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Feature

# Blue Carbon: the Sea, the Coast and the Climate Crisis

**"Natural systems are being pressured by human activity, leading to a very real threat of dangerous climate change. These threats are as great in the marine environment as on land."**

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Natural systems are being pressured by human activity as never before, leading to a very real threat of dangerous climate change and biodiversity collapse. Policies related to amelioration of impacts tend to focus on a few terrestrial habitats. This article shows how coastal and marine habitats can absorb and lock away carbon and argues that this must be incorporated into national climate change accounting alongside terrestrial peatlands and woodlands, to drive protection, enhancement and restoration.

Natural systems are being pressured by human activity as never before, leading to a very real threat of dangerous, perhaps catastrophic, climate change (sometimes referred to as climate breakdown) and biodiversity collapse.

These threats are as great in the marine environment as on land. Ocean warming is already resulting in shifting marine species distribution and sea level rise, human development is leading to the loss of coastal habitats, and ocean acidification, caused by increased $CO_2$ uptake, is exerting pressure on many species with shells based on calcium carbonate. But, just as on land, natural processes in the marine environment provide opportunities to mitigate climate changes and address the loss of habitats and species. In this article we describe the role that coastal and marine habitats play in the oceanic carbon cycle, how they can absorb and lock away carbon and the value of protecting, enhancing and restoring natural processes in mitigating climate change. We also argue that these habitats must be incorporated into national climate change accounting alongside terrestrial peatlands and woodlands.

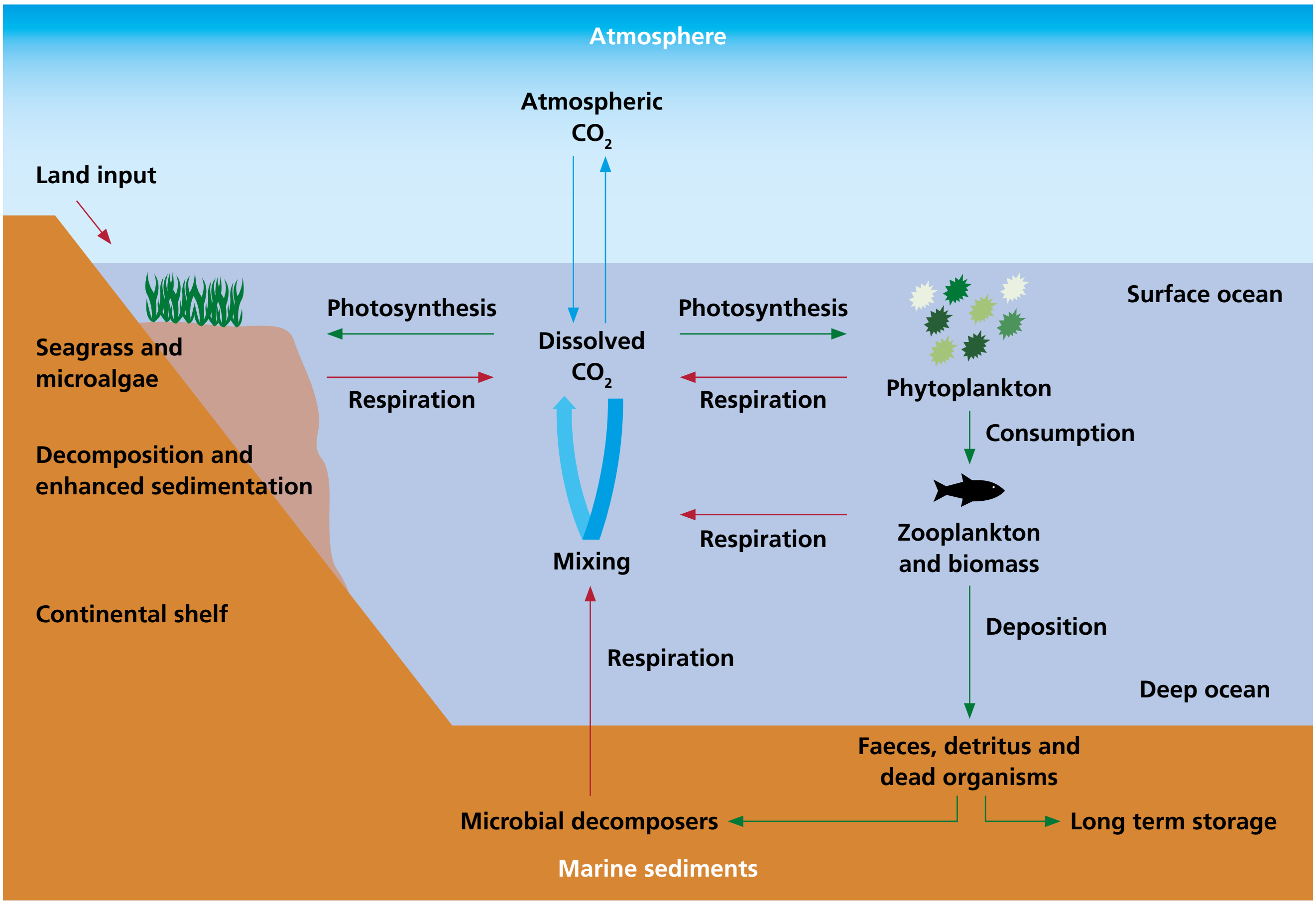


Figure 1. Conceptual diagram of the marine carbon cycle. Based on Natural England Research Report NERR 094 (licensed under the Open Government Licence v3.0).

Oceans play a significant role in the planet's carbon balance, cycling an estimated 83% of all carbon. Figure 1 provides a simplified conceptual diagram of the oceanic carbon cycle. Atmospheric and dissolved $CO_2$ are in dynamic equilibrium, making the carbon available for marine biological processes. Phytoplankton and, at the coast, macroalgae and plants, capture this carbon through photosynthesis, underpinning most marine food webs which, in turn, cycle the carbon through a network of consumers. The resulting biomass is deposited in seabed sediments as organic carbon. Inorganic carbon compounds, produced through other processes, also form an important part of seabed sediments. At any one time, therefore, carbon is stored in the living tissue of plants and animals and as organic and inorganic carbon in sediments, collectively known as blue carbon.

It is the extent to which carbon is sequestered by habitats, locked away for the long term, that is of greatest importance in terms of habitats' ability to contribute to mitigating the impacts of human-induced climate changes. Our understanding of the complexities of the carbon cycle in marine and coastal habitats is not yet complete. For example, coastal macroalgae grow extensively around the coast. A recent survey of carbon

Figure 2. Flock of waders on salt marsh, Essex, UK. Salt marsh provides substantial benefits for biodiversity as well as carbon sequestration. Photo: Chris Lawrence Travel, Shutterstock.

**“It is clear that some habitats, especially coastal salt marsh and seagrass meadows, and seabed sediments, have an important role to play in climate change mitigation.”**

Figure 3. Seagrass habitat in the Mediterranean Sea. Seagrass sequesters and stores a significant volume of carbon in plant biomass and sediments. Photo: Rich Carey, Shutterstock

storage and sequestration in different habitats carried out by Natural England (Gregg *et al*. 2021) suggests that the carbon stock of kelp is estimated at around 6.7 tonnes of carbon per hectare ($tC{\cdot}ha^{-1}$). Not all of this can be considered as sequestered. Each winter, kelp is washed up onto beaches, where decomposition will release carbon back into the atmosphere. At the same time, decomposing plant material is washed back into the sea, where it will end up in other coastal and marine habitats. The Natural England report estimates that 11.63 tonnes of $CO_2$ equivalent (a common unit used to describe the global warming impact of different greenhouse gases) per hectare per year ($tCO_2e{\cdot}ha^{-1}{\cdot}year^{-1}$) are lost from kelp beds, of which only 0.33 $tCO_2e{\cdot}ha^{-1}{\cdot}year^{-1}$ reaches subtidal sediments. However, assessing levels of sequestration in coastal and marine habitats is extremely complicated.

Despite the complexities of assessment, it is becoming clear that some habitats, especially coastal salt marsh (Figure 2) and seagrass meadows (Figure 3), and seabed sediments, have an important role to play in climate change mitigation. Coastal salt marsh and seagrass meadows are similar in that small amounts of carbon are stored as plant biomass, with much larger proportions locked up in soil and sediments. The Natural England survey reports carbon stock estimates of around 0.6 $tC{\cdot}ha^{-1}$ for salt marsh vegetation and 56 $tC{\cdot}ha^{-1}$ in salt marsh soil, and 0.3 $tC{\cdot}ha^{-1}$ for seagrass plant biomass and 39 $tC{\cdot}ha^{-1}$ for seagrass sediments. Perhaps a more important measure is carbon flux, indicating to what extent habitats are absorbing or releasing carbon. A recent report from the Environment Agency (Beechener *et al.* 2021) suggests that salt marsh habitats absorb 2–8 $tCO_2e{\cdot}ha^{-1}{\cdot}year^{-1}$, while seagrass meadows lock away 1.6 $tCO_2e{\cdot}ha^{-1}{\cdot}year^{-1}$.

Subtidal sediments are considered the most important store of carbon from biological sources in the marine environment. Although some muddy habitats are rich in organic carbon, particulate inorganic carbon is considered the main carbon store in subtidal sediments. It is also thought that inorganic carbon is more effectively sequestered for the long term, with a residence time of several centuries in undisturbed habitats. The Natural England survey (Gregg *et al*. 2021) reports figures of around 55 $tC{\cdot}ha^{-1}$ for mud and 18 $tC{\cdot}ha^{-1}$ for sand, with an estimate of carbon flux suggesting that 1.98 $tCO_2e{\cdot}ha^{-1}{\cdot}year^{-1}$ is buried in subtidal sediments. More research is needed on carbon storage and sequestration by all coastal and marine habitats; an assessment of the confidence in the figures presented in the Natural England survey is either "low" or, in the case of salt marsh, "medium".

Despite this uncertainty, the need for long-term storage of carbon has significant implications for the future management of coastal and marine habitats. Protection of habitats such as salt marsh, seagrass meadows and sediment from damage and disturbance will ensure that the carbon they have stored in the past remains locked away. Well-managed Marine Protected Areas and effective Environmental Impact Assessments are needed to reduce physical pressures from human activities, including bottom-towed fishing and deep-sea mining. In addition, Shoreline Management Plans that encourage managed realignment to allow natural migration of salt marsh will reduce habitat loss through coastal squeeze. But the climate crisis requires more than simply protecting existing carbon sinks. Increasing the area of carbon-accumulating habitats, for example through projects that deliver restoration of seagrass meadows and salt marsh, will help reduce levels of atmospheric greenhouse gases. An example of managed realignment can be seen at Hesketh Out Marsh on the Ribble Estuary, near Preston, Lancashire, where the Royal Society for the Protection of Birds has created 322 ha of salt marsh by breaching historic sea defences (Climate-ADAPT 2016).

Protection and restoration of coastal and marine habitats has an important part to play in mitigating human-induced climate change. However, this should not be seen in isolation. There are many benefits, for both biodiversity and human society, in enhancing coastal and marine ecosystem services. This has been increasingly recognised in recent publications, including a recent report by Penny Anderson (2021). In addition to the Natural England and Environment Agency surveys already discussed, reports from the British Ecological Society (Stafford *et al.* 2021) and the Natural Capital Committee (2019), and work by Marine Scotland (e.g. Marine Scotland 2020), all highlight the value that these habitats have in addressing the current

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climate crisis, with the Natural Capital Committee report stressing the need provide funding for protecting and restoring threatened habitats.

Future work into assessing and enhancing the ecosystem services provided by coastal and marine habitats, such as that being undertaken by Plymouth Marine Laboratory (e.g. Plymouth Marine Laboratory 2017), and the delivery of effective protection and restoration projects, such as those mentioned in this article, are essential in tackling the joint challenges of

Figure 4. Collecting a sediment core to assess carbon sequestration rates.

## Box 1. Supporting seagrass restoration through Project Seagrass

From 2016 to 2020, CIEEM offset its unavoidable emissions by making a donation equivalent to the average cost of offsetting the annual carbon tonnage, determined by carbonfootprint.com, to support environmental projects in Great Britain and the island of Ireland. For CIEEM's 2019–20 emissions, a donation of £200 was made to Project Seagrass to support the restoration of seagrass in west Wales.

Project Seagrass is an environmental charity devoted to the conservation of seagrass ecosystems through education, influence, research and action. The charity aims to "reverse the loss of seagrass by turning research into effective conservation action and communication through partnerships with local communities and other stakeholders".

This work has been kickstarted with monitoring programmes in North Wales and the Isles of Scilly, and the restoration of 2 ha of seagrass in west Wales. The charity also supports research projects in Europe, across the Indo-Pacific and in the Caribbean, looking at the structure, function and resilience of seagrass meadows. Project Seagrass also aims to launch the first ever full-scale seagrass restoration project. Find out more at www.projectseagrass.org/.

the climate and biodiversity crises. However, to be truly effective, these opportunities need to be incorporated into long-term political visions and actions. The sixth, most recent, Carbon Budget (Committee on Climate Change 2020) fails to include coastal and marine habitats for greenhouse gas reduction, focusing solely on woods and peatlands. While these terrestrial habitats are important for 'green carbon', the fact that blue carbon is not included in national climate change accounting means that UK government policy ignores that role that coastal and marine habitats can play in mitigating human-induced climate change. If the combined threats of catastrophic climate change and biodiversity collapse are to be ameliorated, then all possible actions need to be taken. We cannot afford to overlook any opportunities.

CIEEM is supporting seagrass restoration through carbon offsetting, contributing to the work of Project Seagrass (see Box 1).

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## About the Authors

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