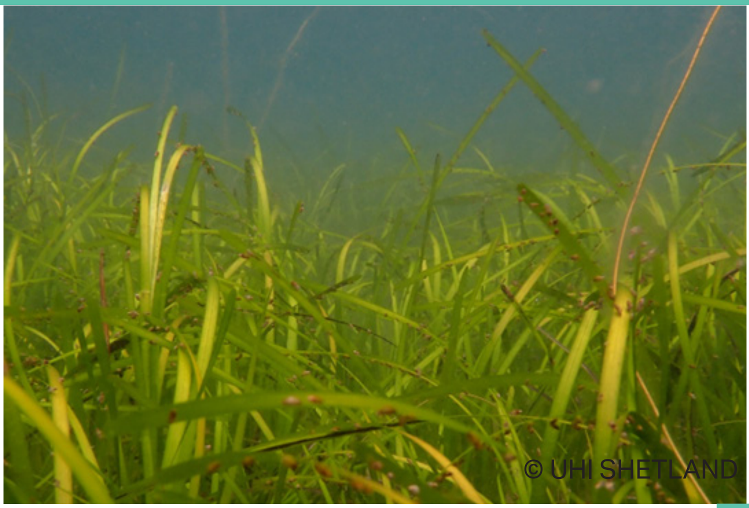
Policy Brief

June 2024



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Towards Net Zero:
The Role of Marine Habitats

What is Blue Carbon?

Shetland's seas are home to many important habitats and species which absorb and store carbon. The term 'Blue Carbon' refers to the carbon captured from the atmosphere (air) and stored by the world's oceans, this process plays a crucial role in mitigating global climate change. Unlike terrestrial forests or peat which are more commonly associated with carbon sequestration (capture and storage), blue carbon ecosystems have the unique ability to sequester carbon in both their biomass and in the sediments below them[1], offering long-term and potentially indefinite carbon storage solutions.

Many of the habitats and species which form part of our global blue carbon resources, including those found in Shetland, are sensitive to disturbance by human activities and climate change itself[2,3]. To avoid this disturbance mapping the occurrence of these important habitats is necessary, and research is needed to quantify their carbon capture potential accurately[4]. Informed and effective marine management, underpinned by precise mapping data, is crucial to realising the full potential of blue carbon as a nature-based solution to climate change, ultimately contributing to global efforts to reach net-zero emissions[5].

The primary aim of this policy brief is to highlight the role of Shetland's blue carbon habitats and species as a nature based solution for achieving net zero. By highlighting the importance of accurate and comprehensive mapping, and outlining strategic recommendations, this brief seeks to support policymakers and stakeholders in the valuation of these habitats and in adopting measures that will protect and enhance Shetland's blue carbon stores.

Key Messages

- Informed marine management is essential for leveraging blue carbon as a nature-based climate solution.
- Accurate mapping is crucial for identifying hotspots, guiding conservation efforts, and integrating blue carbon into marine management strategies.
- Modelling can help predict changes and inform restoration strategies.
- Local management measures in Shetland, such as closed areas, protect sensitive habitats and support blue carbon storage.
- Restoration efforts can enhance carbon sequestration and biodiversity support.
- Human activities and climate change pose threats like physical disturbance, ocean acidification, and warming.
- Mapping blue carbon facilitates informed marine management, contributing to global climate goals and coastal environment conservation.

UK Blue Carbon

In the UK, it is estimated that blue carbon ecosystems have the potential to capture and store approximately 2% of the UK's emissions per year[6], highlighting their importance in national climate strategies. This capability is essential as the UK strives to meet its climate targets, including those set out in the Paris Agreement and the UK's own commitment to reach net-zero carbon emissions by 2050.

Definitions

Carbon Sequestration

Any process (natural or artificial) by which carbon dioxide is removed from the atmosphere and held in solid or liquid form[7].

Carbon Stock

The quantity of carbon held in a habitat pool at any specified time is the carbon stock or store[7].

Mechanisms of carbon storage

In Shetland, blue carbon habitats encompass the carbon stored in various coastal ecosystems, including maerl beds, horse mussel beds, brittlestar beds, kelp forests, and seagrass meadows (Figure 1). This carbon capture then storage can be done in several ways, including through photosynthesis[10] and storing of carbon in calcified skeleton[12].

Carbon capture occurs when carbon dioxide dissolved in seawater is absorbed and kept within the tissues of seaweeds such as kelp, and marine plants such as seagrasses and those found in salt marshes through photosynthesis[8, 9]. The efficiency of these kelps and seagrass in capturing carbon is vast. Around Shetland's coast seaweeds cover extensive areas along our rocky coastline. Carbon capture also occurs when carbon is integrated into the bodies or shells of marine animals such as brittle stars and mussels.

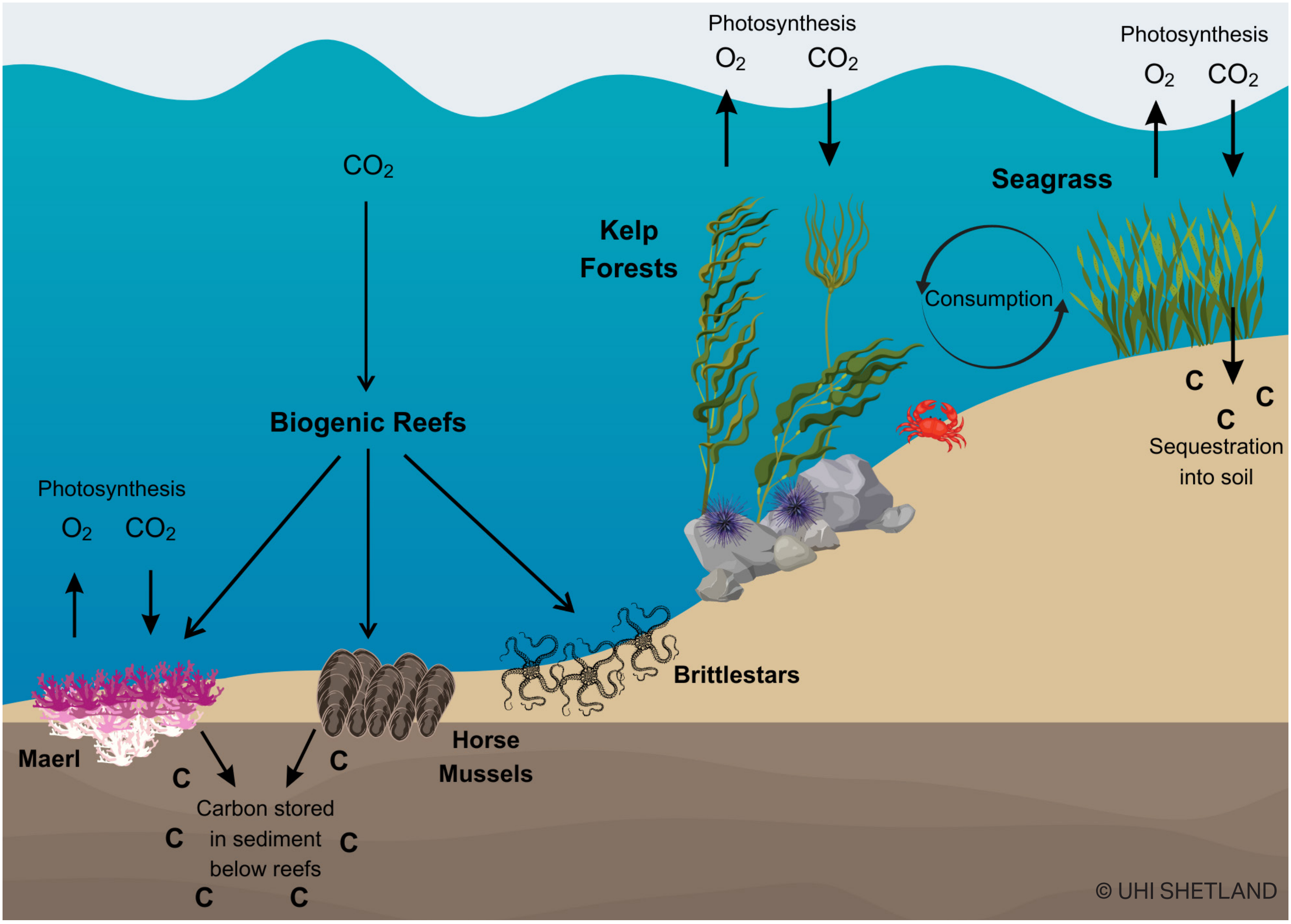

Figure 1. Pathways for carbon capture and storage by Shetland's blue carbon habitats.

Carbon storage occurs when carbon becomes integrated into sediments. For example, kelp material is exported from subtidal rocky reefs to deep-sea environments where it can be buried in sediments[10], or when dead seagrass and salt marsh plants become trapped in oxygen-free sediment stabilised by their roots and rhizomes[11]. In both cases, the carbon can remain captured indefinitely if undisturbed. The carbon captured by marine animals can also become permanent stores, for example when mussel shells accumulate, sometimes becoming buried in sediments.

It is not known how much carbon is captured or stored in our blue-carbon habitats around Shetland, and quantifying these values would require further research.

Horse Mussel Beds

Description	✚ They form beds on soft or mixed sediments helping to stabilise the sediments. ✚ Horse mussels actively filter seawater, capturing organic particles. ✚ Horse mussel beds are found in tidal areas such as Yell Sound and Bluemull Sound.
Mitigation Role	✚ Their shells contain carbon, contributing to carbon capture[17]. ✚ These beds act as carbon sinks, especially when mussel shells accumulate.
Co-benefits	✚ Support biodiversity including economically valuable fish species[18]. ✚ Their filter-feeding behaviour improves water quality[19].

Brittlestar Beds

Description	✚ Brittlestars are relatives of starfish but have a disk like body with thinner and more fragile arms. ✚ They form large aggregations on soft and hard sediments. Large beds of brittle stars are found in tidal areas in Shetland sounds and headlands.
Mitigation Role	✚ Brittlestars have a skeleton made from calcium carbonate[6,12,22]. ✚ Further research is needed to understand their full role in carbon capture.
Co-benefits	✚ Their presence creates microhabitats for small organisms.

Seagrass Meadows

Description	✚ Found in shallow, sheltered, sandy areas and coastal lagoons around Shetland. ✚ Locally and globally meadows have been lost due to wasting disease
Mitigation Role	✚ Capture carbon through photosynthesis. ✚ Roots aid in storing large amounts of carbon in the sediment[11,13].
Co-benefits	✚ Provide shelter and food for diverse marine organisms. ✚ Improve water clarity by trapping sediments and filtering nutrients[14].

Maerl Beds

Description	✚ Consisting of free-living, calcifying red algae that form intricate structures on the seabed[15]. ✚ Many beds are thought to be over a 1000 years old and are found in shallow waters with individuals living up to 100 years and growing very slowly, at ~1mm every year[12]. ✚ Beds exist around Shetland, with the largest found between Yell and Fetlar.
Mitigation Role	✚ Maerl incorporates dissolved inorganic carbon into their calcium carbonate skeletons[12]. ✚ The calcified structures of maerl persists over time, locking away carbon[16].
Co-benefits	✚ Support a variety of marine species with their branching forms creating important nursery habitat for marine organisms including economically valuable fish and shellfish species[16].

Kelp Forests

Description	✚ Kelp forests are found around Shetland's exposed coastline down to a depth of 20m. ✚ They grow along rocky coastlines in cold, nutrient-rich waters[10].
Mitigation Role	✚ Kelp rapidly photosynthesises, capturing CO_2 and incorporating it into their tissues[10,20]. ✚ Kelp forests capture carbon efficiently, rivalling terrestrial forests.
Co-benefits	✚ Support fish, invertebrates, and other algae[21].

Mapping, modelling and protecting Shetland's blue carbon habitats

Importance of accurate mapping

Mapping blue carbon habitats is necessary for understanding their distribution, extent, and carbon sequestration potential. Accurate mapping enables the identification of key blue carbon hotspots. The resolution at which habitat mapping is conducted can greatly influence the appropriateness of decisions made, helping to guide development and is critical for targeted conservation and restoration efforts[4].

UHI Shetland has actively mapped many of these blue carbon habitats using their survey vessels[23,24]. This mapping is important as many historical records have been found to be inaccurate and to ensure new records are properly investigated. Habitats such as maerl and horse mussels are now known to occur over large areas in Colgrave and Hascosay sound and have informed local management measures implemented by the Shetland Shellfish Management Organisation (SSMO) and the Shetland Islands Regional Marine Plan. Coastal plants like seagrasses, and salt marshes are also important, although their distribution around Shetland is more limited but UHI Shetland are working with community volunteers to map current and historic records.

Benefits of effective mapping

- Providing spatial data for effective marine management (Figure 2);
- Identification of areas for conservation and restoration;
- Integrating blue carbon into marine management strategies ensures long-term benefits for both ecosystems and communities.

Modelling blue carbon habitats

Surveying in the sea is slower and more expensive than on land and modelling where these habitats may occur can help to target survey efforts. It can also be used to help predict future changes in blue carbon habitats under various scenarios, such as climate change, pollution, and management efforts.

UHI Shetland has recently completed work on creating a high resolution map of the modelled distribution of the dominant marine habitats within Shetland's 12nm limit for this purpose[25] (Figure 2).

Local management case studies

Shetland has unique powers to manage its seas; via the SSMO who are responsible for managing Shetland's shellfish fishery out to 6nm, the ZCC Act which gives Shetland licensing control out to 12nm, and the Shetland Islands Regional Marine Plan which provides a policy framework to guide marine decision making. Surveys conducted by UHI Shetland have involved mapping and modelling important habitats providing critical data that support the creation and management of appropriate management measures, ensuring that measures are based on the best available science. The SSMO has proactively protected sensitive marine habitats through a series of closed areas (Figure 3) with UHI Shetland undertaking the necessary surveys to support these measures[24].

These closed areas protect biodiversity and fish nursery areas, but also support our most import and sensitive blue carbon habitats, including areas of seagrass, maerl, and horse mussel beds. These closed areas were developed in collaboration with the fishing industry and are now also protected by the Shetland Islands Regional Marine Plan[23] (developed by UHI Shetland and the SIC).

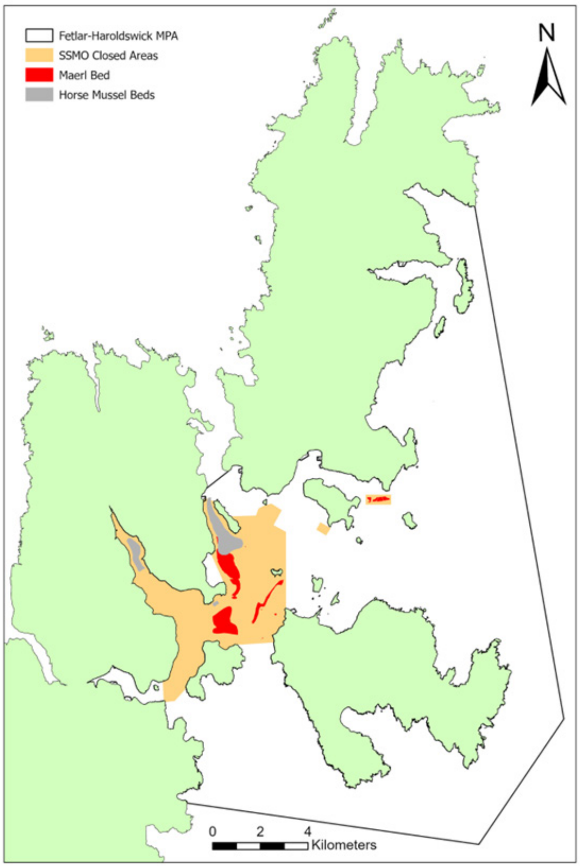

Figure 3. Blue carbon habitats within the Fetlar-Haroldswick MPA and voluntary closed areas by the SSMO.

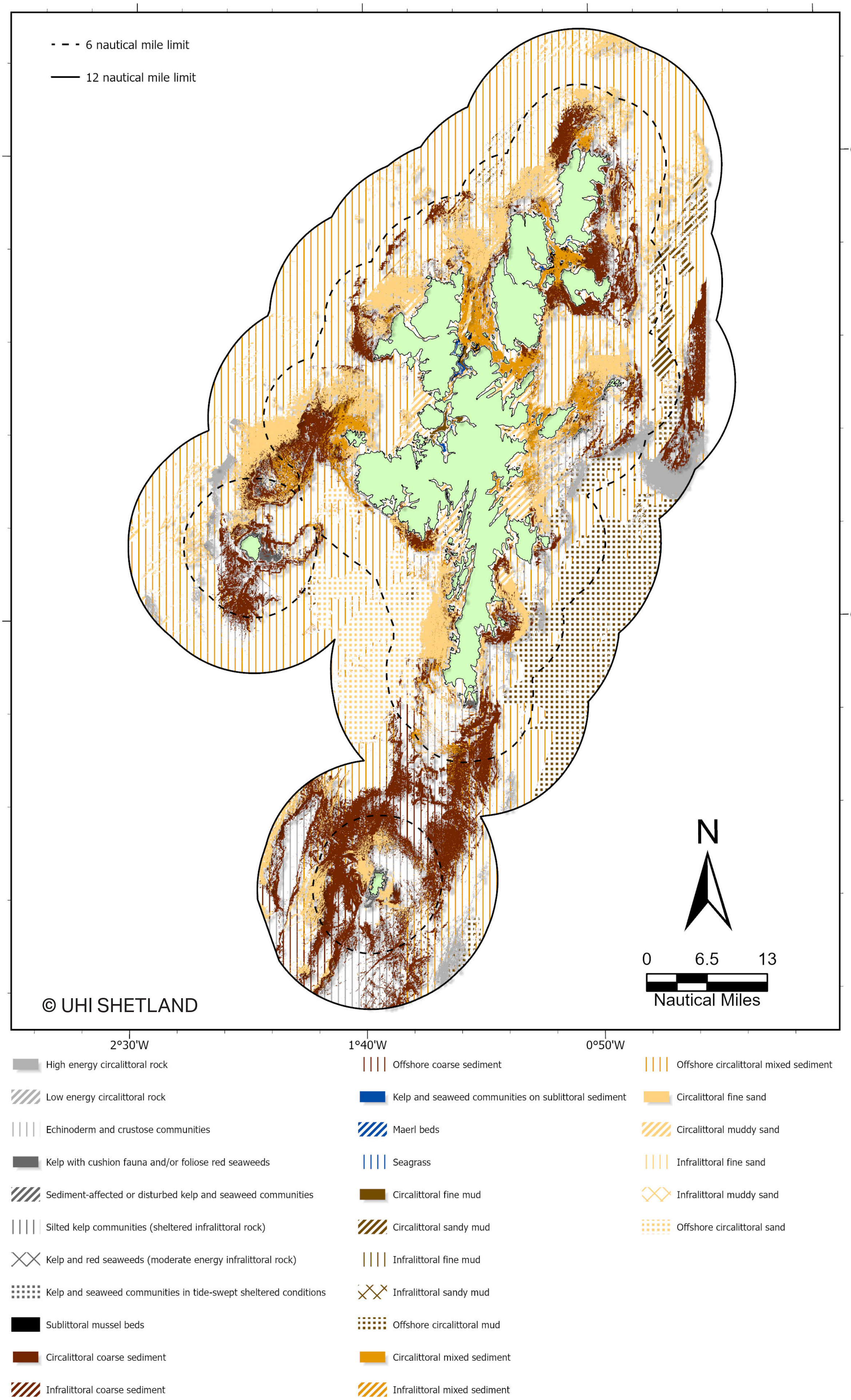

Figure 2. Shetland Islands dominant marine habitat map.

Mapping Shetland's seagrass meadows

Seagrass meadows are valuable blue carbon habitats, capable of absorbing large amounts of carbon dioxide. Seagrasses are the only type of flowering plant in the ocean. There are two types of seagrass found in Shetland. Eelgrass (*Zostera marina*) is a fully marine species and can form lush, dense meadows while the smaller tasselweeds (*Ruppia spp.*) prefer less salty water and are found in coastal lochs and lagoons. These beds provide many benefits in addition to their role in sequestering carbon, including stabilising sediments with their root system[11,13], serving as crucial nursery habitat for commercial fish species, and enhancing water quality[14].

Eelgrass beds in Shetland are restricted to sheltered voes in west Mainland. Historical records show that in the early 1900s these beds used to cover large areas in Whiteness and Weisdale Voe[26], and in Marlee Loch near Brindister Voe. Much of this disappeared in a mass-dieback in the 1930s, some has been lost in the last 20 years, and the status and location of the remaining fragments is uncertain.

The marine spatial planning team at UHI Shetland are conducting a project to find the remaining beds and assess their condition to help prevent further loss. This project (supported by funding from the SMEEF), is mapping the distribution of Shetland's seagrass beds using aerial drone surveys and working with community volunteers to assess the health the condition of existing beds.

Restoration

Initiatives to restore degraded blue carbon habitats can enhance their capacity for carbon sequestration and biodiversity support. Globally, progress has been made in recovering lost seagrass meadows over the past few decades. Across the UK, there are a number of initiatives in England and Scotland that are trialling different methods to replant seagrass beds[27]. However, for restoration to be successful it is fundamental to first understand the health of existing beds, and the reasons why it is in decline in the area of interest. Habitat suitability modelling can help inform restoration by identify areas where the conditions might be suitable for restoration.

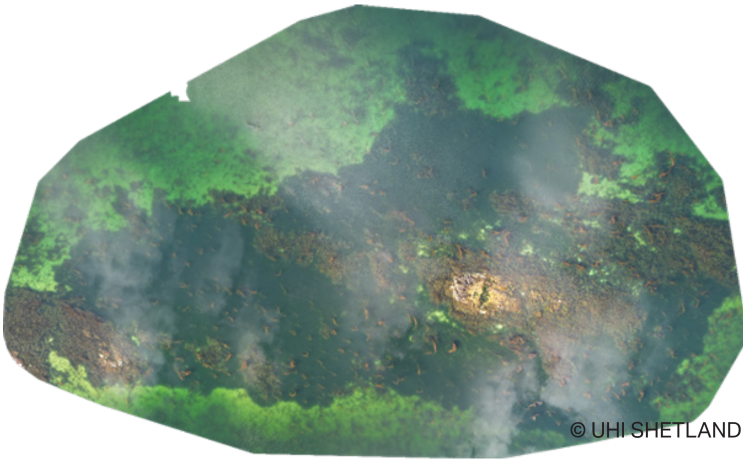

Figure 4. Aerial image of an eelgrass bed, taken by drone in Whiteness Voe, Shetland.

Restoring seagrass habitats can offer extensive benefits for climate change mitigation, biodiversity, fisheries, and water quality.

Key Threats to Shetland's blue carbon habitats

It is important that current and future threats to our blue carbon habitats continue to be managed. For some of these threats, such as physical disturbance, Shetland has proactively developed management measures, but other wider seas threats such as ocean acidification and ocean warming are harder to manage locally. Understanding where blue carbon habitats occur and the value they hold is key to effective management.

Physical disturbance pressures

Physical disturbance pressures from human activities can lead to stored carbon being released[11]. These pressures include the transformation of seabed types, where natural habitats are replaced by artificial structures or altered environments, disrupting the delicate balance of these ecosystems. Additionally, the removal of non-target species through lethal means, either inadvertently or intentionally, further destabilises these habitats by disrupting intricate food webs and ecological functions. Sedimentation can smother these habitats, inhibiting growth. Penetration from activities like anchoring can physically damage the habitat and disrupt root systems, while surface abrasion, can erode and disturb sediment layers, increasing habitat degradation.

Climate change pressures

Climate change poses another threat to these habitats through ocean acidification, warming, sea level rise, and increased storminess. Ocean acidification impairs calcareous organisms like maerl (Figure 5), while rising temperatures cause thermal stress and species shifts, reducing habitat resilience. Sea level rise inundates coastal habitats, leading to the loss of intertidal zones and salt marshes, and more frequent and intense storms cause erosion and sediment displacement, further degrading these habitats.

Addressing both human-induced pressures and climate change impacts is crucial to protecting and restoring Shetland's blue carbon habitats, ensuring their continued role in carbon sequestration and ecosystem support.

Opportunities for Shetland

Mapping blue carbon is a powerful tool for informed marine management. Further research is needed to quantify the amount of carbon that is sequestrated by Shetland's marine environment. This understanding well help ensure decision making fully accounts for all potential impacts. This understanding can support Natural Capital Assessments in line with the Scottish Government's Blue Economy Approach. By understanding these ecosystems' distribution, we can protect and restore them effectively, contributing to global climate goals and safeguarding our coastal environments.

Future Work

- Invest in continued survey efforts to map blue carbon habitats accurately.
- Develop locally tailored methodologies to quantify carbon capture and storage in different blue carbon habitats.
- Regularly update mapping data to capture changes over time.
- Use modelling to forecast potential changes in blue carbon habitats under various scenarios, including climate change impacts and management interventions.
- Continue to protect blue carbon habitats, supported by scientific surveys and community engagement.
- Invest in restoration projects to enhance the capacity of blue carbon habitats for carbon sequestration and biodiversity support, guided by mapping data and scientific expertise.

Figure 5. Maerl bed and brittlestar taken by drop down video in Mousa Sound, Shetland.

Challenges and Opportunities

	Challenge	Opportunity	Importance
Local and global knowledge gaps	+ Our understanding of the distribution and extent of blue carbon habitats remains incomplete	+ Conduct comprehensive mapping efforts to identify and quantify these ecosystems across different regions.	+ Accurate spatial data will inform conservation strategies and facilitate targeted restoration efforts.
Mapping and understanding Blue Carbon stocks	+ Gaps exist in our knowledge of the total carbon stocks held by different blue carbon habitats.	+ Develop robust consistent methodologies for assessing carbon content in blue carbon habitats.	+ Accurate stock assessments are essential for setting realistic climate targets and tracking progress.
Valuing Blue Carbon aspects	+ The economic valuation of Blue Carbon remains underexplored.	+ Develop frameworks to assess the monetary and non-monetary value of these ecosystems.	+ Valuation can drive investment, policy support, and sustainable management actions.

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