National Assembly for Wales
Senedd Research

Blue Carbon
Research Briefing

December 2019

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Introduction

The carbon sequestered in vegetated coastal and marine ecosystems, in particular seagrass, saltmarsh, mangrove and seaweed habitats, is termed “**blue carbon**”.

The vegetation in blue carbon habitats removes carbon dioxide (CO_2) from the atmosphere and surrounding seawater (during a process called **photosynthesis**), then stores carbon **within plants and underlying sediments**.

This research briefing details the main marine habitats that contain blue carbon, where they are located and the various **threats** they face. It describes the links between blue carbon habitats and climate change, specifically in terms of the ability of these habitats to sequester carbon and store it over **millennial timescales**, as well as their capacity to release carbon into the atmosphere if they are **degraded, damaged or destroyed**. The briefing also highlights blue carbon research and conservation programs, as well as various policies relevant to blue carbon including **national marine plans**, **climate change mitigation and adaptation strategies**, and **global biodiversity targets**.

Welsh seas cover **32,000km²** (with a 2,120km coastline) and contain seagrass, saltmarsh, and seaweed habitats. Analysis presented in this briefing indicates that more than 99km² of blue carbon habitat is located within the Welsh Marine Protected Area network. Blue carbon is therefore an important consideration for **climate change mitigation and adaption** in the context of the **climate emergency** declared by the Welsh Government.

Blue carbon habitats

Blue carbon habitats have been **ranked among the most intense carbon sinks in the world** and have been found to be **disproportionately important** in sequestering CO_2 compared with terrestrial habitats. **Mangrove, saltmarsh** and **seagrass** habitats store twice as much carbon as terrestrial habitats per unit area, and unlike terrestrial soils, their underlying sediments **never become saturated** with carbon.

Despite occupying just **0.2%** of the ocean surface (**49 million hectares**), vegetated marine habitats (including **seaweed**) are responsible for more than **50%** of carbon storage in marine sediments. Seaweed is **increasingly recognised** as an important blue carbon store, due to the presence of **macroalgal carbon in the deep sea** and the **carbon stored in living seaweed.**

The units used to measure the carbon stored in the coastal and marine habitats described in this briefing are specified in Section 10.

Seagrass meadows


Seagrass © Pembrokeshire Coastal Forum

Seagrass is a marine flowering plant (**angiosperm**) that lives in shallow, sheltered areas. It grows anchored in sand, mud or fine gravel, on the seafloor of **temperate and tropical coastlines** and is often found in large groups, known as “beds” or “meadows”, that resemble terrestrial grasslands. Globally seagrasses extend across **319,000km²**, which is approximately **0.1%** of the seafloor. Seagrass meadows are found along the UK coastline in sheltered areas such as harbours, estuaries, lagoons and bays. Globally there are **60 species** of seagrass, **four** of which are native to the UK.

Seagrass meadows support high levels of biodiversity and are an important habitat for many UK species. They provide **nursery grounds for various commercial fish species** (e.g. **Atlantic cod**), habitat for protected species including the UK’s **two native seahorse species**, and at low tide **wildfowl birds** feed on exposed seagrass. It has been estimated that one hectare (ha) of seagrass can support as many as

80,000 fish and 100 million invertebrate species. Seagrass meadows also provide valuable **ecosystem services**, for example, filtering pollutants, cycling nutrients, stabilising sediments, reducing coastal erosion and **storing carbon**.

Seagrass sequesters CO_2 dissolved in seawater, then stores carbon in living tissues or buries it in underwater sediments. Despite accounting for just **0.1%** of the seafloor globally, seagrass ecosystems store as much as **19.9 PgC** (billion tons of carbon). This accounts for between **10 - 18%** of the ocean’s annual carbon storage. Estimates for seagrass accumulation of carbon in sediments range from **27.4 TgCyr^{-1}** (million tons of carbon per year), to as much as **48-112 TgCyr^{-1}**. These estimates demonstrate that seagrass meadows store at least **twice** the carbon per hectare as terrestrial soils, and unlike terrestrial soils seagrass sediments **never become saturated** with carbon. Furthermore, while terrestrial forests can bind carbon for decades, seagrasses meadows can bind carbon for **millennia**.

Saltmarshes


Saltmarsh © Wikimedia

A **saltmarsh** (PDF 41.7KB), also known as a coastal saltmarsh or tidal marsh, is a coastal ecosystem that **establishes within the shelter of estuaries, lagoons, beach plains, natural harbours or behind barrier islands** (PDF 196KB), where fine silt and clay sediments settle. Saltmarshes are located in the upper intertidal portion of **mudflats** (PDF 3.91MB), where salt-tolerant flowering plants (**angiosperms**) can grow on a substrate of fine sediments. Saltmarshes have a **global occurrence**, covering almost **55,000km² of the worlds’ coastlines**. In the UK, **26 types** of saltmarsh vegetation have been defined and can be **found in sheltered estuaries and natural harbours.**

UK saltmarshes are important **feeding, breeding, nesting and refuge sites** for many bird species. For example, approximately **50% of the British redshank population** use saltmarsh as breeding habitat. An abundant and diverse range of **invertebrates also live in saltmarshes**, and they provide **sheltered breeding, spawning and nursery grounds for several commercial fish species** (PDF 3.91MB). Acting as a transition zone between the land and sea, saltmarshes protect coastlines from **flooding and erosion**. By cycling nutrients and retaining sediments, they also improve **water quality, control coastal pollution** (PDF 3.91MB) and are important **carbon stores**.

Saltmarsh plants capture CO_2 from the surrounding air and water column, and subsequently store carbon in their tissues and underground sediments. Saltmarshes have the **highest carbon burial rate per unit area** compared with other blue carbon habitats, with total global accumulation of **10.2 $TgCyr^{-1}$**, with estimates ranging between **5 – 87 $TgCyr^{-1}$**. Saltmarsh sediments also have the ability to accumulate carbon without reaching **saturation** and can store carbon over **millennial** timescales.

Mangrove forests


Mangrove © Flickr

A **mangrove** is a salt-tolerant woody shrub or small tree that grows in the intertidal zone of sheltered tropical and sub-tropical coastlines. Mangroves are flowering plants that grow in **slow moving saline and brackish waters, which allow fine sediments to accumulate**. Mangroves can be identified by characteristic **prop roots** that make the tree appear to stand on stilts, allowing most of their leaves to grow above water while their roots remain submerged. Estimates of mangrove extent vary, however spatial mapping estimates they cover **137,760km^2** worldwide. There are approximately **70 species** of mangrove plants, which are only found in **tropical and sub-tropical climates**.

Mangrove forests are **exceptionally productive ecosystems**, forming the base of marine and terrestrial food chains. The intricate root system of mangroves serve as breeding and nursery grounds for **coral reef fish, commercial fish and crustacean species**, Mangrove forests **stabilise coastlines**, providing flood and storm protection while reducing erosion from tides and storm surges. They also **recycle and retain nutrients, filter water, provide food and material resources for coastal communities** and **store carbon**.

Mangroves sequester carbon from the atmosphere and surrounding waterbody which is then stored in their underlying sediments and plant biomass. Mangroves are estimated to sequester carbon at a rate of **24$TgCyr^{-1}$**, and globally store **4.19 PgC**, with estimates ranging between **4.0 – 20 PgC**. This accounts for approximately **14% - 15%** of the global ocean annual carbon sequestration, despite mangroves covering less than **0.1%** of the ocean surface. Per unit area, mangroves can sequester **twice as much** carbon as forests, and like seagrass and saltmarsh habitats, can store carbon over **millennia**.

Seaweed


Kelp © Natural History Museum

Seaweed., or **macroalgae,** refers to species of macroscopic, multicellular marine algae. There are three main **seaweed types**; red (***Rhodophyta***), brown (***Ochrophyta***, ***Phaeophyceae***) and green (***Chlorophyta***). Seaweeds have a global distribution and are generally found living attached to rock or other hard substrates in the **shallow region** of coastal areas. They can range in **size** from microscopic **phytoplankton**, to small coralline algae which forms spikey underwater **maerl "beds"**, and large **kelps** which form vast underwater "forests". **Kelp forests**, made up of giant brown seaweed, are distributed along **25%** of the world's coastlines **in temperate and polar regions**. They are considered some of the most **productive and biodiverse** regions on earth and are significant **carbon stores**.

UK coastlines are home to more than **650 species** of seaweed which represents approximately **14%** (PDF 1.73MB) of the world's known marine seaweeds. Compared with other countries in Europe, the UK has the most diverse community of kelp with **7 out of the 14 European kelp species**.

Macroalgae are dominant **primary producers** in the coastal zone, forming the basis of **marine food webs** (PDF 7.6MB) and are a key food source for sea urchins, gastropods and chitons. Seaweeds create underwater **habitats** (PDF 1.29MB) that provide shelter for fish, crustaceans and other invertebrate species, as well as nursery grounds for juvenile fish. They also **protect coastlines** (PDF 3.31MB) by reducing wave action and storm damage. Seaweeds are also a **commercially important** resource and are harvested for food, cosmetics, biofuel, fertilizer and medicines.

Unlike angiosperm-based habitats such as seagrass meadows, saltmarshes and mangrove forests, macroalgae has largely been **excluded** from blue carbon assessments. Most seaweed species have a **limited capacity to act as long-term carbon sinks** as they tend to grow on hard substrates, which limits their ability to develop carbon-rich sediments. However, the blue carbon potential of seaweed is being increasingly recognised through the presence of carbon stored in **living biomass and macroalgal carbon accumulation in the deep sea**. Macroalgal carbon accumulation occurs when seaweed becomes dislodged and wind and water transport it across the ocean surface until it **is eventually deposited in**

coastal habitats, the deep sea or on land. Globally, macroalgae is estimated to sequester around **173 Tg of carbon each year**, of which approximately **90%** is exported to the **deep ocean**, while the remaining **10%** is stored in coastal sediments.

Quantifying blue carbon habitats

The extent of blue carbon habitats across different scales is presented in Table 1, alongside carbon storage and storage rate values where available.

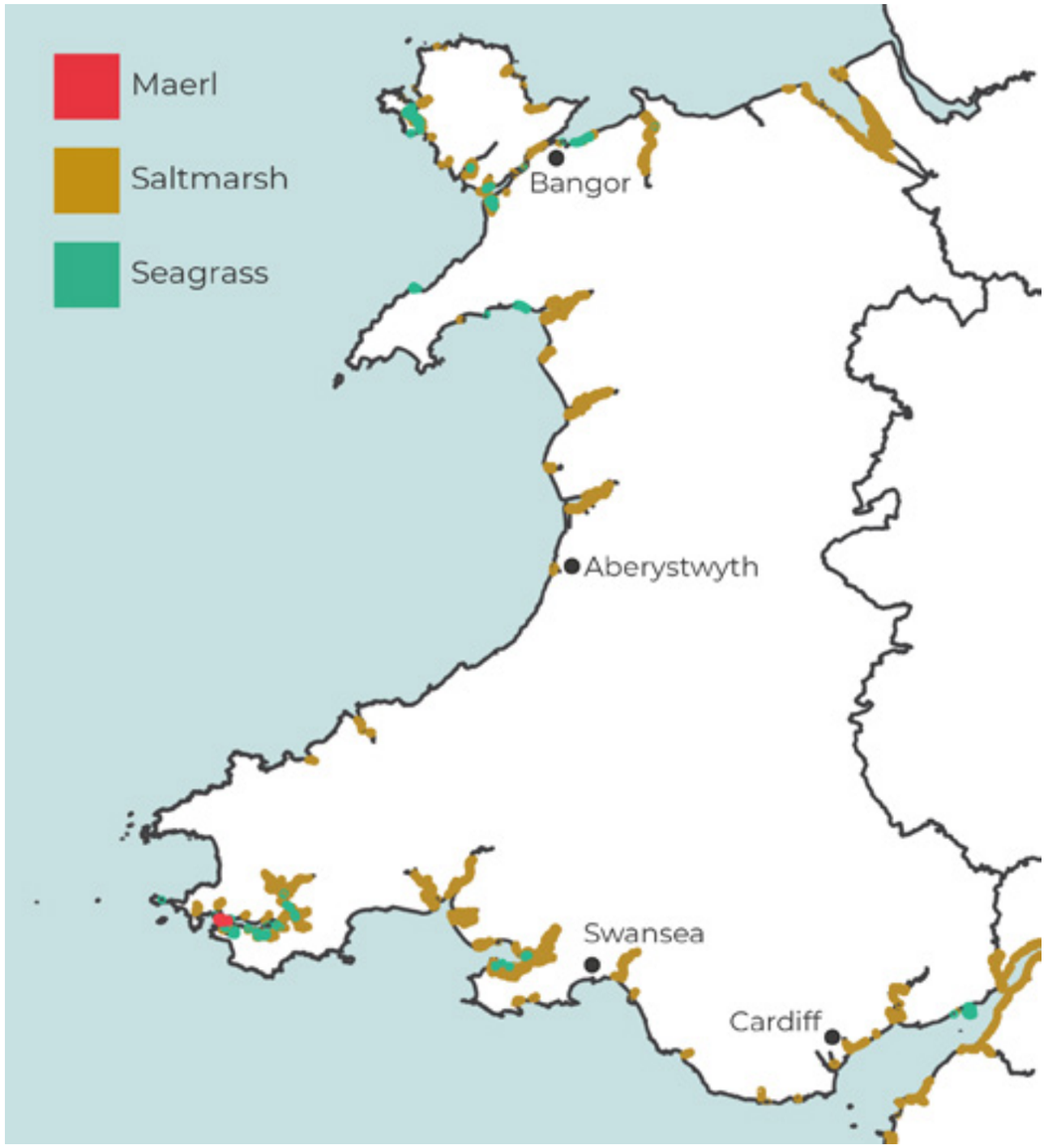
Table 1: Estimated blue carbon habitat extent, carbon storage and storage rate[1]

	Seagrass meadows	Saltmarshes	Mangrove forests	Seaweed habitats
Global extent (km^2)	319,000 **(Siikamäki et al, 2013)**	54,951 **(Mcowen et al, 2017)**	137,760 **(Giri et al, 2010)**	2,000,000 -6,800,000 **(Duarte et al, 2013)**
Global carbon storage (PgC)	19.9 **(Fourqurean et al, 2012)**	Unavailable	4.19 **(Hamilton & Friess, 2018)**	Unavailable
Carbon storage rate ($TgCyr^{1}$)	27.4 **(Fourqurean et al, 2012)** 48-112 **(Mcleod et al, 2011)**	10.2 **(Ouyang & Lee, 2014)** 5-87 **(Mcleod et al, 2011)**	24 **(Alongi, 2014)** 31-34 **(Mcleod et al, 2011)**	173 **(Krause-Jensen & Duarte, 2016)**
UK extent (km^2)	50-100 **(Garrard & Beaumont, 2014)**	470 **(Beaumont, 2014)**	0	8,151 (Kelp) **(Smale et al, 2016)**
UK carbon storage ($tC \times 10^3$)	8-16 **(Smale et al, 2016)**	199 **(Smale et al, 2016)**	0	5,250 (Kelp) **(Smale et al, 2016)**
Wales extent (km^2)	45.8 **(Brown, 2015)**	69.5 **(McKinley et al, 2018)**	0	Unavailable

1 Multiple figures are reported for carbon storage rate to reflect values reported in different sources. Figures have been standardised (e.g. to km^2) so direct comparisons can be made. The figures have been collated from multiple different sources with sources cited and hyperlinked below each figure. It was not possible to locate figures quantifying Welsh blue carbon storage and storage rates at this time.

Welsh blue carbon habitats

The map displays maerl, saltmarsh and seagrass habitats located along the Welsh coastline.[2] This map is indicative and habitats are not mapped precisely to scale.



2 Data sourced from **Wales Marine Planning Portal**. The map is not comprehensive and small habitat patches are not clearly visible on the map. Kelp data in Wales are currently unavailable.

Blue carbon habitats in Welsh Marine Protected Areas

Marine Protected Area (MPA) designations in Welsh waters include one **Marine Conservation Zone** (MCZ), **four Ramsar sites**, **13 Special Protection Areas** (SPAs), and **15 Special Areas of Conservation** (SACs). **MCZs** are designated to protect a range of nationally important rare or threatened habitats and species, **Ramsar sites** protect internationally important wetland habitats, **SPAs** protect important bird areas and **SACs** protect important areas for habitats and non-bird species.

Further information about MPAs in Wales is available in the **Senedd Research MPA publication**.

Table 2 highlights some of the blue carbon stores present in Welsh MPAs, as an illustration of the presence of these habitats in Wales. For the purposes of this briefing, blue carbon habitats within **Sites of Special Scientific Interest** (SSSIs) with marine components have not been analysed. This table is not exhaustive and additional blue carbon stores are also likely to be found outside the MPA network. The blue carbon stores highlighted are not necessarily protected features of the site but are located within the MPA. This analysis demonstrates that at least 99km^2 of blue carbon habitat is located within the Welsh MPA network.

Table 2: Welsh MPAs reported to contain blue carbon habitats.[3]

MPA	Designation	Blue carbon habitat	Size
Anglesey Coast	SAC	Saltmarsh Seagrass	1.59km^2 (saltmarsh) **(JNCC)**
Burry Inlet	Ramsar SPA	Saltmarsh Seagrass	22km^2 (saltmarsh) **(NRW)**
Cardigan Bay	SAC SPA	Saltmarsh	0.36km^2 (saltmarsh) **(North Wales Wildlife Trust)**
Carmarthen Bay and Estuaries	SAC SPA	Saltmarsh	27.1km^2 (saltmarsh) (**JNCC**)
Dee Estuary	Ramsar SAC SPA	Saltmarsh Seagrass	25.4km^2 (saltmarsh) (**JNCC**)
Dyfi Estuary	Ramsar SPA	Saltmarsh	0.36km^2 (saltmarsh) (**Montgomeryshire Wildlife Trust**)
Holy Island Coast	SAC	Seagrass	0.01km^2 (morwellt) **(Seasearch, PDF 998KB)**
Kenfig	SAC	Saltmarsh	0.12km^2 (saltmarsh) (**JNCC**)
Lavan Sands, Conway Bay	SPA	Saltmarsh Seagrass	n/a
Lleyn Peninsula and the Sarnau	SAC	Saltmarsh Seagrass	0.28km^2 (seagrass) (**Unsworth, 2015**) 17.5km^2 (saltmarsh) (**JNCC**)
Menai Strait and Conwy Bay	SAC	Saltmarsh Seagrass	1.33km^2 (saltmarsh) (**JNCC**)
Pembrokeshire Marine	SAC	Maerl Saltmarsh Seagrass	1.54km^2 (seagrass) (**Bertelli et al, 2018**)
Severn Estuary	Ramsar SAC SPA	Saltmarsh Seagrass	1.4km^2 (saltmarsh) (**Severn Vision**)
Skomer	MCZ SPA	Seagrass	0.01km^2 (seagrass) (**NRW PDF 1317KB**)
Total			**99km^2**

3 A list of Welsh SACs, SPAs, Ramsar sites and MCZs known to contain blue carbon habitats. The information in this table has been collated from a range of sources cited and hyperlinked below each figure. All blue carbon habitat sizes have been converted to km^2.

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Threats to blue carbon habitats

Seagrass meadows

Seagrass meadows are one of the most **rapidly declining** ecosystems on earth and are classed as a **globally threatened habitat**. An **assessment** of 215 studies found that seagrasses have suffered annual losses of 7% since 1990, and seagrass extent has declined by 29% since 1879. In the last couple of decades, an estimated **30,000km²** of seagrass has been lost globally. The worldwide trend of seagrass **loss and degradation** has been driven by **multiple anthropogenic threats** including coastal development, dredging, pollution, overfishing and climate change.

In the UK, **92%** of seagrass has **disappeared** in the last century due to disease, poor water quality, coastal development, pollution, use of mobile fishing gear, and other human disturbances, with UK seagrass meadows now classified as **nationally scarce**. A **2016 study** found that most seagrass meadows around the coast of the British Isles are in a "perilous state". The three seagrass sites in Wales assessed in the study (Gelliswick Bay, Skomer MCZ and Porthdinllaen) were among those in the worst condition. Seagrass loss and degradation threatens **dependent species** that rely on seagrass for food and habitat. As a result, seagrass meadows are listed as a **UK Biodiversity Action Plan (BAP) Priority Habitat** (PDF 1.61MB) for conservation action.

Saltmarshes

In recent decades, **saltmarsh decline** has accelerated worldwide. The **primary driver** (PDF 6.52MB) of this decline is conversion of saltmarsh habitat to other land uses. Land reclamation has **threatened saltmarshes** (PDF 1.61MB) for centuries, however there is an ever-increasing reclamation pressure on saltmarsh habitat for farming, recreation, housing and industrial development. Sea level rise and climate change also threatens saltmarshes with "**coastal squeeze**" where erosion reduces saltmarsh size while fixed flood defences prevent saltmarshes from migrating inland. Other **threats** include industrial and agricultural pollution, boating, erosion by walkers, dredging and overgrazing by livestock.

Despite a lack of regular comprehensive surveys, UK **saltmarsh extent** (PDF 1.29MB) is considered to be generally decreasing. As a result saltmarshes have been listed as a **UK Biodiversity Action Plan (BAP) Priority Habitat** (PDF 1.61MB) for conservation action.

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Mangrove forests

Between the early 1980's and 2000, **35%** of mangrove habitat was lost globally with loss rates of 2.1% per year. This loss rate slowed between 2000 and 2012 to annual rates between **0.16% and 0.39%, resulting in a 1.97% loss** of mangrove coverage during that period. Mangrove decline is currently estimated at approximately **1 - 2% per year**. The **IUCN Red List of Threatened Species** lists 11 of the 70 known species of mangrove (**16%**) at risk of extinction, and academics have stressed that mangroves face extinction within the next **100 years**.

Major **threats to mangroves** include human activities such as urban development, **aquaculture**, mining, and overexploitation of timber, fish, crustaceans and shellfish. **Climate change** and its associated impacts such as sea level rise and altered weather patterns also represent a major threat to mangrove persistence.

Seaweed

Despite being a diverse group, seaweeds have not been granted as much **conservation attention globally as other taxonomic groups** (PDF 43.5KB). In the UK, seaweeds are an **under-recorded group** with limited data available to inform conservation evidence and decisions. An **initial IUCN Red List assessment** of UK seaweeds in 2013 classified 34% as "Data Deficient" meaning there is not enough information to determine their distribution and status. Over half (55%) are classed as "Least Concern" and are not currently at risk of extinction, while 5% are assessed as "Vulnerable" to extinction and 1% as "Critically Endangered", with a high risk of becoming regionally extinct in the near future.

Loss of habitat, an increase in non-native species, environmental change, boating activities and potential impacts from harvesting are some of the **pressures facing UK seaweeds**. For example, Wales' **only live maerl bed**, located within the **Pembrokeshire Marine SAC** MPA, could be damaged by anchoring and mooring activity. In 2011, a voluntary agreement was endorsed by the **Milford Haven Harbour Users Association** (PDF 259KB) which granted the maerl bed protection from boating activities.

Seaweed is also threatened by **climate change impacts** such as rising sea temperatures and ocean acidification. A **2014 study** has forecasted that in view of current climate change projections, ocean warming is likely to eradicate UK kelp forests and ocean acidification will remove maerl habitat within the next 100 years.

Climate change and blue carbon

Global climate change

The release of the **greenhouse gas** carbon dioxide (CO_2) into the atmosphere due to anthropogenic activities is one of the primary drivers of **global warming** and **climate change** The concentration of CO_2 in the atmosphere has risen by almost 50% since the start of the industrial revolution, from **280ppm** in the mid-1700s to **417ppm** at **NOAA's Barrow Observatory** in Alaska in 2019, the highest level recorded in the last **3 million years**. The increase in atmospheric CO_2 has been attributed to human activities, particularly **burning fossil fuels (coal, oil and gas), deforestation and intensive agriculture**.

The Paris Agreement

In November 2016, the UK Government **ratified** the **Paris Agreement** (a global climate change accord), pledging to plan and regularly report on its contribution to climate change mitigation. The **long-term goal of the Paris Agreement** is to limit global temperature rises to below 2˚C of warming above pre-industrial levels. Despite global **climate change agreements and commitments to reduce carbon emissions**, worldwide carbon emissions reached a record high of **37.1** gigatons in 2018, an increase of 2.7% from 2017.

Natural climate solutions

The Nature Conservancy has demonstrated that **37%** of carbon emission reductions needed to meet the objective of the Paris Agreement by 2030 can be achieved by **natural climate solutions**. **Biosequestration** is an example of a natural climate solution, where biological processes (e.g. **photosynthesis**) remove carbon from the atmosphere and store it in the natural environment. Much focus has previously been granted to the carbon sequestration ability of **terrestrial environments** such as **forests** and **peatlands**. However the carbon storage capacity of **coastal habitats** and the **ocean** is being increasingly recognised.

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Climate change mitigation

Seagrasses, saltmarshes, macroalgae and mangroves contribute **50%** of carbon burial in marine sediments, despite occupying just **0.2%** of the ocean surface. The annual carbon sequestration of these blue carbon habitats is equivalent to **1%–5%** of current CO_2 emissions from fossil fuel combustion.

Recent attention has been brought to the **high loss rates** of vegetated coastal ecosystems due to anthropogenic threats (e.g. **habitat conversion**) and impacts of climate change (e.g. **ocean acidification**). This represents a major loss of the natural carbon sink capacity of blue carbon habitats, as the carbon stored in the biomass and sediments of vegetated ecosystems is released back into the atmosphere when they are **degraded, damaged or destroyed**. The loss and conversion of vegetated coastal habitats causes the release of **1 Pg CO_2** into the atmosphere annually, exacerbating global warming.

Conserving and restoring blue carbon ecosystems maintains and enhances CO_2 sequestration and long-term storage capacity. **Academics** and **NGOs** have advocated for the protection and restoration of blue carbon habitats, to **prevent further degradation and release of additional CO_2 emissions**.

The **long-term carbon capture and storage** of blue carbon habitats is an important consideration for **climate change mitigation and adaptation**, particularly in the context of the **climate emergency** declared by the **Welsh Government** in 2019.

Blue carbon projects

Welsh projects

Seagrass Restoration Project

The **Seagrass Restoration Project** was launched in 2019 and aims to restore 20,000m^2 (2 hectares) of seagrass by planting one million seagrass seeds in **Dale Bay, Pembrokeshire, Wales**. This is the largest seagrass restoration project in the UK and is a collaboration between **Sky Ocean Rescue**, **Swansea University**, **Cardiff University**, **WWF** and **Pembrokeshire Coastal Forum**. The project aims to tackle climate change and create habitat for marine life, while outlining the way forward for large-scale seagrass restoration throughout the UK. The newly planted seagrass is expected to sequester up to **half a tonne of CO_2 per hectare** from the atmosphere each year.

Severn Vision Project

In 2016, the **Severn Vision Project** was launched by an alliance of organisations including the **Wildfowl & Wetlands Trust** (WWT), **Wildlife Trusts**, **RSPB**, **National Trust**, **Campaign to Protect Rural England** (CPRE), **Salmon & Trout Conservation**, and **Severn Rivers Trust**. The Severn Estuary is the **largest tidal range in Europe**, encompassing **190,000ha of coastal, intertidal and subtidal habitat, including 1,400ha of saltmarsh habitat** (PDF 3,188KB), which supports internationally important wildlife such as **74,000 birds** during winter months. The project aims to restore **6,000ha** (PDF 3,188KB) of estuary's blue carbon habitats by 2040.

Project ReStore

The **Seagrass Ecosystem Research Group** (SERG), is an inter-disciplinary marine research collaboration between scientists at the **School of Biosciences at Swansea University** and the **Sustainable Places Research Institute at Cardiff University.** SERG set up the charity **Project Seagrass** which works to improve knowledge of seagrass systems, raise awareness of seagrass ecosystem services and restore seagrass habitats. **Project ReStore** is a Project Seagrass initiative to trial seagrass restoration methods in the coastal village of **Porthdinllaen** in North Wales. The **29ha** seagrass meadow found in Pordinllaen is the **largest in North Wales** and is part of a marine conservation area called **Pen Llŷn a'r Sarnau Special Area of Conservation** (PDF 1.51MB). In 2015, over 1,500 seeds were planted as part of the first seagrass restoration trial in Wales.

Cwm Ivy Marsh Habitat Creation Project

In 2014, **Natural Resources Wales** (NRW) and the **National Trust** began working partnership on the **Cwm Ivy Marsh Habitat Creation Project** (PDF 806KB) to create up 39ha of new saltmarsh habitat on the coast of North Gower, Wales. The project is supported by the **Welsh Government's National Habitat Creation Programme** (NHCP), which aims to create and restore coastal habitat.

In 2015, NRW also created **7.5ha** of saltmarsh as part of a **flood defence scheme** at **Morfa Friog** in Fairbourne, mid Wales.

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UK Projects

Help our Kelp

The **Help our Kelp** campaign launched by the **Sussex Wildlife Trust**, **Blue Marine Foundation**, and the **Sussex Inshore Fisheries and Conservation Authority** in October 2019, is the UK's first kelp rewilding initiative along the Sussex coastline. Kelp forests in Sussex have declined by over **95%** from 177km^2 in the late 1980s to 6km^2 in the late 2010s due to storm damage, poor water quality and fishing pressure from trawlers. The **plan** to restore Sussex kelp forests involves a new by-law to prevent trawling within 4km of the coastline, which will allow natural regeneration. **David Attenborough** has supported the campaign and has narrated a **short film** to help "save Sussex's magical kelp forests".

Marine Scotland Blue Carbon

In 2017, **Marine Scotland within the Scottish Government** began a **five-year blue carbon research programme** (PDF 457KB) in partnership with **Scottish Natural Heritage** (SNH), **University of St Andrews**, **University of Glasgow**, **Heriot-Watt University**, and the **Scottish Association for Marine Science** (SAMS). The programme aims to gain a fuller understanding of Scotland's blue carbon resources through one post-doctoral study and six PhD studentships.

Hesketh Out Marsh Realignment

The UK's **largest saltmarsh recreation by managed realignment** scheme was carried out at **Hesketh Out Marsh** in Lancashire between 2008-2017 by the **RSPB**, **Environment Agency and Natural England**. The original saltmarsh site was reclaimed for agriculture in the **1980s**. The scheme restored saltmarsh by a process called "**managed realignment**", where seawater is allowed to flood some of the land. The scheme's restoration efforts re-created **160ha of new saltmarsh habitat** for wildlife, flood resilience and climate change mitigation.

Help the Kelp

In 2018, the **Sustainable Inshore Fisheries Trust** (SIFT) launched a **Help the Kelp** project in Scotland. The project campaigned to ban the dredging of kelp in the context of increasing demands for wild kelp from pharmaceutical, food processing and textile industries. The **Scottish Parliament enacted provisions to ban mechanical dredging** in November 2018.

Global Projects

International Blue Carbon Initiative

The **International Blue Carbon Initiative** is a global program coordinated by **Conservation International** (CI), the **International Union for Conservation of Nature** (IUCN), and the **Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific, and Cultural Organization** (IOC-UNESCO). It focuses on mitigating climate change through the conservation and restoration of coastal and marine ecosystems. The initiative supports **activities** including mangrove restoration in **Indonesia**, saltmarsh restoration in **Australia** and blue carbon policy development in **Latin America**.

Blue Forests Project

The **Blue Forests Project** is a four-year initiative launched by the **United Nations Environment Programme** (UNEP) and **GRID-Arendal** in 2015, which aims to improve management of blue carbon ecosystems across eight countries in South America, Africa and Asia. In November 2019, the project launched the world's largest community-based mangrove "**carbon finance**" conservation initiative in partnership with **Blue Ventures**, to restore and conserve over 1,200ha of mangrove forest in Madagascar.

The policy context

Wales

Welsh National Marine Plan

In November 2019, the Welsh Government published its first **Welsh National Marine Plan**. Although the plan doesn't refer to blue carbon directly, it states (emphasis added): "Welsh marine natural resources are important assets and Welsh seas support a diverse range of activities across many sectors which make an important contribution to the economy, including through direct tangible benefits like food, oil and building materials, as well as provision of less obvious services like **carbon sequestration** and climate regulation".

Welsh Marine Evidence Strategy

In September 2019, the Welsh Government published the **Welsh Marine Evidence Strategy** in partnership with NRW. The strategy provides an overview of the high level marine evidence priorities in Wales and a framework to meet those evidence challenges. Although the strategy doesn't reference blue carbon directly, the introduction states (emphasis added): "[...] the marine environment [provides] a wealth of benefits supporting the well-being of coastal communities and wider society. These include, but are not limited to: a range of habitats and species that make up the wider marine ecosystem and provide 'ecosystem services' such as **sequestering carbon**, recycling nutrients and mitigating coastal erosion [...]".

Low Carbon Wales

In March 2019, the Welsh Government published its first low carbon delivery plan called **Prosperity for All: A low carbon Wales**, which includes policies and proposals to cut emissions and meet carbon budgets. Although the plan does not reference blue carbon, it describes the **Carbon Positive Project** which has (emphasis added): "evaluated Natural Resources Wales' net carbon status, accounting for both GHG emissions and **carbon sequestration** across the whole of NRW's owned and managed estate".

On 2 December 2019, the Environment Minister Lesley Griffith issued a **written statement** on the Welsh Government's second statutory climate adaptation plan called **Prosperity for All: A Climate Conscious Wales**. The new plan does not reference blue carbon, however, it highlights the importance of peatlands and woodlands for climate change adaptation and mitigation in terms of carbon capture and storage. The plan states "tree planting should form a significant part of our efforts to increase carbon capture and storage". The plan's **Technical Annex** (PDF 2MB) asserts "peatlands in good ecological condition provide the best conditions for maintaining carbon storage and limiting GHG emissions".

The Environment (Wales) Act 2016 & Natural Resources Policy

The ***Environment (Wales) Act 2016*** set out an approach for the sustainable management of natural resources in Wales. The Act placed a duty on Welsh Ministers to set emission reduction targets as well as carbon budgets to ensure that by 2050 emissions are at least 80% lower than baseline levels in 1990.

In 2017, the Welsh Government published its **Natural Resources Policy** as part of the implementation of the *Environment (Wales) Act 2016*. Although the policy does not reference blue carbon, it states that the Welsh Government has committed to (emphasis added): "the development of tools to measure the benefits of integrated approaches to climate change (including ecosystem services, safeguarding biological diversity, **carbon sequestration**, and wider co-benefits that support increased resilience)".

Achieving "net zero"

On 15 October 2018, the governments of the UK, Scotland and Wales **asked** the **UK Committee on Climate Change** (UK CCC) to provide advice on the UK and devolved administrations' long-term targets for greenhouse gas emissions and transition to a "**net zero**" carbon economy.

In May 2019, the UK CCC published **advice** recommending that the UK and Scotland should set a net-zero target by 2050 for the UK, and that the Welsh Government should "legislate for at least a 95% reduction in all greenhouse gas emissions against the 1990 baseline by 2050". This was to reflect "the large share of agriculture emissions in Wales and lower access to suitable sites to store captured CO_2". The greenhouse gas emission reduction target recommended by the UK CCC goes beyond the 80% reduction outlined in the *Environment (Wales) Act 2016*.

On 11 June, Lesley Griffiths, the Minister for Environment, Energy and Rural Affairs, **issued a written statement in response to the UK CCC's advice**. The Minister set out her intention for Wales to go further than the UK CCC recommended target (emphasis added):

> In view of this and the declaration of a **climate emergency** following publication of the plan, we believe whilst accepting the CCC advice, we must go further. Therefore, on behalf of the Welsh Government I am declaring our **ambition** today to bring forward a target for Wales to achieve **net zero emissions no later than 2050**.

In Plenary on 25 June, the **Minister made a statement on delivering a low carbon Wales**. In the statement she said (emphasis added):

> ...next year we will bring forward legislation to adopt a **95% carbon reduction target, representing a huge increase in ambition from our current 80% target** and before the end of 2021, we will set out our next Plan to meet the 2021 to 2025 budget period.

The Minister's announcement on legislating for a 95% carbon reduction target, followed a **declaration by the Welsh Government of a climate emergency** in April 2019. At the time of writing, the Welsh Government intends to **legislate** for a 95% emissions reduction by 2050 target in 2020 but has an **ambition** to achieve net zero emissions by 2050.

UK

UK Marine Strategy

In May 2019, the UK Government launched a **consultation** on its updated **Marine Strategy**. In the **summary of responses** (PDF 511KB) an issue regarding MPAs was raised (emphasis added): "NGOs asked for areas of importance for **carbon storage and sequestration**, e.g. seagrass beds, be mapped by 2021 and incorporated into future MPA management and designation".

In response the UK Government wrote (emphasis added):

> "Government recognises the crucial role of nature-based solutions for climate mitigation and adaptation, such as the **protection and restoration of coastal habitats, including seagrass and saltmarsh**. Whilst the primary purpose of MPAs is to protect biodiversity, protecting coastal and marine habitats provides a number of climate related co-benefits for mitigation and adaptation, including improved ocean resilience to the accelerating impacts of climate change, providing coastal protection from erosion and storm surge, and the **protection and where necessary restoration of blue carbon habitats** and nursery grounds for species of commercial interest and marine conservation importance. We continue to work on developing methods to assess impacts of climate change on MPAs".

Climate Change Act (2008)

Under the ***Climate Change Act (2008)*** the UK committed to reduce emissions by at least 100% of 1990 levels (**net zero**) by 2050. In a 2016 **report**, the UK CCC outlined actions the UK should take to make a fair contribution to the Paris Agreement and meet its own legally-binding **carbon budgets** set under the Climate Change Act. The recommendations include; **reducing greenhouse gas emissions**; delivering on commitments to meet UK **carbon budgets**; and setting out a new strategy to develop options to **remove greenhouse gases from the atmosphere**. Blue carbon habitats may provide options and opportunities for removing CO_2 from the atmosphere to help achieve climate change targets.

Global

The Convention on Biological Diversity

The Convention on Biological Diversity (CBD) is a multilateral treaty agreed by **196 countries** in 2010. It outlines twenty **Aichi Biodiversity Targets** to be met by 2020. **Aichi Target 15** states (emphasis added): "By 2020, ecosystem resilience and the contribution of biodiversity to **carbon stocks** have been enhanced, through conservation and restoration, including restoration of at least **15 per cent of degraded ecosystems**, thereby contributing to climate change mitigation and adaptation and to combating desertification". The **rationale** for Target 15 is to restore landscapes and seascapes, in order to improve climate change resilience and carbon storage capacity, and is therefore related to the restoration of blue carbon habitats.

Glossary

Useful terms	Definition
Blue carbon	the carbon stored in coastal and marine ecosystems.
Biosequestration	the capture and storage of carbon through biological processes (e.g. photosynthesis in plants).
Carbon cycle	a biogeochemical cycle in which carbon is exchanged between the Earth's oceans, soil, rocks and the biosphere.
Carbon sink	a natural reservoir that stores carbon-containing chemical compounds over an indefinite period of time. The main natural carbon sinks are plants, the ocean, soil and earth's interior (mantle & crust).
Climate change	a change in global and regional climate patterns, attributed largely to increased levels of atmospheric carbon dioxide produced by anthropogenic activities.
Global warming	the long-term rise in the average temperature of the Earth's climate system and its projected continuation.
Greenhouse effect	the process by which radiation from greenhouse gases in the atmosphere warms the planet's surface.
Greenhouse gas (GHG)	a gas that absorbs and emits radiant energy, responsible for the greenhouse effect, e.g. CO_2.
Natural climate solutions (NCS)	the protection, restoration and sustainable management of terrestrial, coastal and marine ecosystems as a means of capturing and storing carbon emissions through natural carbon sinks.
Net zero	achieving net zero carbon dioxide emissions by balancing carbon emissions with carbon sequestration.

Scale of units

Symbol	Value	Name
kg	10^3g	Kilogram
Mg	10^6g	Megagram (tonne)
Gg	10^9g	Gigagram
Tg	10^{12}g	Teragram
Pg	10^{15}g	Petagram

(Cyr^{-1} means carbon sequestered per year, e.g. **27.4 TgCyr^{-1}** (million tons of carbon per year))

Blue Carbon: Research Briefing