Blue Carbon Restoration in Northern Ireland – Feasibility Study

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Summary

What is blue carbon?

- Blue carbon refers to carbon captured (sequestered) and stored in the marine and coastal environment. In Northern Ireland, living (biological) marine and coastal habitats (such as saltmarshes, seagrasses, kelp beds, and biogenic reefs) and geological sedimentary stores (such as seafloor and sea lough sediments) store carbon.
- The main threats to blue carbon habitats are physical disturbances, climate change, and land-use and land management changes. If in a poor state of health or unprotected from threats, blue carbon habitats may release their stored carbon, becoming a future source of carbon emissions.
- Management of blue carbon habitats is becoming increasingly crucial as part of our response to the Climate Emergency, with three approaches core to this response: habitat protection, restoration and creation.

Quantifying Northern Ireland's coastal blue carbon habitats

- The estimated current extent of coastal blue carbon habitats (saltmarsh, seagrass meadows, kelp forests, and shellfish beds) in Northern Ireland (NI) is 658 km^2, with 371 km^2 occurring within the inshore MPA network.
- The carbon sequestration rate of these habitats is estimated to be 31,595 t C per year.
- The carbon sequestration rate of the inshore MPA network is estimated to be 14,707 t C per year.
- There is potential to triple the blue carbon value of the MPA network to 52,958 (t C yr^{-1}) through effective protection and habitat restoration/creation within the MPA network.
- The sea loughs are important blue carbon areas as they contained a high proportion of estimated current extent (occupied habitat) and suitable habitat (unoccupied habitat) for many of the species.

The blue carbon estimates provided in this report are based on limited knowledge and understanding of the natural ability of these habitats to capture and sequester carbon at a local scale. Many challenges need to be addressed in order to more accurately estimate the blue carbon within individual habitats.

Partnership working

Ulster Wildlife hosted a virtual workshop on the 17th February 2021 and was attended by 84 representatives from NGOs, academic institutions, government agencies and local councils. It was evident from the workshop that partnership working is essential for habitat restoration programmes in order to access the expertise, funding and resources required for success. This workshop forged the beginnings of potential partnerships for future blue carbon habitat restoration work in Northern Ireland.

Priority areas for future work include:

Evidence:

- Develop a baseline inventory of all blue carbon habitats in Northern Ireland: their extent, with local measurement of carbon sequestration rates (CSRs) and estimated total carbon storage by habitat, including understanding how the condition of habitat affects CSR.
- Ground-truth current estimated extent and habitat suitability areas in this blue carbon report and identify habitat condition and any notable local pressures at each site.

- Investigate the likely response of blue carbon habitats to climate change, especially those coastal habitats that are the current focus for practical restoration.
- Understand and evaluate the co-benefits of restoration, such as biodiversity gains, enhancement of other ecosystem services such as flood protection, water quality improvement, and community buy-in/ownership.

Policy & Management:

- Raise awareness of the potential for blue carbon to contribute to Nationally Determined Contributions to the UK's greenhouse gas inventory under the Paris Agreement via engagement with policy-makers and the Climate Change Committee.
- Raise public and policy-makers' awareness of blue carbon as a nature-based solution to climate change, including updating the Northern Ireland Marine Plan to strengthen commitment to this approach.
- Develop a cross-cutting blue carbon strategy that would underpin action to protect, restore, recreate and monitor blue carbon habitats, with priority given to protection and restoration of existing habitats.
- Incorporate the carbon sequestration value of blue carbon habitats into the Marine Protected Area designation and management process levering existing policy commitments for this purpose and making MPAs 'climate smart'.

Pilot Projects

Identify pilot projects for coastal blue carbon restoration through

- Further development of the blue carbon restoration feasibility GIS and identification of habitat condition and local carbon sequestration rates, followed by:
- Prioritisation of habitats based on their carbon sequestration and storage potential and practicality of restoration actions (exploring the options of co-restoration of habitats).

The development of partnerships, securing funding and building capacity locally for blue carbon restoration with flagship local projects will inspire further habitat restoration efforts and demonstrate viability, while also monitoring the co-benefits of habitat restoration such as biodiversity value and erosion protection.

The full report can be found here: https://www.ulsterwildlife.org/sites/default/files/2021-05/Blue%20Carbon%20Habitat%20Restoration%20in%20Northern%20Ireland%20-%20A%20Feesability%20Study.pdf

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Research Briefing

Introduction

This research briefing details coastal habitats that contain blue carbon (see table 1) 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 and store carbon. The briefing also highlights blue carbon research and conservation programs ongoing in the UK, as well as various policies relevant to blue carbon.

Northern Ireland's inshore region contains seagrass, saltmarsh, shellfish and seaweed habitats. Analysis presented in this briefing indicates that approximately 658 km^2 of coastal blue carbon habitat is located within Northern Ireland's inshore area. Blue carbon is therefore an important consideration for climate change mitigation and adaption in the context of the climate emergency declared by the Northern Ireland Assembly on 3rd February 2020.

Table 1 Focus coastal blue carbon habitats and species in this study.

Seagrass species	**Shellfish species**	**Kelp species**	***Saltmarsh**
Zostera marina	*Mytilus edulis*	*Saccharina lastissima*	
Zostera noltei	*Ostrea edulis*	*Laminaria digitata*	
		Laminaria hyperborea	

*Saltmarsh – based on the occurrence data provided, it was not possible to differentiate native saltmarsh and that containing invasive *Sporobolus anglicus* (formally *Spartina anglica*) in this research.

Blue Carbon and the role of coastal habitats

Blue carbon is high-density carbon that accumulates in oceans and coastal ecosystems as a result of their high productivity and sediment trapping ability.

Coastal habitats, predominantly vegetated habitats such as seagrasses and saltmarsh, have a disproportionate capacity to sequester carbon dioxide (CO_2) from the atmosphere and incorporate it into biomass, which ultimately becomes buried as organic matter within the sediments. Organic matter in sediment is exposed to a limited oxygen supply, especially in anoxic sediments, resulting in low degradation rates and a low rate of CO_2 release to the atmosphere. Carbon sequestered in marine habitats is partitioned as that associated with living material, termed 'above ground biomass' (photosynthetic leaves, animal tissue and shell) and 'below ground biomass' (roots, rhizomes) and the non-living material in the sediment. Many coastal habitats such as saltmarsh, seagrass and shellfish beds also act to trap sediment which provides a key mechanism in carbon sequestration.

Blue carbon may be viewed as a 'triple value' climate solution, simultaneously offering benefits in climate change mitigation, adaptation and resilience. As a climate action, protection and restoration of blue carbon ecosystems offers a high return on investment across a variety of human and natural impacts. Furthermore, many coastal blue carbon habitats provide a range of important co-benefits, or 'ecosystem services', such as being of high biodiversity value, as fish nursery grounds, by improving water quality (e.g. shellfish beds) and as coastal flood protection/erosion resilience. Such co-benefits become increasingly important as climate change exerts pressures on coastal areas.

Table 2 Blue carbon habitat in Northern Ireland's waters

Marine and coastal habitats:
Saltmarshes*
Intertidal macroalgae
Blue mussel (*Mytilus edulis*) reefs*
Seagrass beds*
Sediments- muds, gravels, sands*
Native/flat oyster (*Ostrea edulis**) reefs
Kelp forest
Horse mussel (*Modiolus modiolus*) beds*
Brittlestar beds*
Subcanopy algae
Maerl beds*
Sabellaria reefs*

Yellow = intertidal
Green = intertidal and subtidal
Blue = subtidal
*= existing priority habitats or species, or pMCZ component habitat

The blue carbon policy context in Northern Ireland

Management of blue carbon habitats is becoming increasingly crucial as part of our response to the Climate Emergency, with three approaches core to this response: habitat protection, restoration and creation.

Box 1 Definitions of habitat protection, restoration and creation

DEFINITIONS

Restoration: the manipulation of the physical, chemical, or biological characteristics of a degraded site, with the goal of enhancing natural functions or species communities in an existing habitat.

Creation: the manipulation of the physical, chemical, or biological characteristics of a site to develop a habitat that did not previously exist.

Protection: an action to remove a threat to, or prevent the decline of the condition of a habitat or species.

(MMO, 2019)

Many countries are already including blue carbon habitats within their Nationally Determined Contributions (NDCs) to the Paris Agreement greenhouse gas (GHG) inventory: this helps better understand the role these habitats have in carbon storage and sequestration and provides an opportunity for habitat restoration to increase carbon storage and potentially offset emissions, which will provide a Nature-Based Solution (NbS) that assists countries in achieving net zero emissions.

There are currently no policies in Northern Ireland to promote restoration of blue carbon habitats, in comparison to peatlands and forestry. This project and other ongoing initiatives are supporting the development of strategies encompassing blue carbon within NI policy.

Some Northern Irish blue carbon habitats are protected from threats, based on their contributions to our biodiversity, mainly in the form of marine protected areas (MPAs). For example, Waterfoot Marine Conservation Zone (MCZ) is a small embayment offshore from the east coast of County Antrim designated for seagrass beds (*Z. marina*). However, blue carbon habitats and species present within MPAs are not necessarily protected if they are not the features for which the site was designated. Furthermore, only 4.48% of NI's inshore MPA network is favourably managed, with potentially damaging activities such as anchoring of recreational boats and bottom-towed fishing gear activity still occurring within NI's inshore MPAs[1].

The DAERA Marine and Fisheries Division have stated that within the current policy framework it is possible to consider carbon storage in the marine environment when designating MPAs (but have not provided details of the mechanism). It is of note that the Scottish Climate Change Act (2019) requires Ministers to set proposal and policies in their Climate Change Plan that consider carbon storage in the marine environment when designating MPAs.

Threats to blue carbon habitats

The importance of blue carbon ecosystems in mediating atmospheric carbon dioxide and, hence, mitigation against climate change is now widely recognised, however, there is a long-term trend of coastal habitat loss and degradation through, for example, land claim, benthic fishing activities, alteration of sediment dynamics and eutrophication. For example, in the UK, it is estimated that seagrass loss amounts to between 84 and 92%[2]. If blue carbon ecosystems are in a poor state of health or unprotected from threats, they may release their stored carbon, becoming a future source of carbon emissions.

There is now an urgent need to manage threats to coastal blue carbon habitats, with an emphasis first on protecting existing areas of these habitats, then restoration and finally potential recreation of habitats. Across the UK, there have been widespread efforts to restore native oyster reefs (e.g. the Native Oyster Restoration Alliance (NORA), the Dornoch Environmental Enhancement Project (DEEP) and the Solent Oyster Restoration Project). Saltmarsh creation and restoration has been achieved through managed realignment programmes undertaken by the Environment Agency and, notably, ABPmer and the National Trust and Project Seagrass (Swansea University) has, for a number of years, carried out research into seagrass restoration techniques and seagrass habitat management.

Quantifying coastal blue carbon habitats in Northern Ireland

The estimated current extent of coastal blue carbon habitats in Northern Ireland is 658 km^2, with 371 km^2 occurring within NI's inshore MPA network. A high proportion of the extent of *Z. marina*, *Z. noltei*, saltmarsh, *M. edulis* and *O. edulis* occurs within the sea loughs. Both *L. digitata* and *L. hyperborea* are extensively distributed along the open coast. *S. latissima* appears to prefer more sheltered waters and occurs both along the open coastline and in the sea loughs. The estimated current extent of blue carbon habitats is presented in table 3. It is important to note that the extent is based on presence only and should not be taken as a reflection on the condition of the sub-populations within patches.

Each species and habitat were attributed their 'Carbon Sequestration Rate' (CSR) to capture their value for facilitating carbon storage. The CRS values were obtained from the literature and can be

[1] A consultation on the development of fisheries management measures for Marine Protected Areas (MPAs) and establishment of Scallop enhancement sites in the Northern Ireland inshore region opened on 30 Nov 20 and closed 31 Mar 21. Ulster Wildlife submitted a response.
[2] Green, A. E., Unsworth, R. K., Chadwick, M. A., & Jones, P. J. (2021). Historical analysis exposes catastrophic seagrass loss for the United Kingdom. *Frontiers in Plant Science*, *12*, 261.

found in Table 4. Collectively, Northern Ireland's saltmarsh, seagrass meadows, and shellfish beds, potentially sequester 31,595 t C per year.

Modelled suitable habitat highlights the areas with the appropriate environmental conditions for a specific species that aren't occupied by that species. As per the estimates of extent, a high proportion of the suitable habitat for *Z. marina*, *Z. noltei*, saltmarsh, *M. edulis* and *O. edulis* occurs within the sea loughs. The HS maps predict large amounts of suitable habitat subtidally but it is recognised that many subtidal areas cannot persist without sustained aquaculture practices. Suitable habitat for both *L. digitata* and *L. hyperborea* is extensively distributed along the open coast. The preference of *S. latissima* for sheltered waters places suitable habitat both along the open coastline (e.g. Ards Peninsula) and in all of the sea loughs. The high suitability extent of blue carbon habitats is presented in table 4. The reasons why suitable habitat remains uncolonised (or unrealised) may well be due to constraints on dispersal, biological factors (e.g. high predation, competition or disease pressures), or human pressures.

The analysis demonstrates that the blue carbon habitat within the Northern Irish inshore MPA network is potentially storing 14,707 t C yr^{-1}. However, only 4.48% of the inshore MPA network is favourably managed[3], and potentially damaging activities such as anchoring of recreational boats and benthic fishing still occur within these sites and are possibly impacting their carbon storage capacity. Effectively protecting current blue carbon extent and enhancing their blue carbon potential through the implementation of fit-for-purpose management plans and habitat restoration and/or creation within the MPA network, there is potential to at least triple the blue carbon value of the MPA network to 52,958 (t C yr^{-1}). The high suitability extent of blue carbon habitats is presented in table 4, and the blue carbon values are presented in table 5.

[3] https://www.daera-ni.gov.uk/sites/default/files/publications/daera/ni-environmental-statistics-report-2020_0.pdf

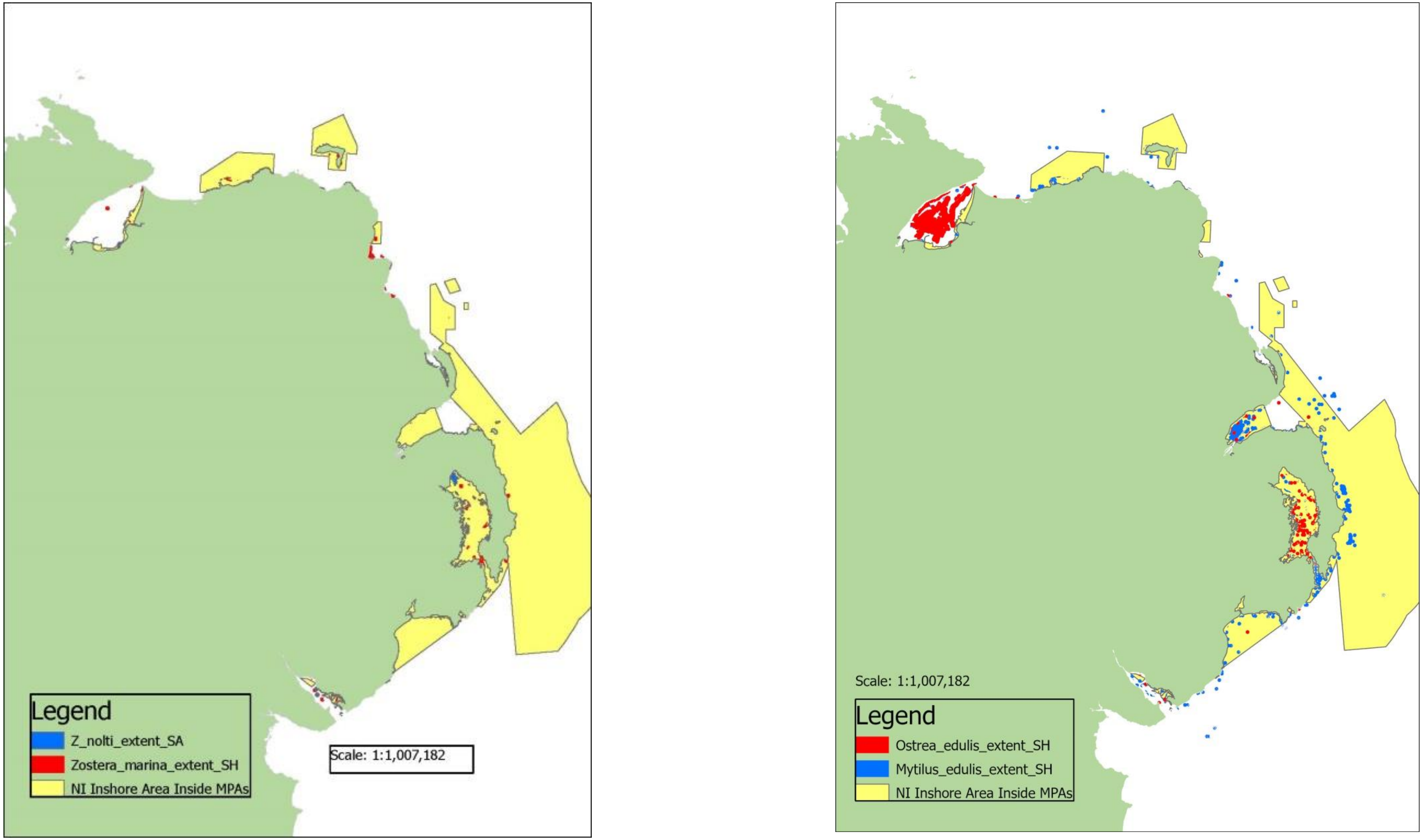
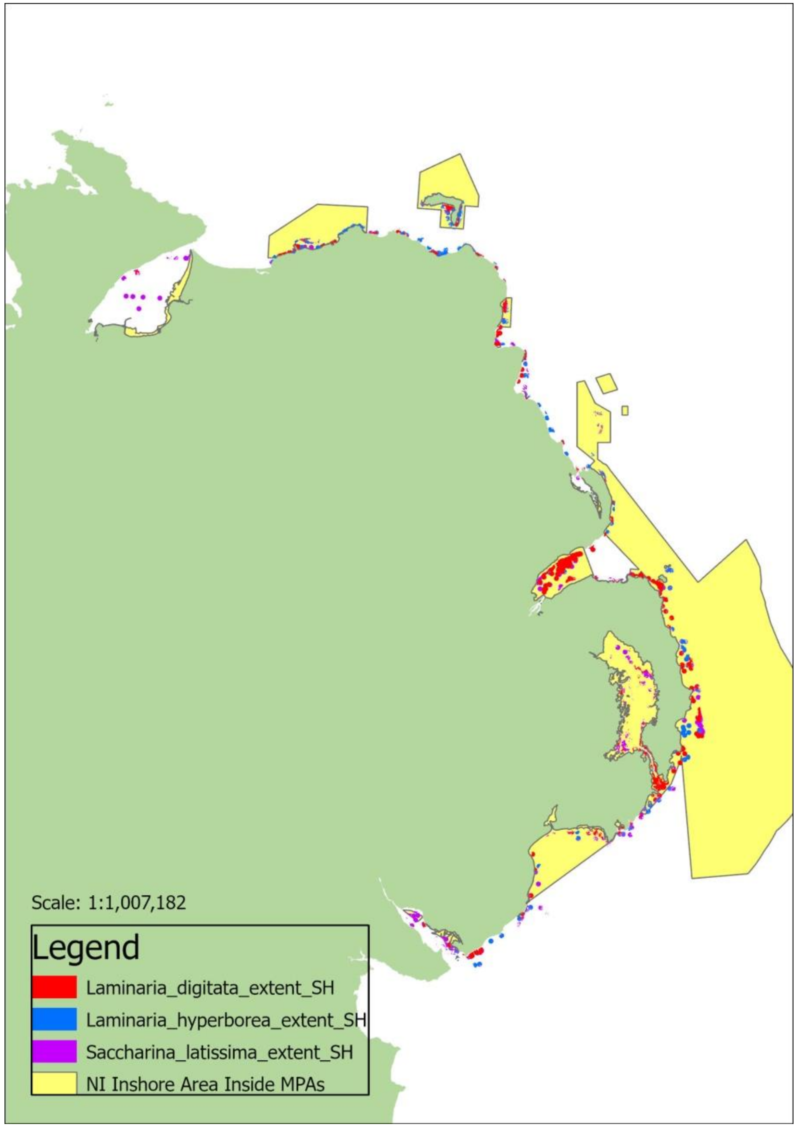


Figure 1 Estimated current extents of coastal blue carbon habitats in Northern Ireland (seagrass species on left, shellfish species on right)



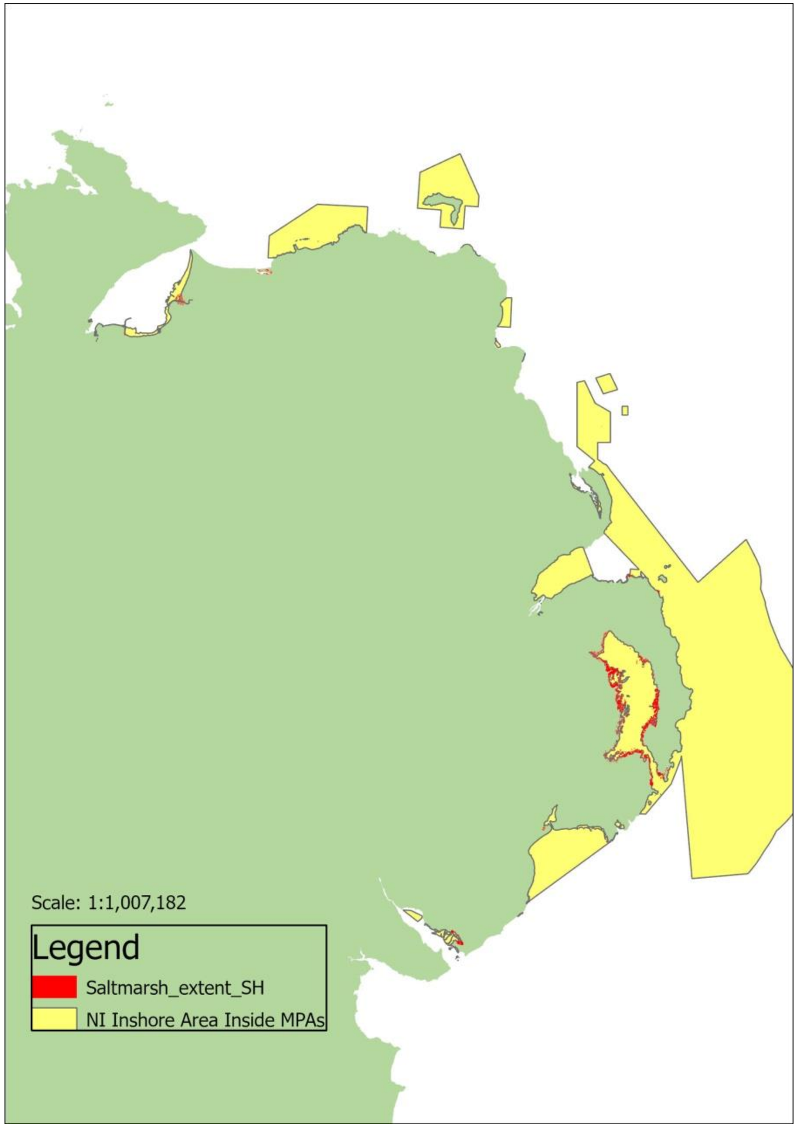
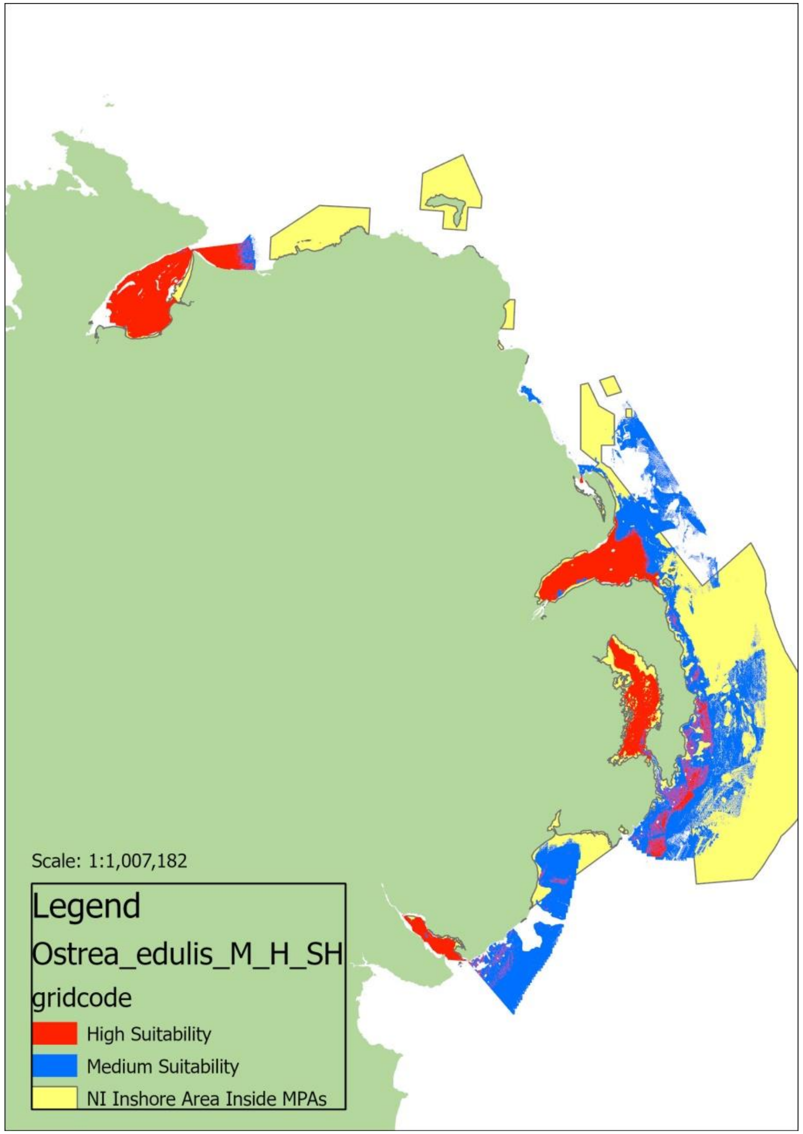


Figure 2 Estimated current extents of coastal blue carbon habitats in Northern Ireland (kelp species on left, saltmarsh on right)



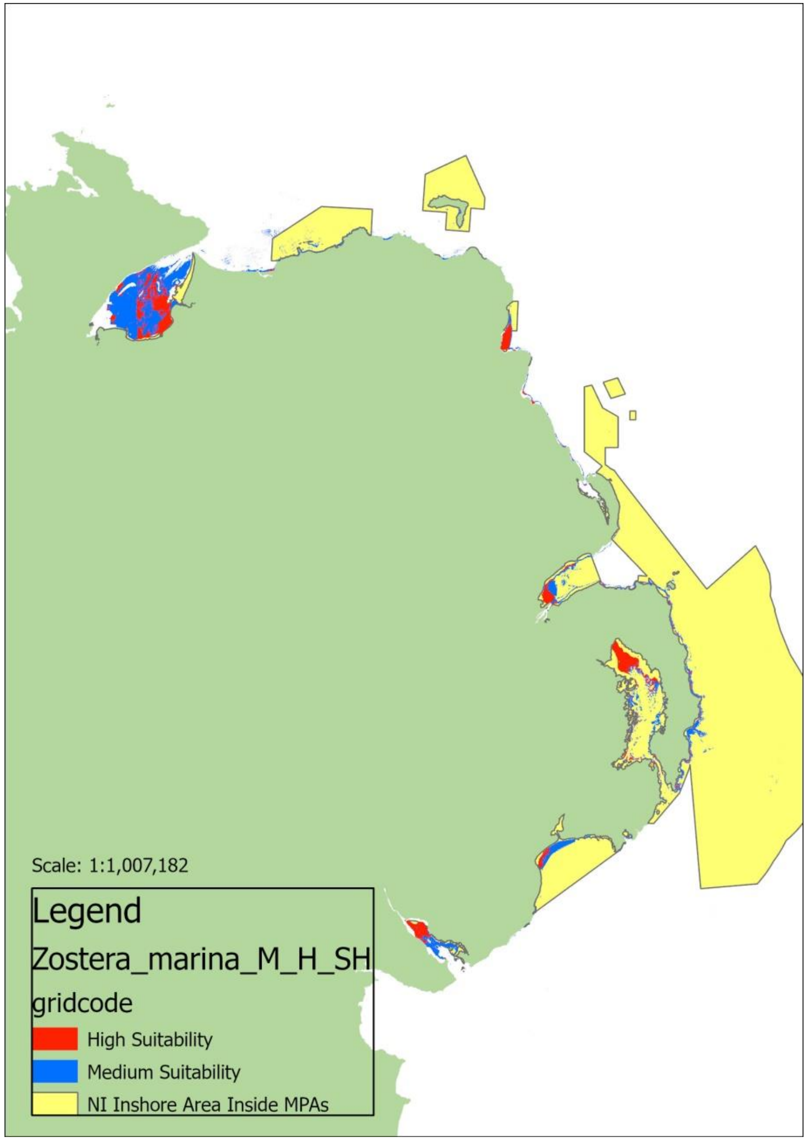


Figure 3 Estimated suitable area for *O. edulis* (left) and *Z. marina* (right). Suitable area habitat maps for the other species are included in the final report

Table 3 Extent and high suitability area for all habitats and species

Species or habitat	Extent area (km^2)	Extent area in MPA network (km^2)	High suitability area (km^2)	High suitability area within MPA network (km^2)
Laminaria hyperborea	82.2	55.1	97.0	70.8
Laminaria digitata	83.7	65.1	122.9	105.1
Ostrea edulis	167.9	41.0	486.3	211.7
Mytilus edulis	140.2	97.6	878.5	404.2
Saccharina latissima	136.0	92.8	290.4	168.8
Saltmarsh	31.1	8.5	13.7	3.2
Zostera marina	15.8	11.1	87.3	38.8
Zostera noltei	1.4	-	127.5	23.3

Table 4 Carbon sequestration rates per species or habitat

Species or habitat	Sequestration rate (g C m^2 yr)	References
Laminaria hyperborea	0	Observations from across the UK and considered suitable for use for Northern Irish populations. Values reported here are from the nearest station to Northern Ireland (west coast of Scotland).
Laminaria digitata	0	Observations from across the UK and considered suitable for use for Northern Irish populations. Values reported here are from the nearest station to Northern Ireland (west coast of Scotland).
Ostrea edulis	50	Values based on 75 ind/m^2, which is significantly greater than the natural density of *O. edulis*. The values reported here are considered an over-estimation of local rates
Mytilus edulis	81	Observations of mussels from Vrdngskar (Baltic). The reported value is a mean of several seasonal measurements and is considered suitable for use for Northern Irish populations.
Saccharina latissima	0	In situ observations from Rhode Island USA. The reported value s here are considered moderately suitable for Northern Irish populations.
Saltmarsh	266	Meta-data mean based on 174 reviews, 414 papers and 56 book chapters. The values report here are considered a suitable average for saltmarsh in Northern Ireland.
Zostera marina	226	The same values were used for a similar study in Scotland. The values reported here are considered to be moderately suitable for use with Northern Irish populations.

Table 5 The blue carbon value (i.e. sequestration rate multiplied by the area) of *O. edulis*, *M. edulis, Z. marina* and saltmarsh in the Northern Ireland inshore region.

Species or Habitat	Value of BC in NI inshore region (t C yr^{-1})	Value of BC in MPA network (t C yr^{-1})	*Potential value of BC in inshore region (t C yr^{-1})	*Potential value of BC in MPA network (t C yr^{-1})
Ostrea edulis	8395	2049	24315	10587
Mytilus edulis	11356	7906	71159	32744
Saltmarsh	8273	2253	3644	863
Zostera marina	3571	2500	19730	8764
Total	31595	14707	118848	52958

* Potential value of blue carbon is based on high suitability area values.

A precautionary approach should be taken when interpreting the maps produced by this study. It is important to note that it is difficult to model species and habitats that occur intertidally or in shallow subtidal habitats. Intertidal and high shore areas often fall between two stools i.e. they are not sufficiently addressed by terrestrial mapping and modelling products or marine products. As such, modelling can be hampered by missing or inaccurate predictor variables. Regardless of the challenges, spatial estimates of occupied and potential habitats are essential for habitat restoration and creation site selection. For example, the extent maps provide valuable information of potential restoration or donor sites, and HS maps will highlight, from a physico-chemical perspective, additional uncolonised sites where restoration and habitat creation might be feasible.

How to deliver restoration

Ulster Wildlife hosted a virtual workshop on the 17th February 2021 and was attended by 84 representatives from NGOs, academic institutions, government agencies and local councils. The objectives of the workshop were two-fold. The first was to share knowledge about the practicalities of blue carbon habitat restoration from those with experience elsewhere in the United Kingdom and Republic of Ireland. We invited 6 guest speakers that shared their lessons learned from restoration projects focused on seagrass meadows, kelp forests, native oyster reefs, and saltmarsh. The second objective was to capture local knowledge of the areas that were identified as suitable for the blue carbon habitats in the modelling exercise.

In summary, the workshop participants agreed that protecting and enhancing current blue carbon habitats should be prioritised, and that wider ecosystem services provided by these habitats should be recognised along with their blue carbon value.

Prioritising habitats

Workshop participants highlighted difficulties surrounding restoration. For some habitats, there is a strong body of evidence to suggest that creation/restoration measures should be possible (see table 6), although success in the UK has been limited. For those habitats where good evidence exists with regard to creation through physical interventions (notably managed realignment of saltmarsh habitat), outcomes of such habitat creation schemes can sometimes be difficult to predict (e.g. with regard to use by a given bird species), and it can take up to several decades for habitat equivalency with adjacent habitats to be reached (though it can equally happen fairly quickly - mudflat can quickly transition to saltmarsh in estuaries with high sediment loads). Restoration efforts are likely to be more successful in areas with existing individuals, however, some restoration and creation methods rely on the sourcing or harvesting of seed or brood stock (e.g. establishing *Zostera* spp. or *O. edulis* beds), and in many cases suitable sources may be scarce or themselves located within existing marine protected areas. However, there may be opportunities to partner with organisations that have expertise or management oversight of these existing resources. It was noted that consistent monitoring and trials are required in an area where considerable potential for restoration exists but it can be challenging to finance and oversee such measures. For example, it seagrass restoration requires monitoring every 2 months for up to 5 years.

Table 6 Restorability of coastal habitats taken from MMO (2019)[4].

NERC Habitat Name	Restorability	Evidence	Confidence
Coastal saltmarsh	High	High	High
Blue mussel beds (*Mytilus edulis)*	Medium	Low	Low
Horse mussel beds *(Modiolus modiolus)*	Medium	Low	Low
Seagrass beds	Medium-High	Low-Medium	Medium

The importance of funding and delivery partnerships

Workshop case studies highlighted the importance of collaborative partnerships required to deliver habitat restoration programmes. Funding for conservation projects is often competitive, sporadic and insecure, but working collaboratively can increase likelihood of securing funding as well as reducing the risk. Furthermore, large-scale habitat restoration is complex and requires a range of expertise (ecological, social science, policy). The workshop was the first step in building potential partnerships for future blue carbon habitat restoration work in Northern Ireland. A list of potential partners is in table 7.

Table 7 Potential partners in Northern Ireland for blue carbon habitat restoration projects. This list is not exhaustive.

Government & Government Bodies	**NGO's**	**Research and Academic Institutes**	**Other**
Local councils	Ulster Wildlife	Queen's University Belfast	Islander Rathlin Kelp
Department of Agriculture, Environment, and Rural Affairs (DAERA)	National Trust	Ulster University	Bord Iascaigh Mhara
The Crown Estate	Wildfowl and Wetlands Trust	University of Bangor	Royal Yacht Association
Inshore Fisheries Partnership Group	Royal Society for the Protection of Birds (RSPB)	Agri Food and Biosciences Institute (AFBI)	Belfast Harbour
Seafish	Project Seagrass	Geological Survey Ireland (GSI) - LiDAR public feature idenfication	Warrenpoint Port
Centre for Environment Data and Records (CEDaR)	Keep Northern Ireland Beautiful (KNIB)		Angling clubs
The Loughs Agency	Citizen Sea		Seasearch NI / Dive NI
Joint Nature Conservation Committee (JNCC)	Coastwatch		Boat clubs

[4] MMO, 2019. **Identifying sites suitable for marine habitat restoration or creation**. A report produced for the Marine Management Organisation by ABPmer and AER, MMO Project No: 1135, February 2019, 93pp

Strangford Lough and Lecale Partnership (SLLP)			The Peninsula Kelp Company
			Sea Grown
			Maccaferri Solutions
			Anglo North Irish Fish Producers Organisation
			Northern Ireland's Fish Producers Organisation

The role of eNGO's in blue carbon habitat restoration

There are many roles for eNGOs in blue carbon habitat restoration; they can be pilots for larger government projects by their ability to act more quickly than government bureaucracy. The expertise within NGO's can also be used profitably as consultants to environmental authorities. eNGOs are made up of professionals concerned about the environment and have a readymade network of enthusiastic citizen scientists. As such, NGOs have rich human resources that can be used in the conservation of coastal and marine habitats and biodiversity. They also use interpersonal communication methods and have recognised the appropriate community entry points for initiating conversation and establishing trust of the community they seek to benefit. NGOs can facilitate communication upward from people to the government and vice versa and are in the unique position to share information horizontally, networking between other eNGOs and organisations doing similar work as proven by the shared learning during the blue carbon habitat restoration workshop hosted by Ulster Wildlife. They can also act as teachers in public awareness programmes for the community.

NGOs such as the National Trust and the Wildfowl and Wetlands Trust own and manage large areas of the coast and play an important role in managing these areas. They also have the option to purchase land specifically for restoration. Additionally, NGOs can provide technical assistance and training to assist governments and other organizations undertaking similar restoration activities. For example, Ulster Wildlife has expertise in using coir rolls for peatland restoration, a technique that can be applied to coastal wetland restoration.

A Recommended Blue Carbon Action Plan for Northern Ireland

1. Develop a baseline inventory of all blue carbon habitats (table 2) in Northern Ireland: their extent, with local measurement of carbon sequestration rates (CSRs) and estimated total carbon storage by habitat, including understanding how the condition of habitat affects CSR.
2. Review coastal blue carbon habitat current extent and predicted suitability via additional surveys/ground-truthing, where possible identifying habitat condition at each site (which may affect carbon sequestration potential) and any notable local pressures – make use of existing monitoring programmes to gather such data and develop specific surveys for this purpose.
3. Examine historical records (pre 1980) of coastal blue carbon species and habitat extent (e.g. native oyster reefs) and examine how these relate to current habitat suitability models for potentially suitable conditions for these habitats.
4. Implement the five step plan for incorporation of blue carbon protection in existing Marine Protected Areas (see box 2), levering existing policy commitments for this purpose and making MPAs 'climate smart'. Part of this plan would be addressed by steps (1) and (2).
5. Raise awareness of the potential for blue carbon to contribute to Nationally Determined Contributions to greenhouse gas inventory under the Paris Agreement via engagement with policy-makers and the Climate Change Committee.
6. Understand the role of other blue carbon pools, such as sedimentary habitats, within Northern Ireland's waters, and whether these need additional management and protection.

7. Raise public and policy-makers' awareness of blue carbon as a nature-based solution to climate change, including updating the Northern Ireland Marine Plan to strengthen commitment to this approach. Develop a cross-cutting blue carbon strategy that would underpin action to protect, restore, recreate and monitor blue carbon habitats, with priority given to protection and restoration of existing habitats.
8. Identify pilot projects for coastal blue carbon restoration though further development of the blue carbon restoration feasibility GIS (see below), crucially identifying habitat condition and local carbon sequestration rates then prioritising habitats based on their carbon sequestration and storage potential and practicality of restoration actions, exploring the options of co-restoration of habitats, developing partnerships and securing funding. Through this, build capacity locally for blue carbon restoration with flagship local projects to inspire further habitat restoration efforts and demonstrate viability, while also monitoring the co-benefits of habitat restoration such as biodiversity value and erosion protection.
9. Investigate/research the likely response of blue carbon habitats to climate change, especially those coastal habitats that are the current focus for practical restoration.
10. To make the case for restoring coastal blue carbon habitats, ensure a strong understanding (and valuation where possible) of the co-benefits of restoration, such as biodiversity gains, enhancement of other ecosystem services such as flood protection, water quality improvement, and community buy-in/ownership.

Box 2 A five-point plan for improving the protection and effective management of blue carbon ecosystems in MPAs under the CBD in support of the Paris Agreement on climate change (Laffoley, 2020)[5].

1. Recognise the full extent of blue carbon ecosystems present in MPAs
2. Act on operations likely to cause deterioration or disturbance and take the additional management measures needed not to secure blue carbon values of well documented blue carbon ecosystems
3. Map extent and quality of the carbon value of less well documented carbon ecosystems within current MPAs and implement relevant management measures
4. Designate new MPA based primarily on the carbon values for blue carbon ecosystems that lie outside existing MPAs rather than just focusing on traditional biodiversity value alone
5. Take measures to complement the MPAs using tool such as MSP and fisheries management to recognise, protect and best manage blue carbon across seascapes

[5] Laffoley, 2020. ***Protecting and effectively managing blue carbon ecosystems to realise the full value to society – a sea of opportunities.*** An opinion piece by Dan Laffoley for WWF-UK. Woking, Surrey, UK. 42 pp