Healthy seas play a critical role in climate action42 but the capacity for marine species and habitats to store carbon and help curb climate change is threatened by the ecosystem impacts of offshore oil and gas, and by the climate impacts they exacerbate too43. The concept of blue carbon has only become mainstream in the past decade4 and the importance of carbon laid down in marine sediments and captured by marine species and habitats has only recently been appreciated but it is now recognised as a leading nature-based solution for climate change44,45. Currently, the best known and most comprehensively studied blue carbon habitats occurring in the UK are seagrasses and saltmarshes which are now under consideration to become the first marine habitats to be included in the UK national greenhouse gas inventory40. In future the protection and enhancement of these habitats will be of conservation importance46 and relevant to international emissions reporting and compliance with domestic and international emissions reduction targets32,47,48. Seagrasses in UK waters have been confirmed as storing significant carbon, and are comparable with tropical seagrasses49. Saltmarshes and seagrass beds are both coastal habitats, so oil and gas developments are most at risk from large accidental oil spills which make landfall50 or from habitat loss associated with bringing oil and gas to shore, for example pipelines, refineries and port infrastructure51. Seagrass meadows around the UK have been much depleted by human activities over the past century52,53 and are also at risk from extreme heat events54 which are made more likely and more severe by climate change.

In terms of total carbon accumulation, it is marine sediments that have the greatest capacity Extensive work has been done in Scotland55,56 and also further south in the English North Sea12 that has shown the importance of offshore sediments36 in storing carbon. One of the emerging threats to blue carbon habitats is fishing using trawls and dredges but this damage is beginning to be addressed in some of the UK’s MPAs, for example with the new fishing restrictions recently introduced on the Dogger Bank57. The impacts of offshore oil and gas must be also carefully considered from a blue carbon perspective12. Blue carbon habitats can be lost directly when they occur in the development footprint of oil and gas project or are impacted by a major oil incident. They are also at risk from smothering by drill spoil58and long-term contamination by wastes and toxins released during operation59.

Blue carbon is also stored in marine animals, and recent studies have highlighted how large fish17 and marine mammals60 which die naturally and sink to the bottom of deep sea areas, can be a vital carbon store. Work has been done on the blue carbon value of whales60 and has also highlighted the importance of whale faeces in providing a nutrient boost to phytoplankton which can also contribute to blue carbon61.This work is still developing, and it is unlikely that this blue carbon will be included in inventories in the near future62 but it highlights the complexity of nature-based climate solutions and the importance of healthy ecosystems. The pollution and disturbance associated with offshore oil and gas can impact on marine mammals present in the licence areas, including some of our biggest animals such as sei whales and fin whales which forage in and migrate through some areas of very high oil and gas activity. Whilst these oil and gas impacts rarely kill whales and large fish outright, they do reduce the capacity of whales and dolphins to reproduce successfully and exacerbate climate change impacts63,64 which will reduce future populations and the overall carbon that will ultimately be stored in the deep sea. The importance of larger predators as blue carbon sinks has also been highlighted65, again emphasising the carbon benefit of generally healthy and well-balanced ecosystems.

So offshore oil and gas is also impacting on blue carbon in myriad ways, which are currently difficult to quantify but will become more easily measurable as blue carbon science develops. Some of the main impacts and risks are summarized below:

**(a) Habitat loss in and around the footprint of infrastructure**

This is a relatively small impact from each development, but measured for all oil and gas infrastructure and their radii of impact, it becomes significant. It is hoped that information from Strategic Environmental Assessments, Marine Spatial Planning initiatives, location of Marine Protected Areas and individual Environmental Impact Assessments would all help avoid the most important habitats being included in the footprint of developments and therefore seriously degraded. However, given that carbon is stored in all seabed sediments.

**(b) Habitat loss because of contamination by pollutants**

Many habitats are very susceptible to pollutants. For example horse mussels and blue mussels respond to oil contamination with cardiac arrests 66 Seagrass meadows can be degraded or lost completely through major and minor pollution events67.

**(c) Loss of blue carbon through the long term and widespread cumulative impacts of oil and gas associated underwater noise** reducing the fitness, fecundity and longevity of large whales and fish. This is almost impossible to quantify as a direct blue carbon impact but it could be an important part of the picture. Other Work Packages have highlighted the many ways in which underwater noise can impact on the behaviour and health of marine mammals, and this can lead to reduced reproductive success and decreases in populations. In turn this potentially means that less large whale species like minke whales and humpbacks are growing to their maximum size and dying at sea where their carcasses could have made major contributions to blue carbon.

(d) **Loss of blue carbon through the long term and widespread cumulative impacts of oil and other pollutants**

Pollution from major oil spills and chronic pollution is contaminating ecosystems and accumulating in large marine mammals. A wide range of contaminants from the oil and gas industry are impacting on marine mammals and impacting on their capacity to reproduce. This is very likely to be having population impacts that is reducing the population size of large marine mammals and therefore the amount of carbon being sequestered as large individuals die and sink into deep waters where their carbon becomes permanently sequestered and removed from the atmosphere 61.

**(e) Impact of climate change on blue carbon**

The climate change impacts exacerbated by continued oil and gas development are actively impacting on the ocean’s capacity to curb global temperature increases and to increase blue carbon storage. From the loss of temperature sensitive habitats to the impacts of ocean acidification on marine animals and plants with hard shells, these climate impacts are adding to the other anthropogenic pressures.

# Summary table: The impacts of oil and gas on blue carbon

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| **Oil and gas impact on marine environment** | **Blue carbon consequence** |
| Habitat loss from drilling, construction of wells and platforms, pipelines, inshore and coastal infrastructure | Direct loss of carbon-storing habitats e.g. offshore sediments, leading to greenhouse gas emissions68.  Degradation of habitats from high carbon storing capacity to low. |
| Habitat loss from major oil spills | Direct loss of coastal blue carbon habitats on landfall of major oil spill – e.g. shallow water and intertidal seagrass67 and coastal saltmarsh  Direct loss of deeper water carbon-storing habitats e.g. high value offshore sediments12.  Degradation of these habitats by pollution, reducing their capacity to store carbon. |
| Habitat loss from chronic pollution | Poor outcomes for Marine Protected Areas and restoration projects designed to boost blue carbon capacity38 because of reduction in ecosystem health20.  Pollution impacts on key faunal species sediments changing communities69 and reducing ecosystem health and capacity to build blue carbon storage capacity. |
| Noise from seismic surveys, construction, operation and decommissioning impacting on marine species | Cumulative impacts on overall fitness and populations of marine mammals and other large marine animals, including predators leading to decrease in blue carbon storage in deep sea/contribution to phytoplankton61,65. |
| Oil spills and chronic pollution impacting on marine species | Cumulative impacts on overall fitness and populations of marine mammals and other large marine animals, including predators leading to decrease in blue carbon storage in deep sea/contribution to phytoplankton61,65. |
| Climate change impacts on marine ecosystems | Climate change is exacerbating other anthropogenic impacts and increasing the pressure on marine ecosystems43. Healthy marine ecosystems can store more carbon and sustain more large animals and predations to lock away carbon when they die42. |

# Managing blue carbon in UK waters

There are a number of main ways to enhance blue carbon in UK waters:

**(a) Stop degrading and destroying existing blue carbon habitats and species** – blue carbon is not yet included in national greenhouse gas inventories70 but it is likely that elements of blue carbon will gradually be added to the inventory as the evidence base and the methodologies develop, with a particular focus on saltmarshes and seagrass beds. This will help to highlight the greenhouse gas emissions implications of ineffectual marine conservation, where high carbon storing habitats can be lost as a result of marine developments and carbon-storing species like large marine mammals and sharks are not effectively protected.

**(b) Actively protect and enhance blue carbon habitats and species inside Highly Protected Marine Areas**

The Marine Conservation Society & Rewildling Britain71 advocate for 30% of UK waters as Highly Protected Marine Areas and 10% as Fully Protected Marine Areas by 2030 and mobile fishing banned in all MPAs designated for benthic (seabed) feature by 2024 to protect and enhance blue carbon as well as protecting biodiversity.

**(c) Actively restore past blue carbon habitats**

This can be done through habitat restoration, like seagrass planting which is already well underway around the UK coastline but also by protecting deep-sea muds and other offshore sediments from fishing but also from the whole suite of other impacts which oil and gas developments contribute to.

**(d) Take a more effective precautionary approach to the protection of marine mammals**

Concerns were raised in the consultation on the recent OSSEA472,73 and individual environmental assessments for offshore developments do not adequately consider the cumulative impacts and the long-term, ecosystems-wide and intergenerational impacts on marine mammals. If we acknowledge that restoring the full potential of large marine mammal populations can contribute to blue carbon then removing one large source of disturbance, pollutions and climate change can only be a positive.

More research and monitoring are needed to understand the cumulative impacts of offshore oil and gas on marine ecosystems and specifically on their climate functions and potential. Some key areas of concern include:

* Loss of offshore sediments, including deep-sea mud habitat – known to have high carbon storage value and vulnerable to direct habitat loss and also contamination74
* Impact of seismic noise on marine mammals leading to overall decrease in populations/thwarting recovery as other protections are put in place.
* Undermining specific role of Highly Protected Marine Areas and other MPAs to protect, enhance and restore blue carbon.
* Emerging understanding of chronic chemical pollution on ecosystem health and capacity to store blue carbon.
* Emerging understanding of chronic noise pollution on ecosystem health and capacity to store blue carbon.
* Risk of major and long-term blue carbon loss as a result of a large oil spill that makes landfall, impacting on saltmarsh and seagrass habitat.
* Risk of major and long-term blue carbon loss as a result of a large deep water blow out impacting deep water mud habitat and other vulnerable marine ecosystems.

# Uncertainty and future research

Research into the carbon sequestration value of offshore sediments and what impacts on this capacity is continuing and there is still some uncertainty around values. For example, the blue carbon of seagrass can vary by multiple orders of magnitude. One study of eelgrass (*Zostera marina*) from 8 sites around the world (including Japan, California and the UK) found that organic carbon stocks (integrated over 25-cm depth) ranged from 318 to 26,523 g C/m2 with an average of 2,721 g C/m.275.There has been some consideration of the relative blue carbon capacity of seabed that is protected from fishing because it is within the 500 metre exclusion zone around an oil or gas installation versus an area that is not developed but is open to trawling and dredging. It should be noted that this comparison isn’t just about the disturbance of seabed sediments and the damage to habitats that fishing causes versus the relatively small footprint of an oil or gas installation. It is also about the pollution and noise associated with oil and gas extraction which also impacts on the species and habitats in the area.

As considered in other Work Packages, it is very difficult to quantify the impact of offshore oil and gas on species such as whales, in particular the cumulative and sublethal impacts which may reduce lifespan and reproductive capacity in individuals and may have population level impacts76. This raises again the need for a holistic approach to marine management and climate action77 and the active implementation of the precautionary principle78. If we value our marine environment for biodiversity and other ecosystem services as well as acknowledging that its blue carbon function is only going to increase in importance as we understand it better then investment in effective marine conservation can only be a positive79.

If the UK ceased oil and gas approvals and phased out production there would be multiple benefits to marine ecosystems. The smaller footprint of offshore developments would mean that less offshore sediments would be lost, degraded or disturbed. There would be a net decrease in marine pollution (oil, persistent organic pollutants, plastics, heavy metals, radioactive substances) which would promote healthier ecosystems. Reduction in the currently overwhelming cumulative impacts of offshore oil and gas should lead to healthier populations of large marine mammals and large fish. Current science indicates that these ecosystem benefits would also translate into blue carbon benefits and help achieve the urgent challenge of keeping global temperature increases to 1.5˚C or under.

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