Research Report No. 1293 Development of a marine and coastal enhancement project assessment framework for Scottish inshore waters

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Background: Habitat enhancement and restoration projects have seen rapid growth in recent years in response to drivers such as habitat loss, threat to species, risks to the wider ecosystem and impacts from climate change. There has been a growing sense of ambition and environmental stewardship both from communities and partnerships, as well as Government and private sectors, with a recognition that environmental improvement may often provide a range of benefits. This ambition has been delivered predominantly through voluntary actions on a site-by-site basis. Improved legal frameworks for commitments and compliance in environmental enhancement help Scotland to achieve international and national objectives. These objectives are addressed through legislation that sets out planning for Scotland's marine area and specific site and feature protection including Habitats Regulations, Marine Protected Areas and Priority Marine Features. This framework guides individual enhancement projects to achieve more widespread goals and objectives for environmental health as a whole.

As Scotland's nature agency, NatureScot provides key advice on marine and coastal enhancement projects in Scotland. Positive outcomes for such proposals can be optimised by providing an efficient, consistent, transparent and robust assessment approach. NatureScot commissioned GoBe Consultants

Ltd. and subcontractors Heriot-Watt University, Swansea University and UK Centre for Ecology & Hydrology (UKCEH) to develop a marine and coastal enhancement project assessment framework for Scottish inshore waters. The project focused on the four habitats and species (‘features’) of highest interest: native oysters, seagrass, saltmarsh and coastal sand dune. ‘Enhancement’ has been used, for the purpose of this project, as an umbrella term for a range of different mechanisms through which a species or habitat may be improved at a site, including: habitat or species recovery, regeneration, restoration, creation or (albeit less often in the marine environment) rewilding.

The framework developed aims to guide those planning an enhancement project through the process, advising on the types of information required by NatureScot, other regulators and funding bodies, as well as what approaches are most likely to lead to success. Ultimately the framework provides a clear structure from which applicants may build their proposals and map out the necessary components to ensure an efficient process.

Through provision and use of a consistent framework, NatureScot can provide better advice, in a timely manner, ensure consistency between different projects and in doing so improve the chances of success in enhancement projects. The framework will also allow NatureScot to provide guidance for projects during the early phases of their development to minimise risks and delays prior to projects progressing to key delivery stages.

The project was informed by a literature and legislative review and 20 case studies in Scotland, the UK and internationally. The review identified key elements of project planning that are most important for project success, as well as drawing out lessons learned. The outcomes of this review form the main body of this report.

The review provided in this report was used to guide development of a project assessment form. This was developed to be used by those planning enhancement projects in Scotland. The form was initially guided by a ‘long list’ of information types and criteria which was reviewed at a workshop held by GoBe and attended by 14 NatureScot specialists. These discussions informed the selection and prioritisation of the information types that would be useful in the form as well as the approach taken.

The form is supported by a detailed guidance document.

Main findings

The form includes questions to explore the most critical components of a project at the early stages. The form assists applicants in working through the various considerations and will assist NatureScot in offering the best level of advice to support project development and delivery.

The form and accompanying guidance document set out a series of eight proposal development areas as follows:

1. Project information (feature, enhancement type, location, off-site and site process, timescales)
2. Underlying principles (primary objective, driver and funding, success criteria, scheme alternatives)
3. Site profile (natural dynamics, activities and pressures, existing data, baseline monitoring key gaps)
4. Regulation and management (species, protected areas, activities, access)
5. Risks (biosecurity, translocation, genetics, wider ecosystem, climate change, socioeconomic, funding, mitigation)
6. Benefits (biology and ecology, socioeconomics)
7. Engagement (early engagement, stakeholder group, public outreach, communicating success)
8. Management, monitoring and evaluation (implementation, data collection and monitoring establishing success)

The framework is considered to be best supported by an iterative process of engagement during project development, where there is an initial discussion focusing on project information, followed by submission of the proposal form and then with follow up discussions with NatureScot providing steer and further advice.

Contents

Introduction

1.1 Overview

Owing to the increasing number of marine and coastal habitat enhancement proposals being submitted to NatureScot, a project was commissioned in December 2020 to review existing case studies and guidance and use this to develop a marine and coastal enhancement project assessment framework for Scottish inshore waters. The work, as presented in this report, is focused on four species / habitats (referred to as features) that applicants most frequently propose as enhancement and restoration opportunities: native oysters, seagrass, saltmarsh and sand dunes. This project was led by GoBe Consultants Ltd (GoBe), with expert support from Heriot-Watt University (native oysters), UK Centre for Ecology and Hydrology (UKCEH) (saltmarsh and sand dunes) and Swansea University / Project Seagrass (seagrass).

1.2 Requirement For This Project

Leaving the environment in a better state than which we find it in, rather than simply conserving it as it is, has been a growing area of focus over the last decade. This approach has been supported across the world, initially by voluntary measures, and more recently with increasing legal frameworks for commitments and compliance (**Section 2**). This report builds on what was already provided through a growing voluntary movement promoting marine enhancement, for example by developers on specific projects. Overall, there is a general sense of ambition and environmental stewardship from communities and partnerships, Government and private sectors; and the realisation that environmental improvement may often provide a full circle feedback benefit to a range or sectors.

Many of the marine and coastal enhancement proposals submitted to NatureScot are novel and therefore require thorough consideration, including the evidence requirements to support them. They need to be able to demonstrate an understanding of the ecosystem dynamics, sensitivities and impacts in order to provide a robust baseline on which to develop a project. Proposals also raise regulatory challenges such as being located within protected areas or require more detailed consideration of planning legislation and frameworks. As a result, there are concerns that proposals looking to help enhance or restore habitats could be delayed where the existing environmental interactions and/or enhancement outcomes are not adequately detailed or considered and this, in turn, may impede their potential to succeed. Whilst certain guidance exists, from translocation protocols to individual species restoration guidance, as detailed in **Section 3**, none specifically encompass an enhancement framework for the range of habitats and species addressed by this project.

The present framework is now needed to set out a series of principles to help guide the assessment of proposals coming forward. This will ensure appropriate proposals can be supported and that early engagement with regulators and statutory bodies is encouraged.

NatureScot and other regulators also need to build on existing experience and current knowledge of the success of and lessons learned from marine and coastal enhancement projects. This will help to improve understanding of scheme feasibility and effectiveness and strengthen existing guidance and assessment frameworks. NatureScot wishes to draw out lessons learned in order to develop overarching guidance that will assist in the future with the provision of advice in this area.

Positive outcomes for marine enhancement proposals received by NatureScot can be optimised by providing an efficient, consistent, transparent and robust approach. This framework aims to guide those planning an enhancement project through the process, advising on the types of information required by NatureScot, other regulators and funding bodies, as well as what approaches are most likely to lead to success. Ultimately the framework provides a clear structure from which applicants may build their proposals and map out the necessary components to ensure an efficient process. This will in turn provide fair and consistent consideration across proposals and more readily provide the reality of successful enhancement. The provision and use of a consistent framework allows NatureScot to provide better advice, in a timely manner, ensure consistency between different projects, support site suitability assessments and in doing so improve the chances of success in enhancement projects. The framework can help to provide suitable guidance on project compliance and risks to ensure greater project efficiency and progression at the early stages. Therefore a clear framework approach will improve the process for advice and assessment for NatureScot, applicants and relevant stakeholders.

The focus of proposed enhancement activities has recently been around native oyster and seagrass restoration, though NatureScot has also seen enquiries on cockles and saltmarsh habitat enhancement. There has also been a growing interest in connected activities including collection of broodstock for native oyster hatcheries, collection of seagrass seeds and setting up of hatcheries for native oysters and lobsters. Another area of growing interest is use of sand dune enhancement in coastal adaptation as a response to climate change, which is expected to be increasingly applied in the future.

This framework will target the four features that are expected to dominate future proposals namely: native oysters, seagrass beds, sand dunes and saltmarsh.

1.3 Aims

The three principle aims of the contract focused on the four species / habitats, are outlined below:

- Review: Draw up a list of marine and coastal enhancement projects / case studies and deliver a review of these and the lessons learned, as well as reviewing any other available guidance from elsewhere in temperate environments, outlining implications for Scotland.

- Framework: Develop an assessment framework for marine and coastal enhancement proposals, where they occur inside and outside protected areas.
- Recommendations: Identify further guidance and research required to inform and allow effective progression of marine and coastal enhancement proposals in Scotland.

1.3 Scope

As detailed above this project is concerned with marine and coastal habitat enhancement, for the four specific features detailed, but the review will include other types of environmental improvement to inform the framework, as defined within the terminology below in **Table 1**.

Term	NatureScot Interpretation
Habitat Enhancement	This term is applied in relation to those actions that aim to improve the quality, size or geographic distribution of a habitat.
Habitat Recovery	To be used in relation to actions taken to enable a habitat to overcome damage or other disturbance and reach a better state, rather than trying to "turn the clock back". This is seen as a relatively passive process involving removing pressures and allowing the habitat to repair naturally.
Habitat Regeneration	Still conveys a process but with possibly low level interventions taking place alongside removing pressures. The term regeneration can also be used where there is active fishing (see Part 1(ii) for more explanation).
Habitat Restoration	NatureScot consider the term "restoration" to be applicable to projects entailing a high level of intervention, such as those rebuilding a habitat or reintroducing an ecosystem engineering species to assist with enhancing a habitat into a location from which it has been extirpated and where re-establishment could not occur without assistance.
Habitat Creation	Habitat creation can be used in two different contexts – one using more natural approaches and substrata, for example, creating saltmarsh as part of managed realignment work; and one using artificial substrata or creating habitat where it was not historically present, for example, in offshore marine developments.
Rewilding	This term refers to restoring processes and functions in very large, landscape / ecosystem scale projects. Use of this term should be treated with caution for marine habitat restoration. Scientifically and scale wise, marine habitat enhancement is at too small a scale currently for this term to be applied.

Table 1. NatureScot's interpretation of terms for the marine and coastal environment (NatureScot, 2020a).

1.4 Approach

A review of current legislation, policy and regulation relevant to marine and coastal enhancement, and experience applying this to such schemes, was carried out based on Government sources and other scientific and grey literature, as well as consultation with key contacts (as detailed in Acknowledgements). The review also included wider guidance and frameworks to date, as well as specific case studies, both in Scotland and the rest of the UK / internationally, through a review of scientific publications and other grey literature. This has provided particular insight on best practice, the lessons learned and the rules by which some projects operate, as well as highlighting particular strengths and weaknesses in practice and assessment. Some of the primary considerations within the review have included:

- Existing practice;
- Novelty in proposals;
- Regulatory challenges both at site level and within wider regional frameworks;
- Guidance;
- Level of engagement and timing;
- Assessment guidance / principles; and
- Fit within or parallel to other frameworks / guidance.

This baseline review has informed the development of detailed tools to support the framework, justifying criteria and linking back to guidance or legislation where required. These are provided in a separate set of documents including:

- Guidance document; and
- Proposal form.

Current legislation, policy and regulation relevant to marine and coastal enhancement

2.1 International Drivers

Currently, there is global concern about the ongoing degradation of some coastal and marine environments and their supporting species / habitats in particular due to factors such as fishing, development, climate change, pollution and disease (IPBES, 2019). The Aichi Biodiversity Targets established by the United Nations (UN) Convention on Biological Diversity have a specific application within Scotland, including aims for the quality and quantity of wildlife to be improving and flourishing (targets 7, 9, 12, 13, and 14), in accordance with the UN 2030 Agenda for Sustainable Development. There are a rapidly growing number of related programmes that further support these targets (e.g. through the New Deal for Nature and UN Decade On Ecosystem Restoration) along with new strategies, including the Convention on Biological Diversity (CBD) Post-2020 Biodiversity Framework, which will be used to progress to the 2050 Vision of “Living in Harmony with Nature”. The OSPAR commission which aims to protect the North-East Atlantic included restorative targets in their 2010-2020 strategy, aiming to restore marine environments and biodiversity that have previously been adversely affected (it should be noted that the CBD and OSPAR are due to be updated through the COP and new North-East Atlantic Strategy). The Ramsar convention also supports restorative projects in wetland areas, a category they use widely to cover habitats including marshes, estuaries and near shore marine environments valuable to waterfowl. Furthermore, climate change conventions indirectly act as drivers towards enhancement. Habitats such as seagrass and saltmarsh have the potential for carbon draw down, with wetlands specifically included in carbon accounting according to the United Nations Framework Convention on Climate Change (UNFCCC) (IUCN Blue carbon).

2.2 Habitat Regulations

Under the Habitats Regulations (Conservation (Natural Habitats, &c.) Regulations 1994) all competent authorities must consider whether any plan or project will have a ‘likely significant effect’ on a European site (Special Areas of Conservation (SACs) and Special Protection Areas (SPAs)) and if so, an appropriate assessment should be undertaken (this process is referred to as Habitats Regulations Appraisal (HRA)).

NatureScot often provides advice to the relevant competent authority in assessing likely significant effects and must be consulted when an HRA is required. The Scottish Government provide advice sheets on HRA and development plan guidance. The advice sheets contain information on the use of simple mitigation measures, specific policies and caveats, and criteria-based policies within development plans. ‘The Habitats Regulation Appraisal of Plans Guidance for plan-making bodies in Scotland’ (NatureScot, 2015) notes under Stage 5 that there are cases where it is not likely that there will be a significant effect on a European Site, for example where a project or proposal is intended to protect the natural environment, including both the natural or historic environment, or for enhancement measures. However, if the introduction of a protected species affects a European site, an HRA must be completed by the Competent Authority using information provided by the applicant before any licence can be issued.

For marine SACs and SPAs NatureScot is responsible for producing management advice for each site. Each site is managed according to its conservation objectives in line with the requirements of the Habitats Regulations. Management plans may be developed by site or at a regional level. The format of the plan and the level of detail it contains is likely to vary between sites to reflect differences between protected features and location.

Monitoring of MPAs (including marine SACs and SPAs) is guided by the Scottish MPA Monitoring Strategy. Review of the condition of protected features forms part of this monitoring process and the results are used to inform future decisions on the management of sites.

For sea fisheries, management measures are implemented at a site level through the Inshore Fishing Act 1984 which may prohibit certain types of fishing activity (with either spatial or temporal zoning if appropriate).

2.3 UK Legislation and Regulation

2.3.1 Net Gain

The UK Environment Bill addresses the vision set out in the UK Government's 25 Year Environment Plan with a specific requirement for 'net gain'. However, it should be noted that some of the Bill does not apply to Scotland, including Part 6 (nature and biodiversity); however, the Scottish Government conducted its consultation on environmental governance and principles and expects to address this in the UK Withdrawal from the European Union (Continuity) (Scotland) Act. The principle of net gain is the requirement for developments to increase habitat or 'biodiversity net gain' following operations and is supported by the Biodiversity Net Gain toolkit. After consultation, the latest version of the Environment Bill was released on 23 July 2019 with noted changes to the net gain policy. At the time of this repost publication (spring 2021), the legislation was undergoing scrutiny by the House of Commons and approaching its third reading. The policy has been tightened with a 10% net gain requirement confirmed in England (with a few exceptions) and for this to be maintained for at least 30 years. However, discussions within the UK Government are ongoing on the interaction between net gain and protected sites and the prevention of weakened site protection.

Current planning policy in the UK does account for biodiversity net gain, though this is not yet compulsory in the intertidal and marine areas (and with little standardisation of approach. Progress to date includes the development of matrices for biodiversity calculations, baseline assessment requirements, and consideration of potential benefits in the wider environment through these measures (ABPmer 2019). There is no metric currently to assess the marine environment. However, Natural England's metric for intertidal habitats has been developed, informed by longer-term onshore metrics, in partnership with Imperial College London and Defra. V3.0 is due in spring 2021 with consultation gaining further input from various organisations such as the Seabed User and Developer Group (SUDG), Renewables UK and GoBe Ltd.

The metric provides a means to determine the extent of habitats required to compensate loss due to development, determined through various calculations including biodiversity and supported by guidance on intertidal habitats and connectivity. It covers a list of habitats, which includes coastal saltmarsh, littoral sediments dominated by aquatic angiosperms and littoral biogenic reefs including those made by native oysters (it does not include sand dunes as they occur above the mean high-water mark). This metric expands on that provided through the UK Habitat Classification, now providing a greater number of habitats and tackling challenges specific to the intertidal environment, e.g. difficulty to establish boundaries for dynamic intertidal environments and use of habitat buffer zones based on predicted movement. However not all temporal changes can be accommodated by the model such as tidal cycles, wave energy and sediment dynamics, therefore causing some risk to the success of a scheme.

2.4 Marine Legislation and Regulation in Scotland

Within Scottish legislation (Marine (Scotland) Act 2010) and policies (e.g. Scotland's National Marine Plan (Scottish Government, 2015)) there is a commitment to the protection of marine habitats as well as for its sustainable enhancement and restoration. A summary of the legislation impacting on practice in Scotland is summarised below.

2.4.1 Marine planning

The Marine (Scotland) Act 2010 has a three-tier approach to the marine planning system, which covers the use of Scottish waters at regional, national and international level (UK Marine Policy Statement). Scotland's National Marine Plan (2015), currently subject to review, provides the framework for managing all development, activities and interests in and/or affecting the marine area, including conservation and ecosystem services. The National Marine Plan also states the contribution of Marine Protected Areas (MPAs) and other designated areas to the protection and enhancement of a region. General Policy 9 (National Heritage) of the National Marine Plan requires that development and use of the marine environment must: (a) Comply with legal requirements for protected areas and protected species; (b) Not result in a significant impact on the national status of Priority Marine Features (PMFs); and (c) Protect and, where appropriate, enhance the health of the marine area. Further information is detailed in **ANNEX 1**: Scotland's National Marine Plan in regard to Enhancement and Restoration.

There are also eleven Scottish Marine Regions where the aim is to develop regional marine plans led by Marine Planning Partnerships in line with the National Marine Plan. These have so far been developed for Shetland and the Clyde.

The Clyde Marine Plan, for example, aims to ensure that the Marine Protected Area (MPA) network contributes to the protection and enhancement of the Region; that there are opportunities identified for environmental enhancement; and that those activities and development do not significantly impact PMFs. This can be managed via a Marine Licence and Town and Country Planning determination processes, including reference to Local Biodiversity Action Plans and Reports (Clyde Marine Planning Partnership, 2019).

2.4.2 Marine licensing

Marine Scotland Licensing Operations Team (MS-LOT) is the lead regulatory authority in relation to marine licensing and consenting and Marine Scotland Compliance for the monitoring and enforcement of marine and fishing laws and reporting to prosecuting authorities. Marine licences are issued by MS-LOT under the Marine (Scotland) Act 2010 (inshore region, between 0 and 12 nm) and under the Marine and Coastal Act 2009 (offshore region, between 12 and 200 nm). The Scottish Government (2015) note a marine licence is required for several activities including, but not limited to:

- Depositing any substance or object within the Scottish marine area, either in the sea or on or under the seabed, from a vehicle, vessel, aircraft or marine structure. This includes beach replenishment below Mean High Water Springs (MHWS).
- Constructing, altering or improving any works within the Scottish marine area either in or over the sea or on or under the seabed. This applies to removing or adding substrate to the seabed such as shell fragments or stones (e.g. 'cultch' for native oyster restoration, also see Section on Biosecurity) as this changes the particle size of the underlying sediment.
- Using a vehicle, vessel, aircraft, marine structure or floating container to remove any substance or object from the seabed within the Scottish marine area.

- Carrying out any form of dredging within the Scottish marine area (this includes whether or not removing any material from the sea / seabed).

Permission is required from Crown Estate Scotland (CES) for use of the foreshore and seabed. The following activities will require either a lease, licence or consent from CES:

- Aquaculture and seaweed cultivation;
- Wild seaweed harvesting on Crown-owned foreshore
- Coastal protection and flood defence works;
- Dredging and dumping material from, and onto, the seabed;
- Filming on the foreshore;
- Laying of moorings;
- Deployment of research equipment; and
- Seabed investigation work e.g. grab samples to inform research / activities (see Crown Estate Scotland information on marine works).

2.4.3 Relationship between marine and terrestrial licensing

Whilst the terrestrial licensing system is detailed in the following sections, there are arrangements made between the terrestrial and marine licensing systems where the two systems overlap. Marine licensing covers the marine area up to MHWS and terrestrial planning control extends down to Mean Low Water Springs (MLWS); therefore there is an overlap of consenting regimes in the inter-tidal zone. However, for some activities, this overlap extends out to or out to 12 nm, i.e. for fin fish farming (Scottish Government, 2015). Some activities therefore may need both a marine licence and planning permission. In such cases, early engagement with the consenting authorities is even more of a priority to determine which consents are required. These arrangements ensure consistency in detail on how one impacts the other, both for overlapping areas and those adjacent to each other, e.g. liaison between authorities, consistency in proposals, timing and sharing of the evidence base.

2.4.4 Nature Conservation Marine Protected Area (MPA) management

There is a duty on public authorities under the Marine (Scotland) Act 2010 to ensure that their activities and consenting decisions do not hinder the conservation objectives of a Nature Conservation MPA. To aid policy and decision-makers, Marine Scotland created the Nature Conservation MPA management handbook that provides guidance on how the management needs of Nature Conservation MPAs (MPA) will be assessed and how any required measures will be developed and implemented [reference]. The handbook also describes the duty of public authorities in relation to MPAs and provides policy guidance on compliance. Marine Scotland is responsible for the designation and management of MPAs. NatureScot is responsible for producing management advice for each site. Each site is managed according to its conservation objectives in line with the requirements of the Marine (Scotland) Act 2010. Management plans may be developed by site or at a regional level. The format of the plan and the level of detail it contains is likely to vary between MPAs to reflect differences between protected features and location.

Monitoring of MPAs is guided by the Scottish MPA Monitoring Strategy, created by Marine Scotland, NatureScot and JNCC. Review of the condition of protected features forms part of this monitoring process and the results are used to inform future decisions on the management of NCMPAs.

Management measures may be put in place by Marine Scotland, depending on the sensitivity of the features and the site's conservation objectives. Regulators such as MS-LOT or local authorities may consult with NatureScot before issuing licences or permits to ensure that the activity will not hinder the site's conservation objectives, other than insignificantly. This is referred to as an assessment under Section 82 or Section 83 of the Marine (Scotland) Act 2010. For sea fisheries, management measures are implemented at a site level through Marine Conservation Orders which may prohibit certain types of fishing activity (with either spatial or temporal zoning if appropriate).

The Joint Nature Conservation Committee (JNCC) and NatureScot have roles in providing nature conservation advice to Scottish Ministers, on monitoring protected features and assessing the success of management measures and the wider MPA network. NatureScot has a statutory remit to ensure any scheme is compliant with the Wildlife and Countryside Act 1981.

2.4.5 Priority Marine Features (PMFs) management

Scotland's National Marine Plan supports the concept of and policy protection for PMFs. The 81 PMFs adopted by Scottish Ministers in 2014 are species and habitats that were identified as the basis for focussing marine conservation work in Scotland . The PMF list includes three of the features identified by this framework: native oysters, seagrass beds and intertidal mudflats, i.e. including habitat for saltmarsh (coastal sand dunes and saltmarsh are addressed by terrestrial features). The PMF existing designations checklist (summary table for consultation) provides applicants with the various national and international legislation applicable for each feature, i.e. Habitats Directive, Wildlife & Countryside Act, Convention on International Trade in Endangered Species (CITES), Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) threatened and/or declining habitats and species, Biodiversity Action Plan (BAP) priority habitat/species (i.e. sand dunes) and International Union for Conservation of Nature (IUCN) Global Red list status. This is supported by a suite of PMF guidance documents including a checklist form regarding impacts on PMFs from development / activities.

2.5 Terrestrial Legislation and Regulation in Scotland

The policies and principles found in the National Planning Framework and the Scottish Planning Policy set out how the Scottish Government expect Planning Authorities to address national issues, such as coastal change, in Strategic Development Plans and their regional-scale Local Development Plans.

2.5.1 Terrestrial planning

Planning authorities in Scotland have a duty under the Climate Change (Scotland) Act 2009 to deliver the Scottish Climate Change Adaptation Programme, which addresses the risks set out in the Climate Change Risk Assessment (Scotland) including erosion and flooding risks to the natural environment, infrastructure, people and built environment and business.

Both the Flood Risk Management (Scotland) Act 2009 and the Coast Protection Act 1949 provide the legislative background to coastal management in Scotland. The Coast Protection Act aims to prevent erosion and encroachment by the sea whereas the Flood Risk Management (Scotland) Act deals with flood bodies in Scotland so in effect, they are implemented together. The Coastal Protections Act 1949 (part I) empowers Local Authorities with coastlines to carry out protection works inside and outside their area subject to approval from Marine Scotland (maintenance of existing works only).

Scottish Environment Protection Agency (SEPA) is the authority responsible for flood risk management and for implementing the Flood Risk Management (Scotland) Act 2009. Shoreline Management Plans (SMP) have been produced for only short sections of the Scottish coast: Local Authorities include Angus, Dumfries & Galloway, East Lothian, Fife and Ayrshire. SMP are the over-arching management approach to each stretch of coastline agreed by local authorities, the local communities and other interested parties. Local authorities also have powers (but not obligations) under the Coast Protection Act 1949 to protect the land from the sea.

As noted above, terrestrial planning authorities (Strategic and Local Planning Authorities and National Park Authorities) are responsible for all terrestrial planning matters down to MLWS and for marine fish farming (finfish and shellfish) where planning consent is required out to 12 nm (Scottish Government, 2015). In the intertidal zone, between MLWS and MHWS, the terrestrial planning authority overlaps with Marine Scotland's responsibilities for the marine area. As a result, marine and terrestrial planning authorities should consult one another formally during plan preparation.

Some Local Development Plans have identified needs for enhancement of both the environment and natural heritage, for example, Aberdeen City Council (2017). This highlights the need for Natural Riparian Buffer Strips to be created for the protection and enhancement of water bodies and local biodiversity, including lochs, ponds, wetlands, rivers, tributaries, estuaries and the sea. It also identifies a need for the protection and enhancement of natural heritage outwith designated sites (in proportion to the opportunities available), with specific aims to enhance biodiversity through the creation and restoration of habitats and, where possible, incorporating existing habitats (Aberdeen City Council, 2017).

Scottish Borders Council, together with stakeholders, has taken further measures to promote enhancement through the development of a biodiversity offset scheme that accounts for the residual environmental impacts of developments (e.g. renewables) in upland species / habitats, including blanket bog (Scottish Borders Council, 2017). The implementation of eight such schemes has allowed biodiversity improvements to be mainstreamed into the planning process by seeking biodiversity benefits at the landscape scale, whilst simultaneously benefiting ecosystem services. These include flood protection, water quality, carbon storage (woodland, grassland and bog habitats) and recreation (game and fisheries management) (see RSPB Planning naturally). Negotiations with farmers and landowners have balanced their needs with those of biodiversity and flood protection gains.

2.5.2 Terrestrial licensing

The Coast Protection Act 1949 (part I) enables Local Authorities with coastlines to conduct coastal protection works under licence inside and outside their jurisdiction as necessary, with approval from Marine Scotland. Proposed schemes, other than maintenance or emergency operations, must be advertised by the Coast Protection Authority and a notice of works served upon a number of bodies, including NatureScot and SEPA.

Depending on the nature and scale of a scheme proposed by either Local Authorities or individuals, planning permission may be required under the Town and Country Planning (Scotland) Act 1997, where the proposal extends above the MLWS mark. Permission of the landowner will also need to be acquired prior to the commencement of the scheme.

Under the Planning etc (Scotland) Act 2006, SEPA assist the Scottish Government. SEPA provide advice to Marine Scotland and the applicant when enhancement or restoration works result in the relocation of sand / shingle to restore beach levels. To safeguard against pollution for marine ecology interests, the applicant should refer to SEPA’s Pollution Prevention Guidelines and SEPAs standing advice on marine licence consultations. Authorisation under the Water Environment (Controlled Activities) (Scotland) Regulations 2005 from SEPA may also be required. Enacting environmental enhancement may also fall under the Flood Risk Management (Scotland) Act 2009 which requires SEPA to ensure that flood risk management is undertaken sustainably (see Marine Scotland advice on coastal erosion and flood risk management).

Other considerations to be taken when considering land for enhancement include protections around wild land which should be safeguarded as part of the planning application (Scottish Planning Policy, 2020). Also, should woodland removal be necessary as part of enhancement this should occur in line with UK Forestry Standards and should be included in the planning application to the relevant authority (Forestry Commission Scotland, 2009). For woodland removal permitted under the Forestry Act 1967, legal enforcement of the actions required to implement a change in land use will normally be based on felling licence conditions.

2.5.3 Protected Areas

The Nature Conservation (Scotland) Act 2004 (as amended) requires all public bodies to further the conservation of biodiversity. This resulted in the production of a Scottish Biodiversity List which identifies species considered by Scottish Ministers, to be of principal importance for biodiversity conservation in Scotland and informs the conservation process. This informs the statutory designation of Sites of Special

Scientific Interest (SSSI) made by NatureScot. For any applications within an SSSI, applicants (the landowner or occupier – see NatureScot guidance for land managers) must apply to NatureScot for consent to carry out certain operations as set out in the Operations Requiring Consent (ORC) list for that SSSI and application form, which is also available from Sitelink. This will be assessed by NatureScot operations officers with advice from specialists as necessary.

The Wildlife and Natural Environment (Scotland) Act 2011 provides additional wildlife and habitat protection, along with management of non-native species and sets out biodiversity duties including restoration. The Act provides the means for management of invasive non-native species (INNS) in Scotland, including a code of practice, and enables licences for protected species to be granted for any social, economic or environmental purpose, under the Wildlife and Countryside Act 1981.

2.5.4 Terrestrial features management

Planning Authorities, and all public bodies under Section 2 of the Nature Conservation (Scotland) Act 2004, have a duty to further the conservation of biodiversity and this must be reflected in development plans and development management decisions. Coastal sand dunes and saltmarsh are a UK BAP Priority Habitat along with Annex I of the Habitats Directive 1992 and the Wildlife & Countryside Act 1981.

2.6 Current practice within NatureScot

The number of marine and coastal enhancement proposals received by NatureScot has increased over the past 18 to 24 months. NatureScot advises on proposals in line with NatureScot's statutory duties, with each proposal treated in a similar but ad-hoc approach. Due to this notable increase, NatureScot drafted an initial internal note to define guidance for responses to marine habitat enhancement queries, including pathways and contacts within NatureScot, guidance used / referred to and primary case studies for each habitat (NatureScot, 2020b). Whilst the aspects relating to individual habitats are captured in the following chapters, the overarching pathways to processing proposals currently are provided in **Figure 1**. As illustrated in the figure, this current provisional framework calls particularly for:

- Early engagement with regulators;
- Information required;
- Need for biosecurity measures;
- Use of guidance from the Scottish Code for Translocations and NatureScot published guidance documents;
- If within a Special Area of Conservation (SAC) or Special Protection Area (SPA), then need for HRA under the Conservation (Natural Habitats & c.) Regulations 1994 (as amended), for NCMPAs assessment under Section 82 or 83 of the Marine (Scotland) Act 2010 or SSSI consent may be required if an SSSI could be affected; and
- Circumstances required for a PMF checklist to be completed.

Proposals have mostly been handled on a case-by-case basis to date, with a combination of local operations officers and species and habitat specialists receiving and dealing with proposals. However, as enhancement projects have grown in volume, there has been a range of specific issues identified within the process. These include:

- Proposal volume: Staff capacity at NatureScot as the volume of proposals increase and there is a resulting need to make efficiencies internally as well as fair and consistent assessment across all proposals.
- Proposal complexity: There is a current move towards more complex projects e.g. with multi-species / trophic proposals and the need to involve multiple staff and teams.
- Enquiry process: Enquiries are direct to specialist advisors or via operations officers.. There is a need for consistent advice across all staff.
- Applicant's organisational structure: Multiple organisations / individuals enquiring about one site.

- Applicant's formal obligations: Applicants unclear on contacts and teams at relevant organisations, e.g. Marine Scotland, Crown Estate Scotland, NatureScot, SEPA and the relevant Local Authority; as well as the licensing process and variables requiring consideration, e.g. location / conflicts, scale, links to resources, e.g. biosecurity and other species-specific requirements.

These different aspects and challenges are addressed by the new framework being proposed as part of this work. NatureScot note an iterative process of engagement is required with the applicant, firstly encouraging pre-application engagement followed by a review of the full proposal and steer depending on its nature; second providing advice depending on the consenting process triggered; and thirdly engagement with the relevant parts of Marine Scotland.

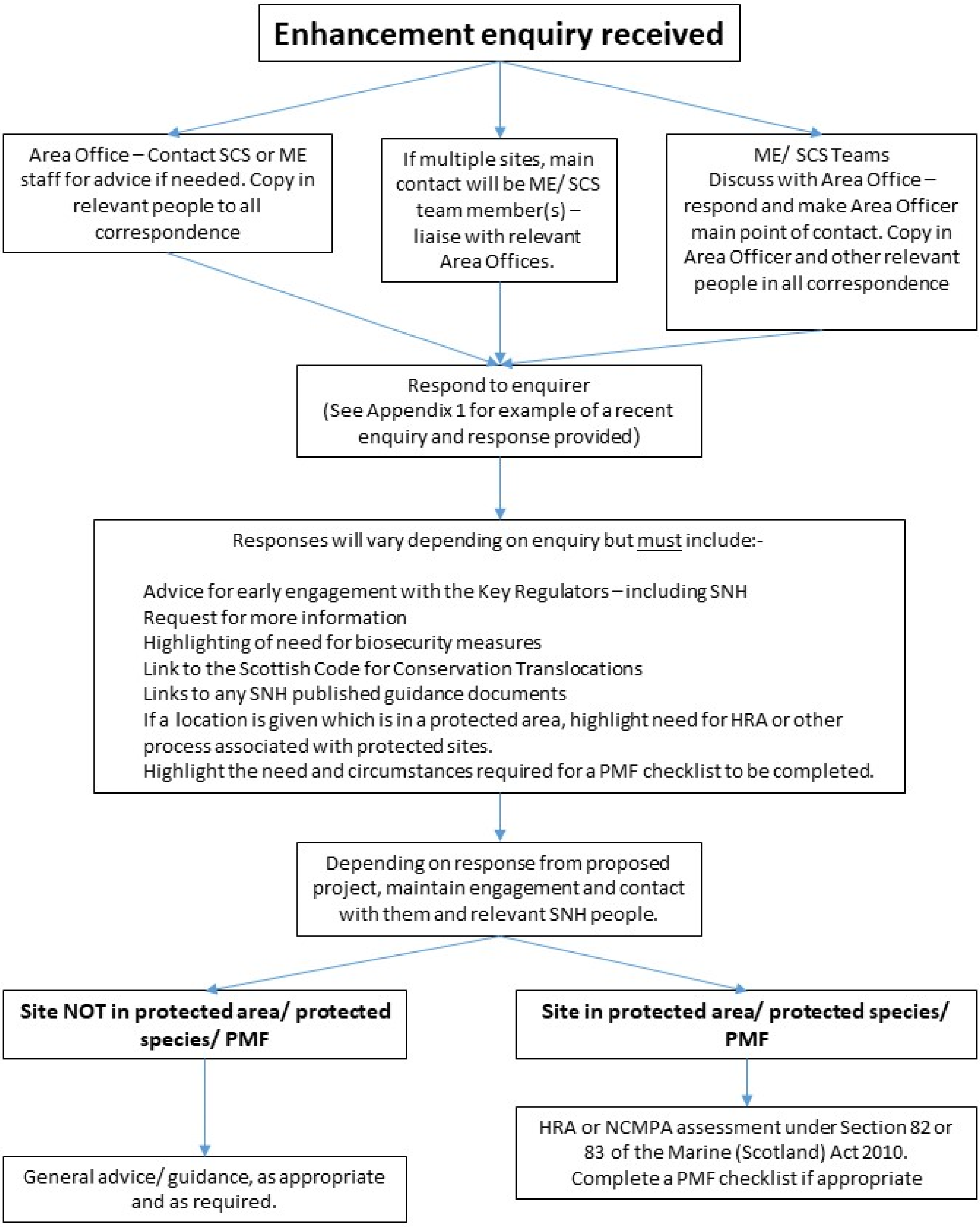

Figure 1. Flow chart detailing the early steps taken if an enhancement enquiry is received (source NatureScot, 2020b). Note the NatureScot teams Sustainable Coasts and Seas (SCS) and Marine Ecosystems (ME) are abbreviated in the diagram.
Click for a full description

3. WIDER FRAMEWORKS AND PROGRAMMES RELEVANT TO MARINE AND COASTAL ENHANCEMENT

Whilst information on both national and international polices relevant to enhancement projects in Scotland are provided above, the following section provides a review of wider frameworks and programmes both within and outside of Scotland.

3.1 Scottish Government

3.1.1 Scottish Code for Conservation Translocations

The Scottish Code for Conservation Translocations is a framework for conservation projects in Scotland that involve moving species. The code highlights the potential risks (e.g. harm to the conservation status of the donor site(s), the introduction of INNS) and benefits of restoration (e.g. enhanced ecosystem services and community engagement). This is a key piece of guidance that has informed the enhancement framework produced through this project. The Code contains a guidance document, a two-page brochure / flier and an assessment template. The code addresses a lot of the aspects NatureScot would like to cover in the enhancement framework, with it being currently used to steer native oyster and seagrass restoration work. The code is currently in review.

3.1.2 Blue Economy Strategy

In the 2020-2021 Programme for Government, the Scottish Government committed to developing a Blue Economy Action Plan which will encompass work across a broad range of marine sectors, including science, energy, seafood, tourism and transport. It will require applicants to demonstrate how their project will deliver against the Blue Economy Strategy, such as enhancing the marine environment, including its quality, reputation and its marine products.

3.1.3 Scottish Biodiversity Strategy 2020 Challenge for Scotland's Biodiversity

The 2020 Challenge for Scotland's Biodiversity, including marine and coastal, calls for offsetting to secure benefits to biodiversity (Scottish Government, 2013). It aims to improve the monitoring of the marine environment and improve understanding of how coastal ecosystems are likely to adapt to climate change and develop appropriate strategies for coastal management. It also aims to improve understanding of special features, including PMFs, which will be protected by a range of mechanisms, including licensing and planning.

The 2020 Challenge for Scotland's Biodiversity aims to provide opportunities for everyone to experience and enjoy nature regularly and acknowledges the benefits of connecting people with nature, including health, wellbeing, education, community development and regeneration (Scottish Government, 2013). In the marine environment, it is not always possible for people to access certain environments, particularly those in deeper, offshore regions. Saltmarsh and sand dunes are readily accessible habitats to the public. Seagrass is thought to be distributed over a wide geographic range in Scotland but its distribution is very poorly mapped and as a shallow habitat often found in sheltered bays, it is considered relatively accessible to the public (Green et al. 2021b). Native oysters are typically found in moderately deeper water, however, recent native oyster restoration projects have increased in community involvement (e.g. Loch Craignish Native Oyster Restoration Project and Lochaline Native Oyster Project). This makes sand dunes, saltmarsh, seagrass and native oyster restoration projects key candidates for community involvement, citizen science projects, community monitoring and a way for coastal groups to connect with the habitats on their doorsteps (NatureScot 2021).

NatureScot and Scottish Biodiversity Strategy working groups will assess how successful Scotland has been in achieving its biodiversity targets. The results of the assessment will influence the new Scottish Biodiversity 2030 Challenge (see Biodiversity Strategy Programme).

3.1.4 Scottish Marine Environmental Enhancement Fund (SMEEF)

The Scottish Marine Environment Enhancement Fund (SMEEF) will support the delivery of marine and coastal environmental enhancement activities in Scottish waters through grant-aided practical conservation projects. SMEEF has been established in collaboration with the government, Non-Governmental Organisations (NGOs) (e.g. Royal Society for the Protection of Birds (RSPB) and Scottish Wildlife Trust), industry and business (e.g. NatureScot, Marine Scotland, CES, offshore wind industry), to support and drive an increase in practical conservation and restoration projects, such as those for native oyster and seagrass, to help strengthen the resilience of the marine and coastal environment, its communities and visitors and enhance the natural capital that relevant economic sectors rely upon. A formal launch is scheduled for later in 2021, with SMEEF currently developing an appropriate governance framework and setting criteria for the grants. SMEEF is part of the Blue Economy Action Plan, part of the Scottish Government's Programme for 2020/21.

It is recognised that evidence on lessons learned from other projects and existing guidance and/or assessment frameworks would be useful to the partners and future applicants to the fund to help ensure funds are allocated effectively and that proposals are likely to meet their objectives. The findings in this report will assist with influencing the development and application of this fund.

3.1.5 Scottish Conservation Finance Project

The £1 Billion Challenge 'Scottish Conservation Finance Project' led by the Scottish Wildlife Trust and SEPA aims to generate new forms of investment in Scotland natural capital, including restoring oyster reefs (amongst other plans on land). A route map for the project highlighted nine opportunities for investment which include a Natural Capital Pioneer Fund, a Marine Fund (see SMEEF above), and a Nature-Climate Bond.

3.2 Private and Non-Governmental Sectors

Some of the various marine industry authorities and trading bodies have specific objectives that inform on environmental enhancement, or work towards this, such as the British Marine Aggregate Producers Association's (BMAPA) biodiversity action plan, ScottishPower's Foundation Marine Biodiversity Fund and Association for Inshore Fisheries and Conservation Authority's (IFCA) biodiversity recovery objectives and focus on the need for biodiversity recovery. With further emphasis from the development of the net gain principle and future legislation, developers have been taking action to date with voluntary compensation measures for habitat loss through development impacts. For example, London Gateway's developer DP World has applied the net gain principle with the creation of 65 hectares of intertidal habitat, largely comprising of mudflats and with a greater extent than the habitat lost to compensate for future losses from climate change and rising sea-level (as a result this project was partially funded and managed by the Environment Agency. Offshore wind developers are in discussions with Natural England about proposing seagrass restoration as mitigation under the net gain principle and early discussions are underway in southwest England with regards to the potential development of a marine habitat banking scheme. In other pilot studies, Orsted is undertaking a pilot study with Blue Marine Foundation (BLUE) and guided by the Essex Native Oyster Restoration Initiative (ENORI). They have been researching the optimum windfarm conditions for native oysters to recover a population to >800t in biomass, with current evidence of successful reproduction. Through this project, a suitability matrix has been developed for oyster survivability in windfarms in the UK, assessed against physical factors as well as the abiotic and biotic conditions. This matrix has been used to assess 50 wind farms for suitability.

Some regional IFCAs are also looking at implementing net gain with significant long-term programmes such as Sussex IFCA's (and associated partners) 10–25-year management plan of Chichester Harbour. This aims to increase blue investment and enable net gain, with a focus on threatened habitats such as saltmarshes and oyster beds.

Within the oil and gas sector, The Energy and Biodiversity Initiative (EBI) has been developed as a collaboration within the private sector to produce practical guidelines, tools and models for integrating biodiversity conservation into upstream oil and gas development (EBI, 2003). This includes recommendations on taking action to mitigate or, where appropriate, offset any unavoidable impacts as well as provide compensatory measures and investments in opportunities to benefit biodiversity conservation when developing in high-value environments. This draws on examples of voluntary compensation to date, such as the creation of ponds and sand dunes by Statoil resulting from demands of German legislation when laying a sub-sea pipeline. Other examples in the UK include EBI trialling new restoration measures in sand dunes at Point of Ayr on the Dee estuary in North Wales. Among recommendations for supporting biodiversity, the EBI suggest creating new protected areas. However, a broader framework has been developed by the oil and gas industry association for environmental and social issues (IPIECA) on the biodiversity and ecosystem services fundamentals for the oil and gas industry but only considers restoration, not compensatory habitat as with net gain (see IPIECA guidance on biodiversity and ecosystem services).

Within the NGO sector, there is currently a strong current push towards the need for a Blue Carbon Code and an Environment Bank that can support Blue Growth in the context of ecosystem restoration.

OVERVIEW OF THE FOLLOWING FEATURE-SPECIFIC SECTIONS

4.1 Introduction

Whilst the framework developed as an output of this project is designed to be relevant to all habitats and relevant species, a review of each of the four specific features focussed on in this project has been carried out in the following sections. The following sections provide a review of the commonalities in practice on the ground, guidance, lessons learned and recommendations to build on the framework.

Each section provides an overview of the types of schemes and context, followed by a review of all projects in Scotland, as well as a selection of others in the wider UK and internationally. Each section is completed with a review of the primary management measures in place, guidance and conclusions providing an appraisal of lessons learned and best practice.

A list of selected projects of interest of relevance to these four features is provided in **ANNEX 3**: Case Study Inventory (though note this is not a complete list). A detailed review of lessons learned from a selection of these features, both in Scotland and the UK / internationally, is provided in **ANNEX 4**: Detailed Case Study Review**.**

5. NATIVE OYSTERS

5.1 Overview

European native oyster enhancement / restoration has been one of the largest and longest-running focus areas of the four features within this project, with approximately two new schemes per year. Scotland is considered to be the leading country involved in native oyster restoration, outside of mainland Europe. Enquiries to NatureScot are mainly focused on restoring native oyster populations or collecting broodstock for hatchery production. The main driver is restoration rather than enhancement because of the historical widespread extirpation of oysters in Scottish waters and throughout Europe (e.g. Fariñas-Franco et al., 2018a; Pogoda et al., 2019; 2020a). Most proposals to date aim to increase biodiversity, with economic benefit often being a long-term objective. Restoration of the historical beds on the East coast of Scotland requires translocation of native oysters, whereas those on the West coast have been proposed on existing remnant habitats. Overall, practice is based on natural habitats / species and their historical environmental range, with an emphasis on strengthening existing populations. However, each project is unique, complex and hard to characterise to a particular ‘type’. All projects are at different stages of development, offering a range of lessons learned that are relevant to this study.

Schemes are developed by either a partnership of existing organisations, including public sector, private, academia and NGOs; else they are community-driven. However, community-driven schemes are a relatively new concept over the last few years and are often brought to life through local active engagement in marine conservation, with the community actively seeking projects. Native oyster enhancement / restoration is a particularly good ‘fit’ for local communities because they are perceived as more feasible and attractive to funders.

5.2 Projects

NatureScot has been directly involved in five native oyster restoration schemes, as detailed below.

5.2.1 Scotland

The Dornoch Environmental Enhancement Project (DEEP) is an ongoing project focused on restoring native oysters in the Dornoch Firth, initially using oyster cages on the seafloor and more recently with oysters laid on shell cultch ‘mini-reefs’. DEEP is a collaborative project between the Glenmorangie Company, Heriot-Watt University, and the Marine Conservation Society (MCS). DEEP is the most significant and longest-running project (since 2013) with the largest engagement and subsequent scope for learning. The scheme has benefited from a thorough translocation protocol, clear objectives and identified mechanisms for consenting, offering a good model for future projects. In the developmental stages, the project obtained Planning Permission from the Local Authority classed legally as an Aquaculture Production Business to enable exclusive rights to the areas where restoration was pioneered. The project has also obtained Marine Licences from MS-LOT to allow shell and oyster deposits to the seabed. NatureScot, Marine Scotland, FHI are engaged to provide advice to the project teams. The DEEP project is located within the Dornoch Firth and Morrich More SAC, the Dornoch Firth and Loch Fleet SPA and SSSI and adjacent to the Moray Firth SAC. In order to move to a fully ‘operational’ scale, the DEEP team are currently being guided through the Habitats Regulation Appraisal, planning, licensing and consenting process with Marine Scotland, the FHI, Highland Council and NatureScot to scale up the project and lay oysters and shell directly on the seabed over several hectares. DEEP has produced a Biosecurity Plan for translocation. The present marine licenses technically require all materials to be removed from the site by end of 2022. Future ‘Operational’ scale restoration is likely to require a licence for construction, through the Marine Licence, from Marine Scotland to enable the restored habitat to be left in place.

The Wild Oysters Project is a three-year restoration project launched in June 2020 and developed as part of a collaboration between the Zoological Society of London (ZSL), BLUE and British Marine. The project is based in three locations around the UK; the Firth of Clyde, Scotland (Inner Clyde Estuary SPA); Conwy Bay, Wales (Menai Strait and Conwy Bay/ Y Fenai a Bae Conwy SAC); and Tyne and Wear, England (Northumbria Coast SPA). The aim of the Wild Oysters Project is for the UK seas to have a self-sustaining population of native oysters, which will provide clean water, healthy fisheries and enriched biodiversity. At each location, the project is building local partnerships, including the Clyde Porpoise Community Interest Company, Bangor University and Groundwork North East. At each hub, oyster nurseries will be installed with caged oysters suspended under marinas along with seabed restoration, which will include baseline surveys and cultch deployment. In the Firth of Clyde, the proposal to suspend oyster cages from the marina / pier was supported by BLUE. The proposal and the route to engagement were through the Local Authority to check planning permission. However, a marine licence for construction / new infrastructure was not required, as the suspended cages were attached to existing infrastructure. The project registered with FHI as an aquaculture business.

The Loch Craignish Native Oyster Restoration Project in Argyll was led by the Scottish charity Seawilding and funded by the National Lottery from 2019. The project has also partnered with local volunteer association Craignish Restoration of Marine and Coastal Habitat (CROMACH), the Ardfern Yacht Centre, Heart of Argyll Wildlife Organisation, as well as Stirling University's Institute of Aquaculture and the Scottish Association of Marine Sciences (SAMS). The project aims to reintroduce a population of native oysters; monitor the oysters' potential for wild spawning and the future restoration of the native oyster stocks, and enable a sustainable community-owned fishery. The project aims to grow 1 million oysters in a floating nursery at Loch Craignish and to translocate the oysters to suitable pre-surveyed sea-bed sites around the loch, where they will be monitored. All juvenile native oysters are sourced from Morecambe Bay Hatchery. No additional cultch has been required as there is an abundance of cockle, oyster and horse mussel shells on the seabed. The project has secured a marine licence and has worked with NatureScot to ensure that biosecurity protocols are followed.

Other oyster restoration projects that Nature Scot are aware of being planned in Scotland include those in the Firth of Forth and Loch Ryan. The organisations involved include WWF, Royal Botanical Garden Edinburgh (RBGE), Heriot-Watt University and local community groups. In March 2021, the Lochaline Native Oyster Project, in the Sound of Mull launched, founding the Community Association of Lochs and Sounds (CAOLAS). Also planned are the Plockton (Lochalsh) and Wester Ross scheme.

5.2.2 UK

NatureScot has engagement with the UK & Ireland Native Oyster Restoration Network and the Native Oyster Restoration Alliance (NORA), both of which are currently developing significant guidance through their communities. Due to Scotland's leading role in native oyster restoration, this project has not drawn further on case studies listed in the rest of the UK in **ANNEX 3**: Case Study Inventory.

5.2.3 International

In Europe, the Netherlands has particularly advanced enhancement projects underway, though these differ from Scottish projects because in some cases the species were not originally in those locations. Enhancement projects are well advanced in France, the Netherlands and Germany, with both the Netherlands and Germany demonstrating experience with native oyster translocation. The knowledge gained from these schemes was inputted into the NORA European Guidelines on Biosecurity in Native Oyster Restoration (zu Ermgassen, et al., 2020a). Experience of oyster restoration, albeit using different species, in America is also notable through the Nature Conservancy NGO. The Chesapeake Bay Foundation (CBF) oyster restoration projects in Maryland and Virginia are considered the longest and largest-scaled restoration projects in America (see **ANNEX 4**: Detailed Case Study Review).

5.2.4 Projects Related to Other Relevant Features

Experience with other bivalve species has been gathered where there are gaps specific to native oysters. DEEP considered subtidal horse mussel (*Modiolus modiolus*) habitat as a reference ecosystem to inform native oyster reef restoration (Fariñas-Franco et al., 2018b). Horse mussel reefs are protected in Strangford Lough, Northern Ireland but were partially destroyed in the 1990s resulting in the introduction of a no-take zone in 2011, protecting the remaining horse mussel habitat. In 2005 the *Modiolus* Restoration Plan was developed to restore horse mussel biogenic reefs to favourable conservation status. Surveys and restoration research that was conducted on natural and restoration sites within Strangford Lough included the use of acoustic substrate mapping, benthic grabs, video tows and diver photo quadrats (Fariñas-Franco et al., 2014, 2018; Geraldi et al., 2014).

The Wadden Sea Plan 1997 contained a trilateral policy and management plan for blue mussel (*Mytilus edulis*) fisheries aiming for an increase of the total area and more natural development and distribution of intertidal blue mussel beds. To protect and achieve an increase in the area of intertidal blue mussel beds, the entire intertidal area in the Dutch Wadden Sea was permanently closed for blue mussel fisheries in 2004. The prohibition of mussel fishery in the intertidal areas should allow natural development of blue mussel beds, however, this has enabled the spread of the Pacific oyster (*Crassostrea gigas*) after its introduction by humans in the 1970s (Folmer et al., 2017). The likely spread of the Pacific oyster is further amplified by climate change which is predicted to significantly increase the reproductive range in UK waters (King et al., 2020).

5.3 Management

5.3.1 Consenting and Policy

Oyster restoration is a relatively new field in Europe compared with other nations such as the US, and therefore management and policy measures may require adaption to develop a suitable best practice and policy framework, that reflect the needs of oyster restoration projects (zu Ermgassen et al., 2020a).

In Scotland, native oysters are Royal Shellfish and property of the Crown. Consent to exploit was previously required from CES. However, since 2017 this consent has passed to Marine Scotland but there is no specific licence applicable to native oysters. Overall, the licensing process is as follows:

- Local Authority for the acquisition of planning permission;
- Marine Scotland for various licensing through the Conservation, FHI or MS-LOT teams (as appropriate); and
- NatureScot for licence concerning translocation to areas of former historical oyster beds.

Native oysters are a PMF and they are regarded as being one of the most sensitive PMFs to the impacts of seabed disturbance. The conservation objectives for native oysters in Loch Sween NCMPA are to ‘conserve’ native oysters. Currently, the MPA network in Scotland is considered adequate for native oysters as on the basis of existing evidence it has not been possible to achieve replication of the feature within the network but if additional areas of importance are identified in the future these could be considered as additional MPAs (Cunningham et al., 2015). Native oysters are also protected by other mechanisms including OSPAR threatened and declining species list (Region II) and UK Biodiversity Action Priority Species list, and in Scotland are included on the Scottish Biodiversity List and the NatureScot Action Framework (2007). Whilst protection against fishing activities is provided at some designated sites, e.g. Dornoch Firth SPA, SAC and SSSI where the DEEP project is located, alternative protection measures may be required in other locations. However, at present, there is a tension between the underlying aims of the Habitats Directive to “maintain or restore” and the required HRA process that mechanically seeks to establish the impact of restoration on present-day conservation features in SACs, with a view to establishing no adverse impact on site integrity (see Fariñas‐Franco et al., 2018).

5.3.2 Biosecurity

Some of the major barriers to progressing native oyster restoration in Europe are the risks of disease, often through aquaculture operations (e.g. *Marteilia refringens, Bonamia ostreae* and *B. exitiosa*) and invasive species (e.g. slipper limpet (*Crepidula fornicata*) or Pacific oyster (*Crassostrea gigas*)). Such risks result from the introduction / translocation of oysters or cultch, i.e. repurposing old shells for use as a settling medium. However, strong biosecurity measures, reinforced by scientific understanding of the vectors of disease and INNS, can be incorporated at both the project planning (specifically site selection) and operation stages; this is key to safeguarding existing disease and INNS-free oyster populations (zu Ermgassen et al., 2020a).

Such measures may include chemical and mechanical cleaning of shell and quarantine; depuration (purification) (zu Ermgassen et al., 2020a; CREW, 2019); and molecular screening for harmful pathogens. For example, molecular screening of *M. refringens, B. ostreae* and Ostreid herpesvirus-1, all listed under EU legislation, has been carried out by the Marine Scotland Science Disease Diagnostic group on behalf of DEEP. Recent studies have also suggested the use of non-lethal diagnostic techniques based on environmental DNA (eDNA) to detect and quantify *B.osterae* DNA in seawater (Mérou et al., 2020; von Gersdorff Jørgensen et al., 2020). With this new method, *B. ostreae* may be detected by only sampling water from the environment of isolated oysters or isolated oyster populations. This non-lethal diagnostic eDNA method could have the potential for future surveys and oyster breeding programs aiming at producing disease-free oysters (von Gersdorff Jørgensen et al., 2020).

Translocation of native oysters (and cultch material) must be supported by a Biosecurity Plan submitted to NatureScot and Marine Scotland; and, if the restoration scheme is classified under an aquaculture business, then the Biosecurity Plan must be available to the FHI. Further guidelines are provided by The European Native Oyster Habitat Restoration Handbook (Preston et al., 2020) and The European Guidelines on Biosecurity in Native Oyster Restoration (zu Ermgassen, 2020a), based on current knowledge and experiences. Along with setting out legal requirements, these documents recommend that projects apply a “Precautionary Approach” to prevent harm caused by accidental or poorly considered transfers, supported by a list of considerations on whether to proceed with translocation and if proceeding, then how to prepare adult oysters for translocation. The guidance also aims to provide those seeking to purchase stock from a hatchery with the information required to understand the biosecurity issues relating to hatcheries and assist those seeking to establish their own hatcheries in understanding the associated biosecurity requirement (zu Ermgassen et al., 2020a).

It is important to realise that no translocation is entirely risk-free and there are no testing methods that are 100% reliable at detection at present. For this and other reasons, disease outbreaks can still occur and INNS is a high-risk factor since it is not covered by FHI statutory regulations, as advised by Marine Scotland and Recent Scottish Government FHI’s epidemiological investigations at Lochnell Oysters, the Dornoch Firth and the Loch Craignish Native Oyster Restoration Project are testament to this. The presence of the parasite *B. ostreae* in consignments of native oyster have resulted in culling at the Orkney Shellfish Hatchery (OSH) Ltd and Heriot-Watt University. Within *Bonamia*-infected areas, techniques should be sought to take advantage of any disease tolerance that has developed in broodstock from high disease load areas, without transferring pathogens; and from reference to the listed potential pathogens relevant to European waters (Preston et al., 2020).

5.3.3 Genetics

The Berlin Oyster Recommendations, (Pogoda et al., 2019) state the importance of preserving the genetic diversity of European native oyster populations in order to maintain the species’ ability to adapt to changing environmental conditions, disease and climate change. This in turn will aid the long-term survival of native oyster habitats. The recommendations (Pogoda et al., 2019) also suggest establishing new hatcheries and spatting ponds for the production of robust and genetically diverse oyster seed, to eliminate the need for bringing in stock, with protocols adapted to preserve the existing genetic integrity of the population.

Understanding whether the potential donor source population is not only genetically distinct but also adapted to their local environment is needed (zu Ermgassen et al., 2020b). The management of genetic diversity of restored populations is of high importance to avoid inbreeding and ensure long-term adaptability (Lallias et al., 2010). It is important that restoration practices, at a minimum, maintain local or regional genetic diversity and adaptations. Furthermore, restoration projects should seek to utilise breeding techniques that maximise the genetic diversity in the offspring to enable resilience to future change (Preston et al., 2020). Lallias et al. (2010) suggest high genetic diversity and bonamiosis-resistance are important features of any sustainable restoration programme. The European Native Oyster Restoration Handbook (Preston et al., 2020) notes that if the restoration area contains diseases such as *Bonamia*, then the program should seek to use locally sourced broodstock to utilise genetic resistance and adaptations.

Genetic variation and disease tolerance were further highlighted at the 2021 NORA Genetics workshop (25/02/2021), where the importance of geneticists in restoration schemes was noted, for providing advice on how to improve / prevent inbreeding in hatcheries and spatting ponds, as well as estimating the genetic variation of the source material and the restored population.

5.4 Guidance

A review of the primary guidance to inform the enhancement of native oyster habitats is provided below.

5.4.1 Scotland

In earlier years, guidance was provided by the Species Action Framework before any native oyster-specific guidance was available. However, NatureScot and Marine Scotland are currently working together on developing a new set of native oyster guidance, specific to the Scottish context (both environment / species and regulation), including learning from recent projects in particular. This will be finalised once the legal and policy framework / consenting approach is fully developed. The guidance will form part of a forthcoming native oyster restoration best practice guidance package for Scottish waters that will be published on NatureScot and Marine Scotland's websites. It will aim to provide advice to would-be applicants and ongoing schemes already in development, including both specific on-site guidance as well as wider geographic considerations.

5.4.2 UK

Much of the other guidance on oyster restoration and enhancement has stemmed from the key associations below:

- The ZSL and the University of Portsmouth jointly run the Native Oyster Network which includes organisations from UK and Ireland. The network was established in 2018 and includes academics, conservationists, oyster fisheries and NGOs who are working to restore self-sustaining populations of the native oyster.
- The European Native Oyster Restoration Alliance (NORA) was established during an international workshop on native oyster restoration hosted by the German Federal Agency for Nature Conservation (BfN) and the Alfred Wegener Institute (AWI) in Berlin in November 2017. NORA was consolidated by the second international meeting in Edinburgh 2019, supported by DEEP partners and Nature Scot. This ongoing European network aims to reinforce and restore native European oysters. Its members include representatives of Government agencies, Universities, NGOs, consultancies and oyster growers.

5.4.3 International

Numerous guidelines for undertaking oyster restoration exist and have been invaluable in the early phases of European oyster restoration, such as identifying suitable cultch material (zu Ermgassen et al., 2019).

The European Native Oyster Habitat Restoration Handbook (Preston et al., 2020) for the UK and Ireland was funded by the LIFE Programme of the European Union and the Environment Agency (with NatureScot on the Steering Committee). Recognised as supporting the goals of the UN Decade on Ecosystem Restoration (2021-2030) it is planned to be one of four handbooks to be produced, with others covering seagrass and saltmarsh restoration, however, these have yet to be published. The handbook provides foundational and practical guidance on the restoration and conservation of both native oysters and native oyster habitats across the UK and Ireland. This includes planning, permitting, licensing, funding, deployment, project techniques, biosecurity risks and public engagement. This publication was written as a native oyster specific annexe to the Restoration Guidelines for Shellfish Reefs (Fitzsimons et al., 2019), providing a detailed overview of information relevant to the restoration of the European native oyster, whilst adhering to international standards of ecological restoration. The handbook recommends goal-based project planning in order to provide a framework whilst ensuring the best chance of achieving the highest level of recovery possible. The handbook also recommends a project feasibility study to establish whether the location is suitable for ecosystem restoration i.e. historical populations of native oyster and determining threats to a project including pollution and fishing; and establishing a reference or target ecosystem; as well as examples of deployment options, benefits of each and points to consider.

Detailed consideration of MPAs, fisheries, other key stakeholders to involve and project funding are recommended. However, the examples provided within the Handbook are predominately English based with minimal input of Scottish issues, such as the difference in legislation.

The European Guidelines on Biosecurity in Native Oyster Restoration (zu Ermgassen et al., 2020a) was funded by the LIFE Programme of the European Union and the Environment Agency, with input from NatureScot. This guidance provides an introduction to working with relevant authorities to ensure restoration work exceeds the mandatory requirements. The handbook notes biosecurity is an integrated part of restoration as it is a pathway for INNS and disease, and highlights the importance of working with local communities to understand risks. The handbook also provides biosecurity guidelines in relation to native oyster and clutch translocation, with the following recommendations:

- Do not consider donor sites outside historical native range;
- Do not consider donor sites with high-risk INNS or diseases that are not present at the restoration site;
- Minimise the physical distance between the donor and the restoration site; and
- Avoid movement across latitudinal gradients.

However, these documents are generic, European-based and they do not address local jurisdiction issues (although, case studies of specific projects are provided in the guidance documents). For example, in a Scottish context, it is more important to avoid translocation between semi-isolated waterbodies, which has proven to be a significant issue. Crossing of latitudinal gradients is less of an issue in Scotland as many organisms are free to move and spread their larvae and progeny up and down the latitudinal gradients of, for example, the west coast.

A list of recommendations that the participants and members of NORA agreed upon are detailed in the Berlin Oyster Recommendations. They provide a foundation to support European countries in implementing commitments under the Habitats Directive, the Marine Strategy Framework Directive and OSPAR recommendations (Pogoda et al., 2019). The recommendations highlight the importance of protecting sites where native oysters are not only abundant but in areas where they were previously recorded or are present but of low density. Recommendations are:

1. Produce sufficient oysters for the restoration of oyster reefs. This should be undertaken by supporting existing hatcheries, spatting ponds and spat collector techniques or support the establishment of new ones.
2. Identify and create suitable sites for the restoration of oyster reefs. This can be undertaken by identifying sufficient undisturbed and suitable areas for the restoration and protection of native oysters in all regions of its historical range. This includes the restoration of a suitable substrate in some areas.
3. Provide suitable substrate for successful recruitment. The extraction of native oyster shells from the marine environment for other uses should be prohibited. The availability of suitable substrates, such as shells, will maximise larvae recruitment.
4. Respect *Bonamia*-free areas. Encourage research on the *Bonamia* parasite and infection dynamics. Biosecurity protocols must be strictly followed in *Bonamia*-free areas.
5. Create common monitoring protocols which will provide comparable results for projects throughout Europe. Where possible, monitoring should include the assessment of ecosystem services on a habitat and ecosystem scale.
6. Preserve genetic diversity of native oysters in Europe by adapting established hatchery and pond production protocols.

The Restoration Guidelines for Shellfish Reefs (Fitzsimons et al., 2019) provides both guidance in decision-making for establishing shellfish reef restoration projects and examples of different approaches undertaken by experienced practitioners in a variety of geographic, environmental and social settings. It also provides a high-level checklist to help guide assessments and links to relevant chapters within the guidance, including establishing a feasibility plan including alternative design considerations, identifying funding sources, as well as undertaking monitoring, evaluation and reporting. These guidelines update and expand on the *Practitioners Guide* (Brumbaugh et al., 2006) (which primarily focuses on supporting community-based restoration efforts in the USA), capitalising on the improvements in knowledge around the ecological function of bivalves in their coastal environments as well as the depth and breadth of experience that now exists globally. The guidelines were produced by and for practitioners, managers and community members involved in shellfish restoration globally, with the main objective of simplifying complex scientific principles and terminology into a resource that would be useful to a broad audience (Fitzsimons et al., 2020). However, the permitting section largely focuses on the USA and the target oyster species are ecologically and functionally a little different to the predominantly subtidal *Ostrea edulis*.

5.5 Appraisal of Lessons Learned to Inform Framework

Whilst a detailed review of lessons learned from case studies is provided in **ANNEX 4**: Detailed Case Study Review, highlights raised in guidance material and strategic reviews specific to native oysters are detailed below.

5.5.1 Site selection

This is dependent on the individual requirements of native oysters, with an ultimate goal to identify sites where restoration measures are most likely to succeed. The selection of suitable sites is of fundamental importance, as it influences the survival, growth, fitness, reproduction, and recruitment of the species and will determine the success of the whole restoration project (Kerckhof et al., 2018; Laing et al., 2005). These reasons have driven a number of feasibility studies, as for BLUE prior to mounting oyster nurseries on offshore wind farms, whereby it was found that the abiotic factors in their chosen location were sub-optimal (Robertson et al., 2021). Site selection is initially defined through ecology history and distribution, the feasibility of restoration and the quality of environmental conditions (Farinas-Franco et al. 2018; Pogoda et al., 2020b). As a result, historical species presence is often cited as one of the key aspects of site selection, such as Borkum Reef Ground Oyster Pilot Project, where 30% of the Dutch North Sea floor was identified as suitable for shellfish reefs. In addition, species distribution models are valuable to inform distributions of known associated species, in order to assist with identifying potentially suitable sites where species-specific data is absent (zu Ermgassen et al., 2020b). While it is useful to learn from national and international examples, it is also essential to consider how these may need to be adapted for application to a specific region or site. A significant effort may be required to establish feasibility at a site such as DEEP (Fariñas-Franco et al., 2018), which carried out archaeological and historical research to demonstrate the former presence of the native oyster at the site in the Dornoch Firth.

5.5.2 Evidence base

Consideration of gaps in knowledge must be addressed after the initial feasibility assessment before full-scale restoration, e.g. development of pilot studies, further research and adaptive management principles (Fitzsimons et al., 2019). For example, DEEP undertook testing and monitoring the suitability of the site (every six months), with a smaller number of oysters (300 in total) before scaling up in increments. Additionally, in the Netherlands, the Borkum Reef Ground Oyster Pilot Project findings influenced and led to the undertaking of the Haringvliet Dream Fund Project.

5.5.3 Regulation

Due to the low levels of experience, close and clear collaboration with the relevant authorities is vital in supporting the development of regulatory frameworks and overcoming existing barriers (Fitzsimmons et al., 2019) and this may incur significant project costs (human / financial resources). For example, there is not yet a framework in place in Scotland that specifically enables restoration activities and some phases of the DEEP project have therefore required the use of aquaculture legislation.

5.5.4 Management

Fitzsimons et al. (2019) highlight the importance of planning and setting restoration goals, with Preston et al. (2020) providing examples of deployment options, benefits of each and points to consider, information on project planning, permitting, licensing and funding; and illustrates a typical project timeline for native oyster restoration

The development of tools are highlighted in the literature, for example, using a checklist to guide the development of the methodology and feasibility studies (Fitzsimons et al., 2019), the use of a decision-making flow diagram to assist in planning and feasibility (Preston et al., 2020) and the use of the 'Ecological Recovery Wheel' to convey the progress of the ecosystem attributes compared to the baseline (Fitzsimons et al., 2019; Preston et al., 2020). The Recovery Wheel conveys the progress of the ecosystem attributes compared to the baseline, as adapted from the Society for Ecological Restoration's International Principles and Standards for the Practice of Ecological Restoration (Gann et al. 2019) (SER Standards).

Due to the low levels of experience, science and tools, measures need to be adapted to develop appropriate best practices relevant to the needs of a project, with validation of the efficacy of the scheme actions being assessed on a case-by-case basis (zu Ermgassen et al., 2019). An example of this is demonstrated by the U.S. Army Corps of Engineers (USACE), which undertook additional investigations into the costs and benefits of sanctuaries and harvest reserves on the Maryland and Virginia Oyster Restoration Project (USACE, 2012). This assessment determined whether these practices were the most suitable for the area in terms of ecological and economic benefits, as such management measures had not been addressed previously in that region. It identified that the establishment of harvest reserves within proximity of sanctuaries could provide near-term support to the seafood industry and establish a diverse network of oyster resources for the Maryland and Virginia Oyster Restoration Project (USACE, 2012). Moreover, management of disease and INNS can be a challenge, particularly in sourcing biosecure stocks of native oysters. This has had big implications for DEEP when *Bonamia* was introduced to the Dornoch Firth. As a result, the lack of available biosecure stock has halted project plans for several months.

5.5.5 Monitoring

At the time of writing, NORA and the Native Oyster Network (NON) guidance on monitoring oyster restoration is expected to be published shortly.

5.5.6 Engagement

Successful communication to stakeholders is noted as important, particularly ensuring traditional owners (for North America) and local industry are included early in communication planning as key partners and audiences for most projects (Fitzsimons et al., 2019). Early involvement has been demonstrated to be effective, e.g. DEEP which has engaged with the local community and provided regular updates to agencies government on the project. Potential engagement tools should be considered, such as educational outreach, websites, social media and newsletters (Preston et al., 2020). It is also important for projects to work with and educate the local community particularly on the potential spread of INNS and pathogens (Fitzsimons et al., 2019; zu Ermgassen, 2020). For example, the Maryland and Virginia Oyster Restoration Project and the Loch Craignish Native Oyster Restoration Project, utilised the community in the restoration program, by setting up workshops to educate the public and to involve them in hands-on restoration and citizen science. Moreover, Fitzsimmons et al. (2019) acknowledge that clear communication with the permitting organisation and policymakers is vital in supporting the development of frameworks and overcoming existing barriers.

Pogoda et al. (2019) also review the NORA guidance and the Berlin Oyster Recommendations· as detailed above and note the importance of maintaining communication within the NORA community to help advance the topics critical to developing oyster habitat restoration in Europe. Similarly maintaining communication with other shellfish restoration networks worldwide will be beneficial where valuable lessons can be learnt. One such example of communication, within Britain, is the Wild Oyster Project which reintroduced oysters across Britain and to do so drew on the Solent Oyster Restoration Project methodology and the Essex Native Oyster Restoration Initiative.

5.5.7 Benefits

Fitzsimons et al. (2020) and zu Ermgassen et al. (2020c) both note potential impacts on ecosystem functions and services as a result of enhancement / restoration projects such as an increase in biodiversity, fish biomass, or water quality. These benefits are noted in the objectives of the Loch Craignish Native Oyster Restoration Project alongside the primary goal of restoring native oyster beds, to additionally improve the water quality following degradation by scallop dredging, fish farming and recreation.

5.5.8 Risks

In relation to pathogens, the literature notes that for *Bonamia*-infected areas, techniques should be sought to take advantage of any disease tolerance that has developed in broodstock from high disease load areas, without transferring pathogens. Preston et al. (2020) list potential pathogens relevant to European waters and detail the importance of biosecurity as part of good restoration practice. zu Ermgassen et al. (2020a) detail the main routes of disease transmission in hatcheries and the requirement of a Biosecurity Plan in order to ensure that any restoration efforts in European waters are carried out responsibly.

In Scotland, climatic events may damage restoration projects, e.g. due to stochastic rainfall events causing freshwater and associated wastewater stress. Also, hot and cold spells may cause mortality in intertidal populations. For this reason, restoration projects should give some consideration to planning for resilience in this context. However, this is generally not relevant to Scotland where oyster restoration schemes are generally subtidal.

Restoration projects often rely on multiple sources of funding, some of which may not be in place at the onset of the project. This can provide difficulties fully specifying projects and can limits MS-LOT, NatureScot and other stakeholders ability to provide advice and guidance such as for licensing by MS-LOT, NatureScot and other stakeholders late consultation with competent authorities to ensure statutory obligations are being met (and the project costs of doing so).

Oyster restoration is still in its infancy in Europe, and policy and management measures need to be adapted to develop appropriate biosecurity ‘best practice’ (zu Ermgassen et al., 2019). There are gaps in knowledge and research and no method that ensures 100% absolute biosecurity within translocations schemes (and may never do) (zu Ermgassen et al., 2020a). Pogoda et al. (2019) note the importance of considering the risk posed by *B. ostreae* and avoiding further spread. NORA also strongly encourage this. Developing research to understand both the mechanisms of *Bonamia* tolerance / resistance, and ways in which scaling up the production of tolerant / resistant native oyster spat for restoration purposes has also been identified and is of high importance (Sas, et al., 2019). It is therefore critical that project managers work with the relevant authorities to develop appropriate best practice protocols in each case, and that validation of the efficacy of the actions undertaken are assessed on a case-by-case basis.

Genetic diversity and *Bonamia* resistance planning are important features of any responsible programme for the restoration of native oysters. Hatchery-produced populations from small numbers of brood stock have shown loss of genetic diversity relative to wild populations (Lallias et al., 2010). Moreover, native oyster numbers are so low, that in recruitment-limited environments there are insufficient mature oysters to allow the population to increase naturally (CREW, 2019; Fitzsimmons et al., 2020). It can therefore be a challenge to use locally sourced brood stock to build genetic resistance and resilience. A waterbody with a greater disease designation than the hatchery location should not be considered as a potential source of brood stock (zu Ermgassen, 2020b).

SEAGRASS

6.1 Overview

Seagrass restoration and enhancement is a fast-maturing discipline with examples of restoration and enhancement projects being implemented in a number of locations including the US, New Zealand, Australia and more recently in Europe (Tan et al., 2020; Brode et al., 2004; Moksnes et al., 2021). With such growing interest, studies have examined the effectiveness of a range of scales and methods of seagrass restoration across the world (van Katwijk et al., 2009). Recent high profile examples of wide-ranging success have been seen in the US where over 3000 ha of seagrass have been planted and brought to maturity in the Chesapeake Bay, leading to full ecosystem service recovery (Orth et al., 2020).

Whilst knowledge gaps remain, there is a growing body of evidence to support the development of effective restoration and enhancement projects, and key advice available in terms of ecological feedbacks and appropriate planning through the use of modelling. Over the past 20 – 30 years there have been several success stories on the east coast of the US, as well as smaller schemes in New Zealand, that can be used to inform and develop strategies to maximise efficacy. Whilst evidence gaps remain, the existing knowledge and experience of restoration projects and associated processes and technology published in the academic literature are considered a major strength for informing future programmes. In addition, the recent funding award from the Sustainable Management of UK Marine Resources (SMMR) Strategic Priorities Fund for the 'Restoration of Seagrass for Ocean Wealth' (ReSOW UK) project will help to address these evidence gaps. The ReSOW project (2021-2024) will facilitate informed management and restoration of seagrass for sustainable social, environmental and economic net gains for the UK.

Whilst initial seagrass enhancement proposals (and therefore guidance) in Scotland has been focused on seed collection, enquiries to NatureScot have recently grown in regard to larger and more varied seagrass restoration / enhancement projects. To date, no experimental seagrass restoration work has been undertaken other than one experimental trial of intertidal planting (Wilkie, 2009). This lack of science focus on seagrass restoration mirrors a wider knowledge gap around the biodiversity, functioning, monitoring and conservation of seagrass throughout Scotland. There is also evidence of historic loss of seagrass around Scotland (Cleator, 1993; Thomas, 2020; Green et al., 2021a), providing an opportunity for environmental renewal.

6.2 Projects

NatureScot are aware of several early-stage projects and proposals in Scotland, as detailed below, but there are no schemes already in place.

6.2.1 Scotland

Current seagrass restoration proposals in Scotland include those around the Firth of Forth and Solway Firth both at very early stages. There is also interest from several community groups to develop projects, e.g. around the Isle of Arran and in Wester Ross . A community-led seagrass restoration project in Loch Craignish is underway with support from the Biodiversity Challenge Fund in collaboration with the SAMS and Project Seagrass.

In addition, small-scale intertidal seagrass transplantation was trialled in the Tay Estuary for *Zostera noltii*. However only two out of the five plots were successful, two years after planting, with conclusions drawn that both elevation and hydrodynamic conditions of the receiving site must be similar to those of the donor site for success (Wilkie, 2009). It is likely that such experiments did not consider the suitability of the habitat and environment for those plants to survive.

Project Seagrass have explored the potential for a restoration project in Scottish waters, guided by a site selection process by NatureScot to scope out suitable (and unsuitable) sites, both for collection of seeds and consideration for potential restoration trials at these sites. NatureScot are working with Project Seagrass and other organisations to fill knowledge gaps around existing seagrass distribution, extent and bed characteristics which are required before strategic prioritisation of efforts into restoration activities can take place, and to inform seagrass restoration advice and guidance. For example, a seagrass genetics project is being carried out in collaboration with the RBGE to understand the genetic connectivity of existing beds; and thus the provenance of seeds in order to help determine the suitability of seed relocations.

Project Seagrass and Swansea University have recently completed building a Scotland wide seagrass habitat suitability model. This uses an ensemble approach and is driven by the use of known data points correlated against spatial environmental datasets. It is also understood that the JNCC are using a similar approach to model seagrass habitat suitability. The Project Seagrass study has shown the power of developing local scale detailed wave models to drive the models and the need for improved spatial datasets on existing seagrass. At Edinburgh University recent postgraduate research has included habitat suitability modelling around the Isle of Skye and the development of a regional and international framework for evaluating effective seagrass management and conservation. Recent studies by Project Seagrass and Heriot-Watt University have examined the current and historic distribution of seagrass in the Firth of Forth, documenting multiple potential areas of decline.

At Heriot-Watt University, postgraduate research has focussed on the distribution of intertidal seagrass species in the Firth of Forth and qualitative assessment of their persistence. Also, an assessment of the status and distribution of *Zostera marina* in Scotland was conducted by an Eden Project Learning student in collaboration with the University of Plymouth. Further research proposals and developments with academic partners may support Scotland-specific evidence and method development / guidance.

6.2.2 UK

To date, there has been limited seagrass restoration on the ground in the UK. Some studies were conducted in the 1970s using transplantation of seagrass ‘sods’ (Ranwell et al. 1974). The work of Swansea University and Project Seagrass was the first to progress and in 2013 trials were started to develop locally appropriate seagrass restoration methods building on the work of Prof Bob Orth and his team in the Chesapeake Bay (US). Comparative studies using transplants of shoots, transplants of seagrass ‘sods’ and seeds were conducted in West Wales alongside widespread trails (over multiple locations) with seeds. Restoration using seeds was found to be the most effective, primarily driven by the European green crab (*Carcinus maenas*) tearing apart the transplanted plant material. Trials of planting seagrass seeds continued resulting in a range of studies for which an initial study has been published (Unsworth et al., 2019).

Seagrass Ocean Rescue project ran between 2019 and March 2021 and was led by Project Seagrass in partnership with Sky Ocean Rescue, University of Swansea, World Wide Fund for Nature (WWF) and Pembrokeshire Coastal Forum in Dale Bay Pembrokeshire, Wales. The project planned to restore seagrass in a small experimental 2 ha area and aimed to inspire future major projects in other regions to restore the UK’s seagrass meadows. To date, the project has successfully planted 1.2 million *Z. marina* seeds, with thousands of mature plants recorded throughout the restoration area. The project has noted that germination has been a lot slower than hoped with some small patches performing poorly as a result of the necessity to store seeds due to extended community consultation. Some of the seeds (400 thousand) were planted in autumn 2020 with the expectation of improved germination due to the fresh planting of viable seeds. Work will now focus on monitoring with expectations of the habitat reaching maturity over a five-year period.

Swansea University and Project Seagrass are continuing work on method development on seagrass restoration. This includes the aquaria planting of seeds, studies on seed storage and a range of studies on different types of planting methods; this included a failed attempt to utilise biodegradable plastic mesh to support seagrass restoration in West Wales (see Mimicry of emergent traits amplifies coastal restoration success). Project Seagrass are currently in the early stages of developing a seagrass nursery as a commercial collaboration with Salix Bioengineering to help facilitate seagrass restoration across the wider UK.

Although limited planting has yet to be undertaken, the Ocean Conservation Trust in Plymouth are developing seagrass restoration planting plans under the REMEDIES programme, but no information has been publicly shared about progress. Other planned projects are being considered in the Humber and the Tees estuaries.

6.2.3 International Experience

Z. marina is extensive throughout the Northern hemisphere and so examples can be sought in multiple continents. For example, the German and Dutch are particularly advanced in seagrass restoration / enhancement, as well as USA. The Submerged Aquatic Vegetation (SAV) Program on the Eastern Shore, Virginia, USA, is considered a leading exemplar of how restoration can be conducted. This large-scale project has aligned decades of research on the biology of restoration with active restoration programmes. This has been focused on restoring the seagrass (*Z. marina*) habitat but also monitored the effect of this restoration on the surrounding ecosystem (Orth et al., 2020). The program included a large-scale seed restoration effort, where 74.5 million seeds were collected using hand and mechanised methods. These were broadcast into 536 individual restoration plots totalling 213ha. The areas have expanded since and so far resulted in a total of 3,612 ha of the vegetated bottom, from virtually no coverage before the restoration. The combined efforts by academic, non-profit and citizen groups stand as a beacon of hope for how Scotland can restore the extensive historic loss of seagrass. It is one of the more successful marine restorations for seagrasses and rivals other large-scale marine restorations in terms of scope, rapidity, dedication, and organisation. Orth et al. (2020) state the success of this restoration stems from several sources: directly from the large-scale seeding efforts over time and indirectly through positive feedbacks that promoted resilience and recovery.

6.2.4 Relevant Projects Focused on Other Features

Experience gained from other similar habitats / species was not considered for seagrass since sufficient experience was available that related specifically to this feature.

6.3 Management

6.3.1 Consenting and Policy

Seagrass restoration (of *Zostera*) is considered in its infancy in the UK compared with other nations, such as the US and several nations in Europe (e.g. Sweden, and the Netherlands) and in Scotland, limited restoration progress has been made. As a result, management and policy measures require adaptation to develop appropriate best practice guidelines and a policy framework that reflects the requirements of seagrass restoration / enhancement projects in Scotland. As a proposed Nature-based Solution (NbS) to climate change policy, the process within the devolved governments of the UK to support restoration is presently not fit for purpose. More information on seagrass extent and distribution would help inform future restoration projects.

In Scotland, seagrasses are a PMF, a UK BAP habitat, an OSPAR threatened and declining habitat and are listed under Annex I of the Habitats Directive. Currently, seagrass beds are protected in 30 MPA locations around Scotland (see the 2018 report to the Scottish Parliament on the MPA network). The marine licensing regime provided under section 21(1) (item 6) of the Marine (Scotland) Act 2010, may regulate the removal of seagrass in those cases where a vehicle, vessel, aircraft, marine structure or floating container is used to remove the seagrass from the seabed. Marine Scotland highlighted that applicants must provide an assessment of the effects of their proposed activity in support of their application. This may involve the collection of baseline data and studies to assess the effects (see Scottish Government strategic environmental assessment of wild seaweed harvesting). However, proposals will be considered on a case-by-case basis. As previously noted, any activity on the seabed will require a lease from CES. However, it should be noted that a lease would likely be considered on a case-by-case basis, with large scale projects potentially requiring a licence. Both NatureScot and MS-LOT should be contacted within the early stages of any proposal to ensure all options have been considered. If a project is considered exempt, an exemption form may be required; and part of the process would include evidence that the applicant has been in contact with NatureScot to assess the biodiversity implications (e.g. if in a protected / designated area). Licencing may also depend on any structures onshore (e.g. seed container / growing facility) and any potential discharge to the sea etc.

6.3.2 Biosecurity

Biosecurity is a recognised risk in seagrass restoration schemes, particularly with respect to the transplanting of plants and also through seed planting. Seeds at Swansea University have been washed in fresh seawater and low concentration of hydrogen peroxide to reduce the presence of associated organisms. Biosecurity is a fundamental element of proposal consideration and biosecurity planning needs to consider best practices for enhancement / restoration. Natural Resource Wales (NRW) required Seagrass Ocean Rescue to treat / sterilise all seagrass seeds prior to placement to prevent the colonisation of INNS species in Dale Bay (see Seagrass Ocean Rescue Project FAQ) however this practice could potentially be detrimental to the seagrass microbiome that likely travels with the seeds. Practice around seed translocation varies between the devolved nations. For England and Wales, there is some movement of seeds between sites due to existing data indicating limited genetic population variability between sites. Work is underway in Scotland to assess the population genetics of existing beds and determine whether translocation would negatively impact the existing diversity (comms. Dr Richard Lilley). Therefore, practices vary between projects from no or little consideration, through to sterilisation of all seeds before planting on a new site, as carried out by Project Seagrass. Outside of the UK, there has been some examination on the movement of seedling e.g. Denmark and Sweden, but no specific records of mechanisms to reduce biosecurity risk have been found. However, the risk is somewhat reduced as a result of donor and recovery sites often being located close together to allow for easy transfer.

6.3.3 Genetics

Experimental evidence on the resilience of seagrass systems indicates that enhanced genetic variability benefits resilience. Given the continued low levels of genetic variability found within English and Welsh meadows and the known extensive loss of UK seagrass, it is likely that isolated populations do now possibly exist and the enhancement of their genetic diversity will be important for the continuing resilience of seagrass in the face of a changing climate. Initial indications from the genetics studies being conducted by the RBGE indicate that some isolated populations may exist but these are limited. This work will be important to place Scottish seagrass in context with previous assessment of local genetic structure and connectivity of Zostera marina in northern Europe (Martínez-García et al, 2021).

Impacts on genetic diversity and connectivity during seagrass schemes may result from translocation, e.g. from east to west coast Scotland; as well as certain activities on-site, e.g. recreation, altering the natural genetics. However, Kendrick et al. (2012) note that genetic differences between seagrass populations (e.g. *Z. marina* and *Z. noltii*) showed limited differences regionally. Ecological studies of *Z. marina* in the US recorded genetic differences between intertidal and subtidal zones and between the False and Padilla Bays (Ruckelhaus, 1998), with effective migration of seed dispersal between the two bays (14 km apart). The importance of using local gene pools has been highlighted by Olsen et al. (2013), with genetic differentiation between *Z. marina* populations six times higher between Norwegian fjords than within fjords. However, Reynolds et al. (2012) suggest seagrass restoration that achieves high levels of genetic diversity will be more successful and will create more resilient seagrass ecosystems where plants survive longer, reproduce more rapidly, more quickly increase in density, and provide more ecosystem services. This is also supported by van Katwijk et al. (2009), which states that suitable gene characteristics for long-term survival can be achieved by transplanting genetically diverse donor material to be able to adapt to environmental changes and avoid inbreeding.

6.4 Guidance

A review of the primary guidance to inform the enhancement of seagrass habitats is provided below.

6.4.1 Scotland

The Scottish Code for Conservation Translocation is the framework upon which seagrass restoration proposals have been assessed to date, whether proposals are for seeds to be planted or adult plants transplanted. However new guidance is in development for seagrass restoration and enhancement in Scotland, forming the most advanced Scotland specific guidelines out of the four targeted features within this project. Much of NatureScot's work has been informed by a recent Swedish handbook on the ecological, political and economic background for restoration (Moksnes et al., 2021) which was translated into English to inform seagrass restoration activities in the UK and beyond. NatureScot has since developed a Scotland seagrass restoration handbook and guidance document in collaboration with Marine Scotland and Project Seagrass (in draft, aim to publish 2021). With a focus on subtidal habitats, this aims to provide background information, regulatory considerations and monitoring / research guidance in one place to ensure projects are evidence-led (suitable location, method etc.). It also addresses evidence gaps on e.g. habitat suitability, genetics and biosecurity. NatureScot has also started to monitor physical parameters at seagrass beds around Scotland (e.g. temperature and light) to help guide site suitability requirements.

6.4.2 UK

UK wide guidance is currently being developed by the Environment Agency, ZSL and Portsmouth University (contracted to bring guidance together) with NatureScot, Swansea University and Project Seagrass engaged in the process amongst others.

6.4.3 International

NatureScot does currently advise some applicants to consider EU guidance, e.g. concerning areas of variability in a project. As noted above, there is a lot of technical information on seagrass restoration / guidance in Sweden and as a result, the handbook (Moksnes et al., 2021). However, whilst the guidance recommends transplanting adult plants, a UK seed-based method has been developed since the publication of the Swedish guidance. The main difference when considering the Swedish manual with regards to Scottish projects is concerned with genetics and policy, otherwise, it is the same species and much of the guidance is applicable.

6.5 Appraisal of Lessons Learned to Inform Framework

Whilst a detailed review of lessons learned from case studies is provided in **ANNEX 4**: Detailed Case Study Review, highlights raised in guidance material and strategic reviews specific to seagrass are listed below.

6.5.1 Site selection

The location of a seagrass enhancement project is key to ensuring that the supporting habitat and conditions are suitable for supporting seagrass beds. Areas that have previously supported seagrass beds may have changed to an extent that any habitat enhancement work may be too costly or impractical to reverse to support seagrass beds. The best approach is site selection suitability modelling followed by detailed site assessment and pilot studies. Poor site selection could not only mean wasted time and money but may pose a risk to biodiversity and ecosystem functioning.

6.5.2 Evidence base

Projects will need to assess the nuances and site-specific conditions of potential projects to maximise success. Accurate information or data on historical changes are useful to understand the stressors and threats in an area that could affect enhancement. Data detailing persistence, loss, gain, or recovery of seagrass beds, and environmental drivers affecting their past, present, and future potential distribution, such as light, sediment, temperature and nutrients, will allow an understanding of the suitability of conditions to support seagrass enhancement (van Katwijk et al., 2016). In practice this level of data is rarely available and often projects will need to be developed to fill local data gaps.

One issue presented by seagrass enhancement is the complete loss of habitat in the past due to a change in environmental dynamics or anthropogenic activities, thereby losing the conditions necessary for their growth, even where there were extensive beds in the past. Also burrowing of infauna such as lugworms (*Arenicola marina*) may reduce seagrass density and biomass, by disrupting the root system, i.e. bioturbation, as recorded for *Z. noltii* in the Wadden Sea (Philippart, 1994).

A key barrier restricting the success of seagrass conservation and restoration is the lack of understanding of ecological feedback mechanisms (Maxwell et al., 2017). Feedbacks between seagrass, other organisms and abiotic conditions can be important for the stability and resilience of seagrass ecosystems. Additionally, the loss of seagrass can impact all trophic levels, due to feedbacks and interactions between seagrass and local environmental conditions (Gutíerrez et al., 2011). The interactions between seagrass and local environmental conditions can result in non-linear relationships between increasing pressure and ecosystem responses (Maxwell et al., 2017). Seagrass meadows may be able to buffer environmental stress to a certain level, but that the capacity of feedbacks to stabilise the ecosystem may be lost beyond this threshold, resulting in ecosystem degradation (Carr et al., 2010).

6.5.3 Methodology

There is no one way to restore seagrass meadows, just an emerging set of ‘good practices’. Broadly seagrass restoration falls into two techniques, restoration via the use of seeds, or via transplantation. However, the methods deployed will depend on a variety of factors, from seed availability, to available labour. In Sweden, local ‘Regime Shifts’ have prevented natural recovery and restoration of lost eelgrass beds along the Swedish west coast (Moksnes et al, 2018) and the short growth season in high latitude environments pose challenges for eelgrass restoration, particularly in areas that receive little light due to e.g. depth or reduced water quality conditions. (Eriander, 2017).

If following the ‘seed method’, results suggest that flowering shoots should be harvested when >50% of the spathes have developing seeds, and that shoots should not be stored longer than 40 days in tanks to obtain an optimal release of viable seeds (Infantes and Moksnes, 2018). In North Wales, Project Seagrass time their seed collection in Porthdinllaen for the first two weeks of August to coincide with this harvest window. However, anecdotal evidence from current Project Seagrass projects in the Solent and Loch Craignish suggest there is variation across sites with southern beds maturing earlier than northern beds.

Critically for large-scale restoration, the collection of seeds for manual planting at regular spaced intervals away from existing beds ensures reduced competition with existing vegetation. Such competition can be a factor compromising seedling survival (Johnson et al, 2020).

If adopting a transplanting method, then modelling (e.g. Adams et al, 2018) suggests that mimicking key emergent traits successfully simulates this positive density-dependent facilitation, thereby increasing growth and survival of isolated transplants and enhancing restoration yields (Temminck et al, 2020). However, yet again this will be site specific, with the success of *Zostera marina* transplant correlating with sediment type (success was positively related to the air-filled porosity of the substrate media and were negatively related to the organic matter content (Xu et al., 2018)).

Due to the number of projects focusing on seagrass restoration and habitat enhancement, a range of novel technologies have developed to help reduce cost and time resource requirements, and to facilitate the scaling up of small-scale projects (Zan et al., 2020). These include buoy deploying seedlings where reproductive shoots are suspended above meadows to increase seeding(REF); dispenser injection seeding whereby sediment and seeds are mixed and dispensed into sediments using sealant guns (REF); anchored shoots using iron nails, artificial in-water structures to anchor and protect shoots; and use of aquaculture systems as seagrass nurseries. In the latter case, Swansea University and Project Seagrass have carried out trials in collaboration with WWF for mechanised collections and a seagrass nursery, with funding to trial seed injection in 2022. However, NatureScot currently advises against the use of mechanised approaches due to the lack of robust data on the impact of such techniques on the donor beds and existing natural habitats.

Due to the wider understanding of seagrass ecology and biological and physical environmental parameters in some areas, there are also opportunities for developing environmental engineering projects. These may be used to enhance local conditions and habitats to increase restoration success, albeit not in Scotland where information is lacking. However, the application of ecological engineering principles can in theory assist with integrating enhancement projects into coastal development or remediation work. This would be relevant where the conditions to encourage settlement and establishment are included in development design or can be developed as a standalone enhancement project in its own right.

Whilst there is a wealth of experience to draw on when developing an enhancement strategy in relation to seagrass beds, many of the approaches deployed globally may not necessarily apply in Scottish coastal waters and to date there are no seagrass restoration monitoring programmes in Scotland. Care will need to be taken to ensure that the final measures will be appropriate for the specific site and project objectives as there is no 'one size fits all' solution. Whilst data from other parts of the UK may be useful, caution should be applied when developing site-specific enhancement projects to maximise efficacy. For example, if seeding, then dispersal mechanisms may have to be considered regarding specific tidal and metocean conditions, particularly in shallow areas (Eriander, 2016; Moknes et al., 2021; Tan et al., 2020).

6.5.5 Management

Suitable planning from the outset is noted to be of significant benefit to seagrass enhancement projects, taking into account what the follow on considerations should be in terms of techniques or practices to be implemented. Strategic prioritisation of efforts has been developed which recommends the initial focus to be on the original stressors, whether to mediate or remove the stressor, whether the environment is altered too much, as well as historic changes to habitat area and environmental drivers (Tan et al., 2020). An understanding of the environmental pressures that resulted in the loss of seagrass extent will be required where possible to correctly plan a habitat enhancement project, though this will be a challenge in many cases when the cause and effect relationship cannot be determined. Good planning and baseline measurements supported by habitat suitability monitoring is key to this process. Confirmation that the pressure has been removed or adequately managed and reduced will be required to confirm the area is suitable to enhance the habitat and promote recoverability. Direct impacts from human activity include, but are not limited to fishing, aquaculture, boating and associated anchoring, and habitat alteration (dredging, reclamation and coastal construction).

Campbell (2002) also set out a framework for developing a successful habitat restoration framework that can assist with addressing these aspects through the application of a series of decision-making flow charts.

There have been many small-scale restoration trials showing success around the globe. However, the challenge remains to translate small-scale success into large-scale restoration programs. Larger projects require long term commitment and collaboration from a number of stakeholders including local communities, NGOs, government and project partners. Along with the often high labour costs associated with implementation, financial challenges exist from the need to ensure propagation and long-term establishment, repeated planting efforts due to losses and a long term monitoring strategy to inform adaptive management measures. As such long-term planning at the start should take into account what is realistic and feasible in terms of scale and longevity.

6.5.5 Monitoring

Long term monitoring data prior to enhancement and following restoration or enhancement work is often lacking. Data that addresses and reports on the rates and patterns of seagrass loss, likely drivers of these losses, identification of potential restoration sites, and monitoring the success of the intervention is not routinely available. Long term monitoring programmes can often cost more than the enhancement or restoration work itself meaning there is often a lack of data. However, this information is required to confirm the efficacy of restoration methods and can also be used to make adaptive management decisions. (The fundamental role of ecological feedback mechanisms for the adaptive management of seagrass ecosystems is provided by Maxwell et al. 2017.)

Unfavourable conditions include continuous sediment resuspension and high turbidity, lack of stable sediments for seedling growth, and strong wave action that damages or uproots plants (Maxwell et al., 2017). Most seagrass monitoring programmes already include biotic as well as abiotic components but with the abiotic variables representing the conditions of the coastal area in general, and not measured at the scale of the seagrass meadow, which should be included (Maxwell et al., 2017).

6.5.6 Engagement

Stakeholder engagement is noted to be critical and stakeholders should be engaged wherever possible, regularly from the start and throughout project development, with stakeholders ranging from local communities, local and national NGOs, and government bodies. Where stakeholders' buy-in determines the success of a habitat enhancement project (most if not all cases), early engagement should aim to ensure that they are willing to engage, assist and contribute. In this way, local stakeholders can develop a sense of ownership with projects that can add to the long-term sustainability of a project through community involvement. This has been enhanced through community funds in some cases, e.g. an award provided by Project Seagrass to fishermen to help engage, one form of community engagement to involve 'citizen scientists'.

Early engagement with communities and stakeholders is key and could assist with reducing monitoring costs through the use of appropriately trained volunteers to assist with monitoring. In the UK SeaSearch is a good example of long-term data collected by 'citizen scientists' that could be used as a model to assist in the development of monitoring programmes.

6.5.7 Benefits

The key benefit noted in the literature includes the promotion of positive biological interactions with other species (Tan et al., 2020).

6.5.8 Risks

Seagrass restoration projects can be costly and time-consuming particularly where they are developed on a large scale. Transplantation of shoots can require a lot of time resource and careful handling, meaning that a large coastal enhancement or restoration project could require significant funding. Whilst seeding can reduce costs of collection and deployment, the establishment success of such an approach will be lower (Eriander, 2016; Moksnes et al., 2021). In Scotland, there is currently no facility with the appropriate facilities aligned to enable seagrass restoration at scale. This is a need that requires investment in facilities aligned to oysters and other marine habitat restoration. Any removal of seeds or shoots from existing seagrass meadows must also be carefully managed to ensure there is not an impact on the sustainability of the existing meadow. Impacts on established and healthy meadows may undermine the aims of any new project.

7. SALTMARSH

7.1 Overview

Restoration of saltmarsh, to mitigate historical and ongoing losses of habitat, has been progressing since 1991 in the UK, with most efforts focused on managed realignment, i.e. the landward realignment of coastal defences and subsequent tidal flooding of reclaimed land (Burden et al., 2020) and conservation grazing management to improve the condition of existing saltmarsh through agri-environment schemes to potentially counteract biodiversity loss as a result of grazing livestock (Mason et al., 2019). Saltmarsh enhancement and restoration to date have typically depended on coastal engineering and construction works to create the right conditions for saltmarsh habitat. They are also being increasingly considered as an alternative and NbS to significant coastal engineering schemes due to the escalating building and maintenance costs. However, these may still require small engineering works.

For saltmarsh, ‘stacking’ of key benefits and ecosystem services e.g. flood protection, habitat creation, carbon storage and sequestration and recreation, make them potentially attractive projects as NbSs. Saltmarsh projects are often driven by land management as well as adaptation and resilience to climate change. Most saltmarsh enhancement is managed realignment which generally involves inundation of seawater to form or re-establish the habitat and does not generally require seeding as propagules are generally available from adjacent and existing habitat (though a few experimental projects have, see below) and rely more on engineering interventions or long-term natural change/regeneration.

7.2 Projects

NatureScot has been involved in one of three Scotland saltmarsh schemes, as detailed below.

7.2.1 Scotland

The Green Shores Project is a long-standing partnership originating from the University of St Andrews to restore saltmarsh in the Firth of Tay and Eden Estuary and in the Dornoch Firth on the east coast of Scotland, now being led by Green Solutions. It is a long-term project that began in 1999 with the Eden Estuary project which focused on translocation and restoration of saltmarsh, with success to date. The estuary had extensive saltmarsh habitat, however, the development of an air base and golf links led to the loss of the upper marsh zone due to subsequent *ad hoc* coastal defences that were constructed, including soil and turf embankments, low cliffs of rubble and inorganic waste, and gabion walls (Maynard et al., 2011). The Eden Estuary project component was considered more of a trial with a very gradual application, with the planting of saltmarsh as the sediment could not maintain seedlings naturally. Restoration efforts within the Firth of Tay and Eden Estuary have been implemented to mitigate degradation and since 2000, Maynard (2014) has been utilizing a direct transplantation approach. Sea clubrush (*Bolboschoenus. maritimus*) plants were harvested from donor marshes within the estuary and transplanted onto selected bare upper mudflat sites to encourage the spread of existing marsh as well as produce new areas (Taylor et al., 2019). The Green Shores Project is the only project NatureScot have been directly involved with, providing key funding (Saltmarsh in the Fringe 2014-2016) and advice.

Other projects in Scotland include the Nigg Bay Coastal Realignment Project (Meddat Marsh), within the Cromarty Firth, which was breached in 2003, removing the engineered flood protection in place since the 1950s. RSPB purchased 25 ha of land behind the 1950s seawall that was unable to prevent the tidal flooding of the reclaimed land. The scheme was led by RSPB (who have a Nature Reserve on-site) and focused on restoration. It provides some useful lessons learned to inform this project (Chisholm et al., 2004), as the Nigg Bay project was the first of its kind in Scotland and therefore there was no experience of the consents or the processes required for securing those consents. The following regulations were required for this project: SSSI consent (Wildlife and Countryside Act 1981); Appropriate Assessment (Habitats Regulations); Consent for coastal protections works (Coastal Protection Act (1949) part I (coastal protection)); and a FEPA licence (Food and Environment Protection Act 1985). An Environmental Impact Assessment (EIA) was not required for this project; however, the RSPB commissioned a Design and Impacts study, which included modelling and various realignment design scenarios (Elliot, 2015).

There are three projects on the Firth of Forth, including Skinflats (RSPB), Kennet Pans (both managed realignment) and Black Devon Wetland regulated tidal exchange, as identified on the Online Marine Registry (OMReg) Habitat Creation Scheme Database, as well as Montrose Basin, a very small 0.3 ha managed realignment project.

7.2.2 UK

There are more than 70 coastal habitat creation case studies in England with a few in Wales which vary from managed realignment to beneficial use of dredged sediment or unmanaged realignment, as logged in the OMReg Habitat Creation Scheme Database**Error! Bookmark not defined.**. Managed realignment projects include Paull Holme Strays, Medmerry, Steart Coastal Management and Northey Island. The Paull Holme Strays Managed Realignment project has created 80 ha of intertidal habitat including 30 ha of saltmarsh. The project is part of the Humber Flood Risk Management Scheme and was designated a SAC following completion of the successful project. The Medmerry Managed Realignment project is the only open-coast managed realignment in the UK, the project aimed to provide coastal flood protection and to create a large expanse of coastal habitat. The Steart Coastal Management project is one of the largest coastal wetland creation projects in the UK, creating 262 ha of intertidal habitat. The largest saltmarsh restoration project in the UK is the RSPB Wallasea Island Wild Coast project on the Essex coast, which aimed to transform nearly 800 ha of farmland back to wetland habitat by the end of 2018, approximately 400 years after reclamation (Burden et al., 2020). Of the land reclaimed 321 ha will be saltmarsh habitat. Restoration of fringe saltmarsh is also starting to be considered as a natural solution to flood protection and wave attenuation along estuarine foreshores. In Wales, Cwm Ivy marsh was flooded in 2014 when a sluice gate gave way under pressure from floodwaters causing the sea wall to fail. As part landowners, the National Trust's 'Shifting Shores' report coastal realignment was allowed to happen as naturally as possible changing habitats from freshwater to saltmarsh. Three years after the breach the marsh was fully exposed to regular tidal inundation with recognisable saltmarsh plant and animal communities.

7.2.3 International

Many of the USA's tidal wetlands have been restored for the benefit of waterfowl, shorebirds and other wetland-dependent plants and animals since 1997, through the efforts of the Department of Energy and Environmental Protection's Land & Water Resources and Wildlife divisions. The Department of Energy and Environmental Protection, in conjunction with many project partners, has completed more than 70 tidal flow restoration projects (over 1700 acres) including for example the Tidal Wetlands Restoration Project, Long Island Sound, Connecticut. Key to the success of this project was the identification of key ecosystem targets and indicators used for projects across individual schemes throughout the project ensuring lessons learned were transferable. These indicators were based on ecological and social metrics underpinned by sound science rather than policies, therefore giving resilience to changing priorities and ensuring consistent and long-term monitoring. The introduction of key legislation for the rehabilitation and restoration of degraded tidal wetlands, and established requirements for organisations to minimise adverse impacts to coastal resources, including tidal wetlands, in their decision making.

The Cheverie Creek Salt Marsh Restoration Project was the first restoration undertaken in Nova Scotia Canada, undertaken between 1999 and 2005. Originally a pilot project, it aimed to restore tidal flow to Cheverie Creek, improving the hydrologic integrity of the site, increase bird and fish populations and enhancing the saltmarsh habitat existing at the site and increasing the extent of saltmarsh habitat (30ha) (see project factsheet). As this project was the first in Nova Scotia, it required actively networking with government agencies and other restoration practitioners in order to develop a protocol, build relationships and earn support for future projects. Moreover, the project team worked closely with the local community and implemented a number of educational programs in order to inform the public about the importance of saltmarsh ecosystems and directly involve the community in the restoration process. Post restoration long-term monitoring has taken place for seven years (2005-2011) after the completion of the restoration project. Monitoring has focused on the physical and biological components of the Cheverie Creek system (both before and after restoration), as well as those of the Bass Creek reference site, in order to record ecological changes and habitat / species responses to restoration.

This project set out the groundwork for future restoration efforts by filling in some of the gaps in knowledge and skills that were existent in this field. There was a lack of data on the extent and condition of saltmarshes and their potential for restoration; there was little information and technical expertise for saltmarsh restoration in Canada, and there was a lack of clarity about the roles and responsibilities of practitioners and the regulations and permits pertaining to saltmarsh restoration. This project also helped draw attention to the imperative for saltmarsh restoration in the Bay of Fundy.

7.2.4 Relevant Projects Focused on Other Features

Experience with other similar habitats / species was not considered for saltmarsh since sufficient information was available that related specifically to this feature.

7.3 Management

7.3.1 Consenting and Policy

Saltmarsh realignment / restoration has been ongoing in Scotland for a few decades. However, as stated above, several of the projects were the first of their kind, and therefore result in a lack of appropriate policy guidance. In Scotland, SEPA issues licences on activities that may cause an impact on wetlands including saltmarsh and an assessment of the impact is made as part of the licensing or planning application. Saltmarsh is protected through legislation and regulatory mechanisms established under the Water Framework Directive, Nature Conservation (Scotland) Act 2004 and the Habitats Directive, as well as the Flood Risk Management (Scotland) Act 2009 and the Coast Protection Act 1949 regarding coastal management and flood risk management. Saltmarshes are also identified as a priority habitat under the UK BAP, with five Local Authorities in Scotland having completed Shoreline Management Plans, as for Angus, Ayrshire, Dumfries and Galloway, East Lothian, and Fife. Any works taking place below MHWS may require a marine licence. Should a marine licence be required, Marine Scotland highlight that applicants must provide an assessment of the effects of their proposed activity in support of their application. This may involve the collection of baseline data and studies to assess the effects. As noted previously in a lease may be required from CES.

7.3.2 Biosecurity

Saltmarshes may be vulnerable to the introduction of INNS which threaten native species; however there have only been a few cases to date in the UK concerning mitten crab (*Eriocheir sinensis*) burrowing into creek banks and causing erosion; and possibly also *Spartina anglica*, though this is generally accepted as part of the native flora now. Therefore, a biosecurity plan is needed to mitigate risk, as supported by the Scottish Invasive Species Initiative. Protocols may include a requirement to e.g. check, clean and dry all equipment entering or leaving the area to prevent eggs, spores and sediment from being transferred between sites during translocation. Also recommended is natural colonisation prior to planting and transplantation between sites close together to prevent genetic differences (Defra and Environment Agency, 2007a). Consent is also required from NatureScot for the introduction of a new species. Relating to such risks, the need for appropriate species selection has been identified for the Eden Estuary scheme (Maynard, 2014). In the rest of the UK, full biosecurity plans are in place for protected areas such as the Solway Firth, Cumbria (Solway Firth Partnership, 2015) and Erme Estuary, South Devon (South Devon Area of Outstanding Natural Beauty Estuaries Partnership, 2017).

7.3.3 Genetics

Although genetic diversity is considered an important aspect to consider in restoration ecology, it has gained little attention within the scope of saltmarsh restoration schemes across North-West Europe (Rouger, 2014). Genetic diversity in foundational plant species is critical for species resiliency and ecosystem processes, both of which contribute to restoration success (Tumas et al., 2019). Whilst restoration schemes that allow seawater to inundate a previously embanked area may result in natural saltmarsh colonisation, ongoing monitoring of plant species diversity or functional characteristics has shown that saltmarshes rarely reach the state of a natural saltmarsh ecosystem (Rouger, 2014). This may be because native plant restoration success is dependent on the genetic composition of the source material, specifically the amount of genetic diversity and genetic similarity to the restored area (Tumas et al., 2019). The Saltmarsh Management Manual (Defra and Environment Agency, 2007a) states that as far as possible, plant species selected should represent the natural species assemblage for the area, in order to avoid the introduction of non-native species and problems with species competition; thereby maintaining the biodiversity of the site. Ideally, transplants should be taken from donor sources as close as possible to the intended receiving area, since minor genetic differences may alter a plants ability to withstand particular environmental conditions.

7.4 Guidance

A review of the primary guidance to inform the enhancement of saltmarsh habitats is provided below.

7.4.1 Scotland

There is no comprehensive guidance available for the restoration or habitat enhancement of saltmarsh habitats that is specific to Scotland. However, the two key projects in Scotland that NatureScot have been involved in (Eden Estuary / Dornoch Firth) provide a basis to guide future work. NatureScot is also one of a suite of partners involved in Dynamic Coasts which is based on research to transform understanding of climate change (both a backwards and forwards look). Outputs include guidance, detailed resilience plans for key sites, as well as a map and spatial database of natural coastal defence features. One particular output of note includes coastal change information to plan for development and infrastructure around the coast (NatureScot, 2017). This provides guidance on how to include coastal change in projects; and reference to Local Development Plan policies and National / Regional Marine Plans. Case study applications provide useful insights on information and decisions to consider, barriers and solutions, the most beneficial design and adaptive measures to consider in planning conditions.

The current Coastal Demonstrator project, 2021-2023, is aimed at optimising NbS with investigation and demonstration of the optimised techniques in the field, carried out by the West Sands Partnership. This project will produce an optimised plan, supplementing localised actions through recommendations of Dynamic Coast. This will cover sand dune, saltmarsh and intertidal habitats within the Eden Estuary and West Sands at St Andrews, aiming to maximise benefits for biodiversity, management of flooding and coastal erosion risk, and carbon sequestration.

7.4.2 UK

The UK is now in its 30th year of saltmarsh enhancement projects and has a wealth of experience to draw on. The Saltmarsh Management Manual published by Defra and Environment Agency (2007a) provides detailed guidance on how saltmarsh conditions should be established and the process for developing the most appropriate programmes for management based on site-specific factors. The UK & Ireland Saltmarsh Restoration Handbook is currently in preparation and will be published in 2021. There has been input from all four devolved nations and Ireland. The Handbook will describe all types of saltmarsh restoration techniques, provide guidance on target setting, success criteria, project timelines, licencing and policy considerations and post-development monitoring.

This new UK handbook will supersede the earlier Saltmarsh Creation Handbook: A Project Manager's Guide to the Creation of Saltmarsh and Intertidal Mudflat (Nottage & Robertson, 2005). This has to date provided guidance on coastal saltmarsh and intertidal mudflat restoration and creation to support the planning and delivery of such schemes. The handbook covers practical issues arising in the project planning phase. The handbook also addresses site selection, project and management plan design, funding considerations, the regulatory framework and the process of EIA, as well as the practical techniques available to restore and create saltmarsh.

7.4.3 International

In the 1990s, saltmarsh enhancement and restoration in the UK were first guided by work in the USA which had a more established practice at the time. However, this did pose issues given the very different substrate in the UK which is mineral-based (compared to high organic-based content in the USA). Nevertheless, there are a number of publications that detail saltmarsh management measures in the USA. These have a greater focus on reviewing existing management practises over the development of effective future management practices (Borde et al., 2004; Niedowski, 2000).

7.5 Appraisal of Lessons Learned to Inform Framework

Whilst a detailed review of lessons learned from case studies is provided in **ANNEX 4**: Detailed Case Study Review, highlights raised in guidance material and strategic reviews specific to saltmarsh are listed below.

7.5.1 Site selection

Globally, saltmarshes are well studied with evidence available to identify appropriate physical, biological and chemical characteristics required to promote natural functioning of saltmarsh habitats for long-term functioning and self-restoration. Saltmarsh does not conform to typical patterns of succession with the upper marsh often continuously being eroded and then accreted over time. Whilst there are often complex relationships and processes that must be analysed and understood there is a solid base of evidence to inform future enhancement projects (Borde et al., 2004; Defra and Environment Agency, 2007a).

A key consideration at the conception stage of a project is to identify the most appropriate sites for restoration or enhancement. The key steps of site selection identified in Borde et al. (2004) are as follows:

- Site assessment involving the collection of information (including desk-based or data collection) to adequately characterise or describe the past, present, and future conditions.
- Development of specific criteria for restoration sites, such as level of site alteration, proximity to healthy wetlands, and target functions. The criteria will vary depending on the goals for restoration.
- Prioritisation of approaches which could include a quantitative or semi-quantitative ranking protocol based on site-selection criteria.

The Defra and Environment Agency (2007a) saltmarsh management manual goes further than Borde et al. (2004) with a detailed description of site appraisal in order to develop a robust enhancement strategy. The Saltmarsh Management Manual has a full appendix with a site appraisal tool that effectively applies the steps above. These are outlined below:

1. Define clear management objectives.
2. Describe the baseline environment (including the pressures / issues impacting saltmarsh habitats).
3. Assess the implications of the alternative management options for the baseline environment.
4. Define the extent of any predicted impacts and actions (in environmental, social and financial terms).
5. Select the option that will best achieve the management objectives (including do-nothing), provide the greatest benefit and the best value for money.
6. Design and implement a monitoring programme.

Identifying the function of a particular saltmarsh and how different abiotic and biotic factors interact can be challenging. The function is often determined by the shelter afforded by large scale coastal morphology and so site selection is often dependent on consideration of conditions across a much larger scale than just the saltmarsh itself.

More local factors which also have to be taken into account include local tidal dynamics, sediment transport pathways, locally generated waves and the presence or absence of vegetation and vegetation type (Defra and Environment Agency, 2007a). Natural hydrology is necessary for restoring functional coastal marshes, and this is often accomplished by returning tidal inundation via a breach or removal of barriers such as dykes and levees, or excavation of fill. However, this is challenging to predict, and adequate baseline data is required (Borde et al., 2004).

Defra and Environment Agency (2007a) note that in several estuaries, particularly on more sandy substrates, there appear to be no absolute preconditions for the growth of colonising vascular plants and the subsequent development of saltmarsh. At the lower limits, saltmarsh growth is controlled by the physical conditions, and by interspecific plant competition at the upper limits. Both are subject to small scale and local variations which impact plant and animal community reassembly. The Saltmarsh Management Manual identifies a number of questions that should be answered in seeking to identify the most appropriate location and measures for habitat restoration.

Around the UK, coastal development has resulted in pressures along the landward edge of coastal habitats where there is often insufficient space to allow natural processes of accretion and erosion to take place. This ‘coastal squeeze’ will often mean that managed realignment is prohibited. Similarly, sea walls or breakwaters that can affect natural tidal processes may mean saltmarsh habitats that are more remote from coastal development can still be affected through related tidal processes. This may result in these areas being rejected for enhancement or restoration projects (Defra and Environment Agency, 2007a). It is important to identify such areas to ensure resources are not wasted where there is little prospect of effective restoration being achieved.

7.5.2 Management

When sustainably managed, saltmarshes will lead to the establishment of natural physical processes that self-manage / self-restore (Defra and Environment Agency, 2007a; Borde et al., 2004). Thus enhancement or restoration projects should aim to support and promote natural ecosystem functioning through the application of management measures aligned with natural physical processes. Defra and the Environment Agency (2007a) have carried out a detailed appraisal of management options: including managing grazing pressure, planting sedimentation fences, intertidal recharges and breakwaters, as well as hard engineering constraints, benefits, monitoring considerations and site suitability. Other key publications consider a similar range of management options (Niedowski, 2000; Bordet et al., 2004). The UK manual advises on constraints in terms of where conditions would be appropriate for each measure and monitoring considerations that should be taken into account. However, all guidance stresses the importance of ensuring that projects are appropriately planned with the most effective measure developed on a site-specific basis.

Difficulties arise in the development of effective restoration or enhancement of saltmarsh habitats due to the difficulties in understanding the complex interactions of the biotic and abiotic factors that support healthy saltmarshes. Borde et al. (2004) provide examples of management measures that appear to work in the short-term but have proven ineffective in the long term. As mentioned above, a key element in mitigating the risk of applying ineffective measures is to ensure projects incorporate adaptive management measures informed by robust monitoring and data collection.

Adequate assessment of coastal restoration requires not only a long-term, systematic approach to monitoring but also a coordinated experimental research program to explain patterns that emerge from the data (Zedler, 2001). This can often be prohibitively expensive, particularly for smaller community-based programmes. Any projects should therefore aim to be realistic about what can be achieved with the resources available.

There may be some specific difficulties associated with management measures which may add further costs, logistical challenges or feasibility issues and should aim to be identified early in project development. For example, if using dredge spoil, the spoil will need to be clean and free of chemical contaminants, procurement of vegetation may have long lead-in times, and some measures may require regular and ongoing maintenance over a significant period of time. In some circumstances costs may favour a process of managed realignment; however, as noted above, issues with coastal squeeze may render this option unfeasible. Remedial techniques (i.e. silt recharge, planting) may be cheaper initially than implementing sound coastal engineering works. However, if there is a requirement for long-term and sustained management and mitigation, this may offset the initial cost of hard engineering works. Therefore, the cost of the total project / scheme should be taken into account when developing the most appropriate strategy. Costs should also take into account ongoing monitoring which will be key to the implementation of an adaptive management strategy. This should consider the costs of initial baseline studies and ongoing monitoring and should aim to feedback into future projects by informing lessons learned.

It is useful to understand how current saltmarsh condition compares with a ‘natural’ saltmarsh in any given site. Often anthropogenic pressures have changed saltmarsh over a period of time such that identification of the original condition is not feasible. Under these circumstances, modelling can be used to understand what the original extent may have looked like. The project should aim to be realistic about what can be achieved and projects should be aiming to re-establish and support natural ecosystem functions and pathways rather than trying to achieve set metrics in the form of extent of vegetation coverage.

7.5.3 Monitoring

All guidance promotes the importance of underpinning development with robust site-specific data and monitoring efficacy through long term ongoing monitoring that incorporates adaptive management. Robust monitoring and adaptive management aim to mitigate the risks associated with the uncertainty in the implementation of management measures.

Most of the practical measures for the management and mitigation of saltmarsh habitats have been implemented and monitored in some form. Whilst there may be additional technologies that increase the speed of application of some measures, the main recent developments are applicable to the project planning stages. For example, satellite remote sensing technology can be utilised for monitoring across large spatial extents and can expand analysis beyond a single location to determine change and/or loss of saltmarsh habitat as a result of stressors, both natural and anthropogenic (Campbell, 2018). The use of satellite imagery has also been used with Google Earth Engine to develop an unsupervised decision tree classification method that automatically classifies satellite images into saltmarsh vegetation, mudflats, and open water (Laengner and van der Wal, 2020). Remote sensing may be particularly useful for understanding current conditions and historical change and can significantly decrease survey costs, as well as help, maximise the efficiency of monitoring future monitoring programmes.

Detailed numerical modelling is now available to inform physical processes that may affect the efficacy of a monitoring programme. This has never been more important with a requirement to consider climatic and sea-level changes in future projects. Numerical modelling can therefore be used at the local scale to help inform processes that could affect erosion and accretion, but also at a wider scale to determine how sea-level rises or how more extreme weather events could impact project management measures. This is particularly useful for the application of managed realignment where it often involves the landward migration of saltmarsh until it reaches a natural equilibrium.

7.5.4 Benefits

Saltmarsh provides important ecosystem services related to its flood control, coastal defence, pollution control, waste disposal and the maintenance of water quality; it also supports fisheries, agriculture, recreation and tourism. This results in a range of pressures but also provides opportunities to incorporate sustainable development into management practices which can raise awareness and help gain support for restoration or enhancement projects.

The wider ecosystem benefits for saltmarsh extend beyond ecological conditions relating specifically to the marsh itself e.g. providing habitats and roosting areas for birds, notably waders and wildfowl. These benefits can be measured by including regular monitoring of birds, for example, to assess the broader value of the project for biodiversity.

8. COASTAL SAND DUNES

8.1 Overview

As with saltmarsh, sand dune enhancement and restoration is often linked with coastal engineering and construction works. However, there is also considerable focus recently on restoring natural sand movement dynamics in coastal dunes i.e. 'working with natural processes' to restore lost biodiversity and enhance the proportion of early successional habitats which support many rare sand dune specialist species. In sand dunes, activity, therefore, focuses around management issues such as forestry, coastal sediment exchanges, as well as reversing the loss of habitat and biodiversity which has occurred through ecological degradation and on- and off-site pressures such as eutrophication. Sand dunes are exposed to several stress factors including loss or decline of traditional grazing practices, climate change (e.g. rising sea-level, changes to storminess, temperature, and precipitation), coastal erosion, atmospheric nitrogen deposition and groundwater contamination, and human-induced habitat disturbance (Burden et al., 2020; Jones et al., 2011).

Projects

NatureScot has been involved in a few Scotland coastal sand dune schemes, as detailed below.

8.2.1 Scotland

The West Sands Dune Restoration Project was initiated by St Andrews University and has been ongoing since 2000, with direct involvement by NatureScot through The West Sands Partnership. It is located within part of the Eden Estuary SSSI, the Firth of Tay and Eden Estuary SAC. The partnership was set up in 2010 after a major storm, causing coastal erosion and flooding (impacting farmland and St Andrews golf course). The dynamic nature of shifting sand dunes is used to provide a natural defence and replenish vulnerable areas of shoreline, partly through the use of fences to help trap blowing sand. The Fife Coast and Countryside Trust secured a licence to remove tens of thousands of tonnes of sand from a 'donor' site (where sediment was accreting) to re-profile the dunes. The enhanced habitat has provided better resilience and protection from flooding and erosion, with the current status reported as 'recovering' as a result of the restoration efforts. In, 2012 The West Sands Partnership agreed and published the Management Plan for the West Sands, St Andrews, from 2012-2025 (Fife Council, 2012), which includes the objective of restoring the entire dune system.

The Sand Dune Restoration Project is a trial site by the Forestry and Land Scotland (FLS) in Morrich More, Tain. The project aims to remove established trees, which were planted decades before in an attempt to prevent dune erosion. The project aims to create conditions to allow dune vegetation to recolonise the area and support the natural process to conserve the coastline. The project is also located within the Morrich More SSSI, which in turn is part of the Dornoch Firth and Loch Fleet SPA and the Dornoch Firth and Morrich More SAC.

Other sand dune enhancement / restoration projects planned in Scotland include the Uist Resilience Enhancement project located in the Outer Hebrides, currently anticipated by NatureScot. Also, see the Coastal Demonstrator project in in Section 7.4.1.

8.2.2 UK

In the UK there have been increasingly large-scale restoration activities, which learn from experience in The Netherlands and build on much smaller-scale restoration activity since the 1980s. Trial remobilisation actions at medium to large scale were conducted at Kenfig dunes in Wales prior to 2010, and more recently at Newborough Warren in Wales from 2013/14 onwards. At present, there are two major multi-million EU LIFE program funded initiatives in England and Wales, with match-funding from Heritage Lottery Fund and other sources. These are the SoLIFE project in Wales and the Dynamic Dunescapes project primarily focusing on sites in England.

8.2.3 International

There is considerable international project work in Europe, primarily in The Netherlands, but also from Belgium, Denmark and France. These have been funded via LIFE projects, but there is also activity within dune systems owned and managed by water companies or consortia (e.g. Amsterdam Water Supply Dunes) and nature conservation organisations in those countries. For the Netherlands and Belgium, there has been substantial dune restoration since the early 2000s, increasing in scale and ambition. This includes extensive management of the invasive tree species *Prunus serotina*, large scale creation of notches in leading dunes, and extensive habitat modification to create areas of bare sand. Much of this work has been undertaken in the Amsterdam Water Supply Dunes in The Netherlands (e.g. Geelen and Oosterbaan, 2020), but has also been carried out on other sites along the North Sea coast. Work in Belgium has also improved our understanding of restoration techniques in dune heath.

8.2.4 Relevant Projects Focused on Other Features

Experience with other habitats / species was not considered for sand dunes since sufficient experience was available that related specifically to this feature.

Management

8.3.1 Consenting and Policy

Notice of works should be provided to several bodies including SEPA and NatureScot. Water Environment and Water Services (Scotland) Act 2003 and associated Orders and Regulations (the Water Framework Regulations) provides the statutory under-pinning for the protection of the water environment in Scotland through river basin management planning, regulation of controlled activities and implementation of remedial and restoration measures. The Act and its associated Orders and Regulations constitute the Scottish legal interpretation of the European Water Framework Directive. The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) or more commonly referred to as the Controlled Activities Regulations (CAR) apply regulatory controls over activities that may affect Scotland’s water environment. The regulations cover rivers, lochs, transitional waters (estuaries), coastal waters groundwater, and groundwater dependant wetlands. Applicants are advised to consult with SEPA (the licensing authority) to identify if a CAR licence is necessary and to determine the extent of the information required by SEPA to fully assess any licence application.

Activities involving the construction of materials upon the seabed, with the movement of beach sediment or the installation of structures below MHWS requires a licence from MS-LOT. Depending on the scale of the proposal it may also require planning permission under the Town and Country Planning (Scotland) Act 1997 if it extends above MLWS (NatureScot, 2000).

8.3.2 Biosecurity

Sand dune sites contain extremely sensitive and specialised species which makes the effect of INNS particularly acute. As many of these INNS originate from gardens, NGOs such as Plantlife via the Dynamic Dunescapes project (Dynamic Dunescapes, 2021) are advocating for proper disposal of garden waste to prevent further spread, as well as check, clean and dry practices. A review of actions at Newborough Warren, Anglesey (Natural Resources Wales, 2013) suggests machinery can play an important role in transporting INNS to new sites, however, it does not lay out methods to prevent this. The movement of sand is often an element in sand dune enhancement. There is guidance which informs on how this should be managed from Defra and the Environment Agency (2007b) and NatureScot (2000), albeit with no reference to biosecurity. The movement of sediment for dune enhancement should also rely on locally sourced material; and similarly transplanting of plant material should rely on local dune systems or, for large projects, a commercial supplier or nursery to limit biosecurity risk (NatureScot, 2000). For the reasons outlined above, NatureScot would recommend a biosecurity plan is provided for all proposals.

8.3.3 Genetics

For dune restoration, genetic diversity may not be relevant for some schemes, e.g. reintroducing sand only from the immediate area. However, any introductions of species or genetic material should consider genetic variation. Parallel variation of genetic and species diversities across a region can also be traced back to anthropogenic alteration, e.g. increased disturbance leading to erosion and fragmentation (Frey et al., 2015). This may result in decreased population size, local extinctions, or genetic drift (Banks et al., 2013). Maintenance of genetic diversity of the restored population is equally of importance, with information on intra- and interpopulation variation considered critical (Greipsson et al., 2004). Restoration measures should also consider genetic variation in isolated populations of threatened species and the genetics of re-introduced species. This can consider establishing new populations at other sites where rare species are at high risk of local extinction and should consider the genetics of trans-located species in re-introduction programmes.

8.4 Guidance

A review of the primary guidance to inform the enhancement of coastal sand dune habitats is provided below.

Sand dune habitat provides an important ecosystem service in the form of coastal defence. Coastal erosion poses a threat to coastal developments around the UK and globally. As such coastal engineering has historically aimed to reduce coastal erosion often at the detriment to natural sediment transport pathways and consequently sand dune ecosystems. Guidance on sand dune restoration or preservation is influenced from two different policy directions: by onshore planning policy aimed at managing sand dune habitats and coastal erosion to protect coastal development, particularly taking into account the pressures of climate change, and by loss of biodiversity and ecological condition due to over-stabilisation of dune systems due to multiple causes. Both aspects have been compounded by historical on-site conservation management which has focused on stabilising any moving sand. More recent guidance instead seeks to re-establish natural processes that self-manage dune ecosystems, provide natural coastal defences and enhance biodiversity.

8.4.1 Scotland

NatureScot (2019) guidance highlights the importance of considering coastal development in the context of natural coastal change. The guidance references the Dynamic Coast: Scotland's Coastal Change Assessment project and outlines how this tool can be used to inform coastal management decisions in highly mobile environments such as around sand dune systems. Whilst the tool is predominantly to inform decision-makers in respect of coastal infrastructure development to ensure future developments are resilient to the pressures of climate change and sea-level rises it may also be useful to inform the development of projects with a focus on these highly mobile and adaptable environments.

In addition, NatureScot published guidance in 2000 (under the previous name of Scottish Natural Heritage) outlining procedures to develop dune management measures: Beach Dunes - a guide to managing coastal erosion in beach / dune systems (NatureScot, 2000). This guidance presented a route map for developing effective practices for restoring natural processes that can self-support dune systems.

Coupled with the more recent NatureScot (2019) guidance and better access to coastal processes modelling there is now a more informative evidence base on which to develop future enhancement projects.

8.4.2 UK

A revised **Sand Dune Managers Handbook** is currently being finalised as part of the Dynamic Dunescapes project (UKCEH et al., 2021). Once finalised the main online version will be available **here**. The Sand Dune Managers Handbook provides guidance on a wide range of management actions on dunes, which are relevant to restoration and all forms of habitat enhancement. This includes new guidelines on planning restoration to achieve particular target communities in dune slacks (see also Jones et al., 2021), which was previously a major knowledge gap. Other studies have assessed the ability of restoration measures to tackle adverse impacts of eutrophication, in multiple habitats including dunes, and provide guidance on how much nitrogen each management technique removes and how it improves habitat suitability (Jones et al., 2017).

8.4.3 International

Various documents provide guidance on undertaking these activities following work undertaken in the Netherlands and Belgium, e.g. Van Til et al. (2019). At European level, there is a 'roadmap' for the management and restoration of dunes to guide activities in this habitat (Houston, 2020).

8.5 Appraisal of Lessons Learned to Inform Framework

Whilst a detailed review of lessons learned from case studies is provided in **ANNEX 4**: Detailed Case Study Review and highlights raised in guidance material and strategic reviews specific to coastal sand dunes are listed below. There are examples of successful dune restoration projects in Scotland, Wales, England, The Netherlands, France, Belgium and further afield in places such as New Zealand. Development of projects to enhance or restore sand dune habitats can therefore draw on lessons learned across the globe. It is worth noting that climate, sand supply, storm intensity, the type and growth form of plant species (particularly sand-binding species), invasive species and visitor pressure are all important factors that may differ around the globe. As a result, not all techniques may be directly transferable to Scotland.

8.5.1 Site selection

Knowledge of the natural processes of accretion and erosion allows sediment schemes to be designed to complement natural sediment pathways and take advantage of sand dunes' natural capacity to self-restore (Dahm et al., 2005), whilst providing a cheaper more sustainable solution than alternative coastal engineering works (Esteves et al., 2017). The same principles apply to working with natural dune mobility within dune systems, which can become self-managing or self-regulating if implemented over larger areas, at least for a few decades.

Site selection will pose a number of challenges in ensuring that projects can be effective. Where development has resulted in irreversible changes to coastal dynamics or where there is insufficient space to restore active dune systems large-scale restoration may not be appropriate. At some coastal dune sites, the available space may be sufficient for a sustainable dune (at least in the short-medium term) but may not be adequate to provide complete protection from the worst practical erosion, including climate change effects. Ecological interventions should be considered at a landscape scale, i.e. taking into account the ecological and geomorphological status across sites in order to best plan which activity takes place at which site.

In the case of coastal erosion, in many cases, coastal protection in the form of groynes and breakwaters will have interrupted the natural processes of sediment movement that are required to support natural dune evolution. In these circumstances, it may not be possible to restore the sand-supply system to a state that is considered natural (Nordstrom, 1994). Similarly, where coastal development has occurred behind dune systems there may be reduced space in which dunes can be rejuvenated to become fully mobile. However, in larger sites, there is usually ample room to allow natural dune mobility since migration rates of mobile dunes are typically under 2 m per year over the last 150 years (UKCEH et al., 2021).

The selection of locations for interventions that will encourage natural dune mobility needs to consider the 'downwind' occurrence of sensitive features and species. For example, creating a notch in the leading dune will lead to sand burial of habitats immediately inland, and could lead to loss of mobile dune habitat for rare species such as sand lizards. Locations should be planned to avoid such conflicts.

Similarly, the inter-relationships between multiple interventions on a site should be planned to enhance each other rather than conflict. For example, since a key reason for the creation of notches is to increase local windspeeds within a site, it makes sense to co-locate notches where enhanced wind speeds will directly benefit restoration interventions within the dune system where greater sand mobility is required.

8.5.2 Evidence base

Significant developments in mathematical modelling can be used to inform the location and approach to dune management (Borde et al., 2004), taking into account long term coastal processes and met ocean datasets, with consideration of climate change scenarios. Modelling of water table dynamics may be necessary to understand the hydrological constraints on the restoration of dune slack communities and to accurately plan for specific target communities as a desired restoration endpoint (UKCEH et al., 2021).

Site-specific data is required to make the most of planning for any dune restoration or enhancement projects. For example, this may require specialist sediment tracing studies to understand the processes of erosion and accretion; similarly, hydrological monitoring is necessary to understand the pattern of within- and between-year variation in hydrological regimes in order to plan dune slack enhancements. The data will assist in developing the most cost-effective and appropriate management measures to maximise efficacy.

8.5.3 Methodology

Addressing critical coastal erosion and flood risk can be achieved through artificial dune construction or maintenance. However, guidance is moving away from this approach in The Netherlands. More natural approaches such as beach renourishment and enhanced supply of sand to key beach areas are better able to mimic natural processes, taking account of the specific coastal processes across the site. For ecological purposes, both small-scale and large-scale interventions on-site often use heavy machinery, so care needs to be taken in planning access and egress from sites, as well as how to dispose of spoil or material (scrub, invasive species, etc.), which is best removed off-site where possible.

There is a good understanding of the fundamental requirements to implement a successful dune restoration project such as ensuring natural processes are maintained and that there is adequate space to allow dunes to naturally evolve across an area of backshore with low relief (NatureScot, 2000). This is further augmented by access to high-level coastal change information where a preliminary assessment can be undertaken to understand coastal mobility and the risk of significant erosion. Recent understanding on how to design restoration of dune slacks for specific outcomes is now available (Jones et al., 2021; Dune Managers Handbook (once available)).

There may be a delicate balance between enhancing natural dune dynamics and preventing erosion of high-priority habitats, and the relative focus on these two components is likely to differ across the UK. Overall, however, there has been a paradigm shift in dune management towards working with natural processes and moving away from automatic attempts to control natural mobility.

Removal of vegetation cover is a key tool to facilitate natural dune dynamics. Examples of this type of management have proven to be effective in the Netherlands (Arens et al., 2005). However, there are complex interactions between vegetation cover, the type of species involved and dune stability which may need to be considered when tackling invasive species. Interactions between vegetation and hydrology also require a good scientific understanding in order to improve the chance of achieving desired outcomes for restoration in dune wetlands.

There can be logistical challenges with some mitigation measures and the programming of projects should take account of longer lead-in times for any equipment or materials (Dahm et al., 2005; NatureScot, 2000). For example, sourcing native dune pioneer grasses and successional grasses can require setting up nurseries with lead-in times in excess of 12 months. Access and egress for heavy machinery should consider sensitive locations within sites. Planning locations for depositing excavated mineral sand should also consider the consequences for downwind locations that will experience deposition of wind-blown sand (to achieve positive outcomes and to avoid damage to sensitive species or features). It should also consider the potential for high nutrient levels in dumped soils to adversely impact other site components.

8.5.4 Management

Removal or effective management of pressures on dune habitats ensures that restoration or enhancement efforts are not undermined. In the case of sand dunes, pressures related to beach access and human behaviour can be addressed through an effective programme of promulgating information to beach users and local communities, as well as restricting access, signage and installation of low impact crossing points. Pressures related to nutrient inputs are harder to manage since sources are usually off-site. Nevertheless, on-site measures can be effective in reducing the impacts of eutrophication, as well as avoiding pitfalls where some management techniques can exacerbate problems (e.g. supplementary feeding of livestock on site, which acts as an additional source of un-wanted nutrients). Off-site measures to reduce nutrient impacts can sometimes be negotiated with nearby landowners. Removing or reducing pressures is usually a better long-term solution than practical technical management measures to mitigate their effects and in many cases, following the removal of human pressures, sand dune systems have a capacity to self-restore (Dahm et al., 2005), although excess nutrient levels have persistent legacy effects (Jones et al., 2013).

Many established management options will also need regular and ongoing maintenance, e.g. wood, geotextile sandbags and other materials can weather quickly in hostile and abrasive coastal habitats. Again, robust planning from the outset should aim to ensure there is sufficient resource to maintain the project long term. Some restoration measures may require chemical or mechanical control of undesirable plant species, particularly those with persistent rhizomes or which rapidly establish from wind-blown seed sources onto bare sand areas.

The development of management measures should also take into account the appropriate scale of any required works. For example, in areas of open coastline coordinated measures may need to span a large area to support the natural sediment dynamics, whereas in small bays measures may be possible at a smaller spatial scale. Early identification of requirements should ensure adequate resources are secured to ensure the future sustainability of a project. Restoration measures aimed at enhancing natural dune dynamics within dune sites generally require larger-scale interventions to be more successful. However, small scale activities focused on the scale of natural blow-outs can also achieve benefits for plants, soil pH and species dependent on bare sand, depending on the context and desired outcome (e.g. Van Til et al., 2019).

8.5.5 Monitoring

As with all restoration projects, efficacy and management decisions need to be addressed through long term monitoring programmes that can inform adaptive management. The costs of monitoring projects can be significant and therefore should be planned from project inception. These should include monitoring of baseline conditions before restoration takes place, and monitoring in control areas with no restoration in order to show that subsequent changes have been due to the restoration itself, and are not due to external influences such as changes in weather patterns, rabbit grazing, human disturbance or numerous other factors.

Understanding a site's capacity for change is essential to deciding longer-term engineering options and success of dune enhancement schemes, requiring a programme of monitoring to identify site condition (ecological, hydrological and geomorphological) and specific nuances, as well as implementing a programme of adaptive management (NatureScot, 2000).

Earth Observation and remote sensing play a role in understanding and monitoring coastal dynamics. Dynamic Coasts utilised aerial photographs, LiDAR and collaborated with NatureScot to collate Pan-Government remote sensing data to include pan-Scotland surveys as part of their methodology. The remote sensing data allows the reappraisal of large sections of the mainland east coast, including the main firths and more spatially limited areas elsewhere (Fitton et al., 2017). The second phase of research (2018-2020) under Dynamic Coast includes trialling novel Earth Observation technology to improve estimates of coastal change.

8.5.6 Engagement

To promote a change to human behaviour Dahm et al. (2005) advocate for engaging local communities and establishing community-driven enhancement projects. This allows communities to take ownership and develop a vested interest in a project that can encourage long term engagement, and minimise adverse publicity. Community participation in ongoing monitoring and maintenance of works can also assist with tracking the efficacy of a project and informing adaptive management decisions. For example, the sand dune citizen science monitoring app developed in the Dynamic Dunescapes project is designed for exactly this purpose. Dahm et al. (2005) consider community involvement as one of the most important factors in ensuring the long-term sustainability of any enhancement or restoration works and presents a process for establishing community-based projects detailing when and how communities should be asked to participate and at what stage of project development. It is also useful to enhance local understanding of the ecology of dunes and how they function, which can be essential to head off adverse publicity or misunderstanding around techniques used to achieve large-scale restoration.

8.5.7 Climate change

Guidance should aim to help those involved in planning for coastal restoration projects to take account of the increasing effects of climate change and sea-level rise in the same way that onshore planning policy requires similar considerations for coastal development and infrastructure projects (NatureScot, 2019). Projects will need to consider the effects of extreme storms and ensure restoration work takes into account the risk of one-off extreme storm events that can cause a rapid redistribution of sandbanks and sediment dynamics. A programme of monitoring and adaptive management can aim to address these issues, as can the use of robust mathematical modelling work (Dahm et al., 2005). Enhancing natural dune dynamics is one way to achieve future-proofing for changing climate. Many dune features become self-managing in this context, e.g. new dune slacks behind migrating dunes automatically form at the level of the new water table. Hydrological modelling, with reference to eco-hydrological guidelines for different dune wetland communities (UKCEH et al., 2021) may be helpful to understand potential climate impacts on water tables.

9. DEVELOPMENT OF THE FRAMEWORK

9.1 Initial scoping

As an output of the review, a list of all the information and criteria that may be considered for the framework was initially compiled in a spreadsheet. These were given further sub-criteria where necessary, with supporting text on description, examples and relevant supporting guidance, grouping of all by theme. The table was considered a ‘long list’ from which to prioritise and select those that would be used in the assessment proposal form and associated guidance document.

9.3 Consultation

A two-hour workshop was carried out on 1st April 2021 with the Steering Group and wider colleagues at NatureScot, led by the GoBe team, including Herriot Watt University. This covered a variety of topics that aimed to provide critical feedback on the framework assessment form, guidance document and report recommendations.

9.2.1 Overview

A lot of the discussion of the framework involved a high-level consideration of how it is framed and presented rather than which individual criteria to include (or not). However, the discussion was guided through consideration of current issues, the proposed criteria and recommendations.

Overall, attendees agreed that the framework requires an open-ended set of questions rather than a set ‘criteria’, with the proposal outline section providing the majority of the assessment template criteria. The remaining criteria / sections were agreed to still be very useful as an internal checklist for NatureScot to guide ongoing discussions with the applicant, though some of these could be brought into the more high-level proposal outline template. Attendees agreed the essential information to ask is the ‘who’, ‘what’ (organisation, project aims and success criteria), ‘how’ (both methods and costs), ‘when’ and ‘can you’ (permissions etc.) with perhaps a three-stage process of 1) initial enquiry with essential limited information by email, 2) main proposal form with selected criteria and 3) ongoing discussion guided by remaining or a full list of criteria.

However, despite this simplified approach, it was also agreed that it is hard to know what barriers a project may meet without requesting detailed information to evaluate the important aspects to a project’s success. It is therefore critical how the questions are framed to encourage an adequate level of detail.

Some of the key points drawn out from the discussions are provided below under the various areas of consideration.

9.2.2 Proposal Outline and Objectives

A consistent concern was evident around objectives, including the lack of clarity and often only driven by single objectives in proposals. Instead, projects should be looked at from a multi-benefit Nature based Solution (NbS) viewpoint.

9.2.3 Scientific Knowledge

Concerns on insufficient scientific knowledge or baseline data were the most common discussion point, particularly around biosecurity, existing environmental pressures and their management, geomorphology, conservation goals and habitat suitability, with this potentially resulting in a lack of detail in project planning and limited consideration of the wider ecosystem. This may be addressed by encouraging a greater level of strategic thinking at an early stage, to ensure a ‘right project in the right place’ approach.

9.2.4 Project Input Required

Comments on logistics echoed earlier conversations that information is often lacking on the overall proposal outline. As part of the proposal, the applicant should also consider the impact of managing conflicting activities on the site to ensure success. Furthermore, concerns were raised around project time scales and strategy being built around funding rather than the needs of the project itself and any issues which might arise.

9.2.5 Legislation, policy, and guidance

These concerns focused on a potential lack of knowledge from the applicant on issues such as designated sites, legislation, and licensing. There was also a request for greater clarity around how or when a site might receive a protective designation/status itself because of a successful restoration or enhancement project. This also prompted questions over the current legislation and consenting process, and potential for change in the forthcoming National Marine Plan revision where strategic policies on enhancement could be introduced; and linking to upcoming Marine Scotland guidance on social and economic impact assessment.

9.2.5 Pressures and Risk

Issues have been found in providing a full assessment of biosecurity risk and impacts from pressures, particularly around how these currently impact, current management and how these will be managed going forward.

9.2.6 Climate change

Projects need to be adaptable and resilient to climate change. To ensure the long-term sustainability of a project an adaptive management approach that can respond to environmental changes should be incorporated into project proposals.

9.2.7 Data and Monitoring

The importance of gathering data on the site during the planning process was noted as good practice. Some projects have lacked clear baseline data or site-specific data collection to underpin project proposals. Site-specific data should be a requirement, as far as practicable, to support proposed future restoration work. Mapping of potential opportunities more broadly (e.g. nationally) would help this but requires further discussion within NatureScot. The NMP and regional marine plans should also help guide aspects and areas for where restoration projects may have potential. A comprehensive long-term monitoring program was also thought to be lacking in some previous project proposals.

9.2.8 Framework and Guidance Structure

Consideration of science, logistics and monitoring amounted to many suggestions and comments around the content, structure, and purpose of the enhancement framework. Multiple comments requested the framework be used to collect information rather than laying out criteria for projects to meet; another comment asked whether the framework should be approached from a risk assessment perspective. This area also broadened the discussion as to whether the framework should be broken down in to a two-stage process and what elements needed to be part of the initial contact. It was also argued that there may be constraints on some of the criteria and locational, ecological, or regulatory specific factors. Furthermore, it was suggested that there should be more focus on the citizen science aspect of projects, including community engagement and involvement strategy.

9.2.9 Communication

The workshop participants also highlighted concerns with communication. The framework needs to not overburden NatureScot staff as they respond to growing demand in applications with the creation of a framework. A clear pathway for contacting applicants concerning enhancement projects is also needed and could take the form of a website. The framework should also enable applicants to contact NatureScot early on in planning to avoid a major problem developing.

9.2.10 Enhancement/Restoration

Finally, the role of enhancement was questioned including whether it is always the best option holistically. Ecologically it was argued that conserving the natural environment we have needed to be a priority over enhancement. Overall NatureScot needs to consider whether the enhancement project proposed is the most powerful tool for meeting the objectives, with elements such as long-term management success being a key factor.

9.2.11 Actions

Whilst some elements of the workshop were already accommodated by the framework their discussion in this workshop highlighted their necessary inclusion, e.g. interaction with ecosystems and geomorphology, objectives, socioeconomics, community engagement, biosecurity, site pressure, site suitability, designations, permissions, duration, long-term monitoring, and site-specific baseline data. Some points recommended and used to improve the framework included:

- Highlight areas where supporting evidence can be uploaded to aid with application e.g. baseline data, ecosystem services, etc.
- Prioritise the essential information.
- Potentially change the phrasing of the form from ‘criteria’ to ‘information’ or similar.
- Evaluate current criteria and establish which areas might be feature or location-specific.
- Compare socioeconomic consideration criteria to the upcoming Marine Scotland guidance on socio and economic impact assessments.

FRAMEWORK OUTPUTS

As an outcome of the review and workshop, a project assessment form was developed. This was designed to be completed by those planning on developing enhancement projects in Scotland, which we envisage will initially be for one or more of the four focus habitats / species in this project but could be used for others. The form is a digestible size, posing questions to explore the most critical components of a project at the early stages. It is a means by which project proposers can engage with NatureScot so they are able to offer the best level of advice.

The form is accompanied by a full guidance document which mirrors the structure of the proposal form, with a set of eight categories as follows:

1. Project Information (feature, enhancement type, location, off-site and site process, timescales)

2. Underlying principles (primary objective, driver and funding, success criteria, scheme alternatives)

3. Site Profile (natural dynamics, activities and pressures, existing data, baseline monitoring key gaps)

4. Regulation and management (species, protected areas, activities, access)

5. Risks (biosecurity, translocation, genetics, wider ecosystem, climate change, socioeconomic, funding, mitigation)

6. Benefits (biology and ecology, socioeconomics)

7. Engagement (early engagement, stakeholder group, public outreach, communicating success)

8. Management, monitoring and evaluation (implementation, data collection and monitoring establishing success)

The framework is considered to be best supported by an iterative process of engagement during project development, where there is an initial discussion by email / telephone focusing on project information (1), followed by submission of the full proposal form and then with follow up discussions with NatureScot providing steer and ad-hoc advice.

SUMMARY AND RECOMMENDATIONS

Through a review of the literature, consultation and development of the proposal form and guidance, a number of recommendations have arisen relating to management, linking to certain legislation and policies, as well as gaps in knowledge and guidance, as set out below.

Regulators

As the number of proposals and engagement with NatureScot grows over time, a more objective approach may be required, as carried out in other countries. For example, this may include site suitability modelling and subsequent prioritisation by NatureScot or through the Marine Planning process. Overall, further research on the features' ecosystem functions and services are required in Scottish waters, particularly where there is an interest in restoring the feature as a Nature based Solution.

It would be beneficial to measure and document the scale of environmental enhancement over time to demonstrate how such projects contribute to meeting various targets, e.g. UN 2030 Decade on Ecosystem Restoration, MPA conservation objectives and blue carbon contributions to mitigate and adapt to climate change.

It is recommended that NatureScot builds on the project outcomes to influence what will be included in the Scottish Biodiversity 2030 Challenge (which will in turn be informed by outcomes of the UN Convention on Biological Diversity (COP15) in 2021).

Engagement

The success of citizen scientist monitoring programmes in the UK has been recognised through various programmes such as UK SeaSearch, the Dynamic Dunescapes Citizen Science App and NatureScot's Community-led Marine Biodiversity Monitoring Project. Such approaches are being increasingly recognised as one of the key components to success in marine and coastal enhancement projects. Although it is the responsibility of the individual projects to monitor success, projects may benefit from a similar national schemes, should one be set up in Scotland to monitor enhancement project success as the number of projects grows. This in turn could lead to supporting community involvement in such projects and raise awareness.

Ecosystem Services

Restoration and improved management of ecosystems can dramatically enhance the ecosystem services they provide. The main benefits usually come from two areas: i) improvements to regulating services (such as maintenance of carbon stocks, or increased carbon sequestration, lower flood risk, improved water quality), ii) but also improvements to the cultural services and the wellbeing benefit people get from natural ecosystems – greater opportunity to enjoy aesthetic habitats and wildlife. The wider ecosystem service benefits are not always quantified or monitored in enhancement programmes, and more emphasis could be placed on this area. A recently released Handbook for Nature based Solutions (Somarakis et al. 2019) draws on primarily European experience but contains a wealth of indicators and guidance to follow.

Climate Change

Guidance should advise on accounting for the increasing effects of climate change in the same way that onshore planning policy requires similar considerations for coastal development and infrastructure projects. For example, this would account for both one-off events such as extreme storms, e.g. that may cause a rapid redistribution of sandbanks and sediment dynamics, as well as longer-term impacts, e.g. sea-level rise, increased storminess and change in climate envelope for species. Such focus of efforts will help future-proofing for changing climate, with many coastal features becoming self-managing in this context, e.g. new dune slacks behind migrating dunes automatically form at the level of the new water table.

Native oysters

Oyster restoration is still within its infancy in Europe in comparison to the USA. Policy and management measures need to be adapted to develop appropriate best practices relevant to the needs of a project, specifically around knowledge gaps, validation of these, guidance and a methodology for biosecurity in translocation schemes. These actions will require project managers to work with relevant authorities.

Strong biosecurity measures, reinforced by scientific understanding of the vectors of disease and INNS, can be incorporated at both the project planning (specifically site selection) and operation stages; this is key to safeguarding existing disease and INNS-free oyster populations (zu Ermgassen et al., 2020a).

Protection from pressures such as fishing activity impacts on oyster restoration sites will continue to be an important focus area.

Seagrass

Seagrass restoration projects can be costly and time-consuming with the careful handling required for transplantation of shoots (yet transplantation has a much better success rate than seeding). In Scotland, there is currently no facility with the appropriate facilities aligned to enabling seagrass restoration at scale. This is a major need that requires investment in facilities aligned to oysters and other marine habitat restoration.

Seagrass restoration is considered in its infancy in the UK compared with other nations, such as the US and several nations in Europe. As a result, management and policy measures require adaptation to develop appropriate best practice guidelines and a policy framework that reflects the requirements of seagrass restoration / enhancement projects in Scotland.

Saltmarsh

Coastal development, seawalls and breakwaters act as a barrier to the landward progression of coastal habitats, impeding natural processes. Moreover, competing interests at the land-sea interface, land ownership, food security, flood defence issues, insurance, cultural and local perceptions of giving land to the sea and changing land use can make the realignment of flood defences a contentious and costly issue. The practice of saltmarsh creation and restoration is well established in the UK and across Europe with (more or less) predictable outcomes. The key factors for implementation are generally logistical, legal and stakeholder-driven. The UK and Ireland Saltmarsh Restoration Handbook (2021) deals with these issues in detail.

Sand dunes

There is substantial new guidance being developed for sand dune restoration, learning from the large-scale application of new (and established) restoration measures. This includes a UK Sand Dune Managers handbook published by Plantlife, based on UK expertise and examples, supplemented with established restoration experience from The Netherlands. A Citizen Science App for monitoring dune restoration has recently been launched which allows the public to undertake a wide range of monitoring activities in support of restoration on dunes. There may be some gaps in relation to Scottish systems, specifically the management of machair, which is not covered and might require different approaches.

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ANNEX 1: Scotland's National Marine Plan in regard to Enhancement and Restoration

Chapter 2. Marine Planning in Context - National and Regional Marine Planning

Section 2.9: This Plan sets out some guidance specifically for regional planners in Chapters 3 and 4 and at the end of each of the sector chapters. The basic legislative requirements for regional plans include:

> Stating the contribution of MPAs and other designated areas to the protection and enhancement of the region.

Chapter 4. General Policies - General Planning Principle

GEN 5 Climate change

Marine planners and decision-makers must act in the way best calculated to mitigate, and adapt to, climate change.

Section 4.19: Reducing human pressure and safeguarding ecosystem services such as natural coastal protection and natural carbon sinks (e.g. seagrass beds, kelp and saltmarsh) should be considered. In some cases, compensatory habitat creation or enhancement may be possible and should be considered as a last resort if significant harm cannot be avoided. Appropriate proactive opportunities for enhancing natural carbon sinks and allowing natural coastal change where possible should also be considered.

GEN 7 Landscape / seascape

Marine planners and decision-makers should ensure that development and use of the marine environment take seascape, landscape and visual impacts into account.

Section 4.29: In making these judgements, planners and decision-makers should have regard to the qualities of the location in question, including any designation. More generally, the siting and design of a development should take account of the local landscape / seascape character and quality. Potential effects on landscapes and seascapes, including cumulative effects, should be considered and developers should seek to minimise adverse impacts through careful planning and design, considering the services which the natural environment is providing and maximising the potential for enhancement.

GEN 8 Coastal process and flooding

Developments and activities in the marine environment should be resilient to coastal change and flooding and not have an unacceptable adverse impact on coastal processes or contribute to coastal flooding.

Section 4.37: Wherever possible, flood risk management and coastal protection solutions should work with natural processes and features, encouraging managed realignment of coastal habitats such as sand dunes, saltmarshes and mudflats. The protective role of geodiversity, geomorphological and natural features such as kelp beds, biogenic reefs and sandbanks should also be considered alongside opportunities for recovery and enhancement.

Chapter 4. General Policies - General Planning Principle: Living within environmental limits

GEN 9 Natural Heritage

Development and the use of the marine environment must:

1. Comply with legal requirements for protected areas and protected species;
2. Not result in significant impacts on the national status of PMFs;
3. Protect and where appropriate enhance the health of the marine area.

Section 4.39: Scotland’s marine natural resource, biodiversity and geodiversity is a valuable asset delivering a wide range of ecosystem services (see Annex A of the National Marine Plan) which provide a large stock of natural capital and support a variety of recreational and economic activities. Nature conservation measures play an integral role in protecting and enhancing the marine natural environment, ensuring it is healthy, biologically diverse, resilient and productive and that ecosystems continue to provide social, economic and wider benefits for people, industry and society.

Section 4.40: Marine planners and other decision-makers should act in the way best calculated to further the achievement of sustainable development and use, including the protection and, where appropriate, enhancement of the health of the Scottish marine area. The Strategy for Marine Nature Conservation in Scotland’s Seas sets out aims and objectives to achieve this. The Strategy outlines a three-pillar approach to conservation: site protection, species conservation and wider seas policies and measures.

Section 4.41: A network of well-managed marine protected areas is being established to meet national objectives and help deliver an ecologically coherent MPA network in the North-East Atlantic, contributing to the protection and enhancement of the area to which this Plan applies. The network will comprise of newly designated MPAs as well as European Sites and marine components of SSSI and Ramsar sites. The management requirements of each of these designation types must be met. These sites, together with other protected areas will make a significant contribution to the protection, enhancement and health of the marine area. Improved health of the marine environment will also lead to increased resilience of ecosystems to climate change.

Section 4.56: PMFs are species and habitats which have been identified as being of conservation importance to Scotland. Most are a subset of species and habitats identified on national, UK or international lists. They provide a new focus for marine conservation in Scotland. The list does not currently include wild bird species, which are protected under the EU Birds Directive. Impacts of development and use on the national status of PMFs must be considered when decisions are being made, taking account of the advice of Statutory Advisors. Where planned developments or use have the potential to impact PMFs, mitigation, including alternative locations, should be considered. Actions should be taken to enhance the status of PMFs where appropriate.

Chapter 11 Offshore Wind and Marine Renewable Energy, Part 4: The future

Section 11.39: The Scottish Offshore Renewables Research Framework (SpORRAn) should provide a collaborative and coordinated research programme supporting the sustainable development of marine renewable industries and better inform future marine planning and decision making for offshore wind and marine renewable energy development. A future coordinated national, regional and project-specific environmental monitoring strategy will also be useful to identify potential opportunities for enhancement and recovery of ecosystem services in the exclusion zones around offshore energy generation sites (i.e. restoration and improvement on habitats damaged during the construction process)

ANNEX 2: Other Frameworks of Relevance

There are a range of evaluation frameworks and guidance that usefully inform this project for both the specific aspects related to the enhancement of the four marine and coastal habitats, as well as informing the structure and approach adopted in offering guidance. The following examples provided below are from international sources such as the US and New Zealand. Examples include generic guidance and those specific to habitats covered in this report such as seagrass and saltmarsh.

Oil and gas industry association for environmental and social issues (IPIECA)

For details see below.

Project Stage	Use Of Mitigation Hierarchy	Questions / Issues Addressed	Mitigation Hierarchy Components
Bid	Risk Assessment	Are there any significant Biodiversity and Ecosystem Services (BES) risks in the area of interest?	Avoidance by selecting less risky areas

Project Stage	Use Of Mitigation Hierarchy	Questions / Issues Addressed	Mitigation Hierarchy Components
Pre-ESHIA (project feasibility and pre-design)	Risk Assessment	• How large is the zone of influence? • Where is the priority biodiversity and how does it interact in the landscape? • What is the approximate magnitude of BES risks from direct, indirect, cumulative impacts? • What are likely stakeholder concerns and ecosystem service dependencies? • Is there a risk of irreversible significant residual ecological impacts / risks or ones that cannot be offset? • Are there any BES ‘showstopper’ issues? • What options exist regarding project alternatives and design? • Are there less damaging alternatives/options which are feasible? • Is it likely that impacts and related risks can feasibly be mitigated? • Is it likely that site(s) can be restored? • Can no net loss (if required) be achieved in principle? • Are project dependencies on Environmental Services manageable?	Avoidance by site location
ESHIA (project design and planning)	Mitigation design Feedback optimization approach to mitigation investment Residual ecological impact assessment Restoration - options assessment and design Offsets - options assessment and design	• What are the major impacts, related risks and mitigation options? • What are the expected project impacts and their related risks? • How far can these be reduced by avoidance and minimisation? • What are the theoretical options for restoration and offsets? • What are the technically and politically feasible options for restoration and offsets? • Will these completely compensate for residual impacts? • How will restoration and offsets be implemented and monitored? • Can significant residual ecological impacts/risks be reduced further through an iterative process (iterative application of the mitigation hierarchy, examining feasibility and cost of implementing restoration and offsets)?	Avoidance by project design Avoidance by scheduling Minimisation through physical, operational, abatement controls (Restoration) (Offsets)
Post-ESHIA (construction and operations)	Performance tracking Adaptive management	• Are BES gains from minimisation, restoration and offsets meeting expectations? • Are further impact reductions possible by deploying new approaches and technologies? • How should management change if performance is not proving as effective as expected?	(Avoidance) (Minimization) Restoration Offsets

Table 2. Restoration and offsetting framework applicable to the oil and gas ESHIA (Environmental-Social-Health Impact Assessment) process IPIECA (2016).

USA national review of coastal restoration

Developing measurable criteria helps ensure the accuracy of the prioritisation process and the likelihood of success. The criteria will vary depending on the goals for restoration. The following sections show examples of restoration site evaluation criteria from the Peconic Estuary, New York Fidalgo Bay, Washington and the Columbia River Estuary respectively.

Evaluation criteria for use in selecting a restoration site at Peconic Estuary in New York, USA (Borde et al., 2004 - NOAA)

Ecological

- Lost habitat value
- Level of degradation
- Historical justification
- Proposed project size
- Habitat contiguity / adjacent land use
- Target restoration functions
- Promoting landscape habitat diversity
- Providing benefit to state-listed species
- Proximity to state / local designated areas

Logistical

- Type of ownership
- Relationship to broad planning efforts
- Current stage of planning achieved
- Committed / leverage funds
- Probability of success
- Support from community / user groups
- Level of post-restoration maintenance

Enhanced public access and awareness

- Enhancing commercial and recreational uses
- Beneficial to commercial recreational species

Evaluation criteria for use in selecting restoration sites at Fidalgo Bay in Washington, USA (Borde et al., 2004 - NOAA)

- Feasibility
- Opportunity to improve ecosystem function
- Site protection
- Potential for sediment deposition / transport processes to support sustained function
- Potential to benefit threatened and endangered species
- Probability of success
- Habitat connectivity
- Restore or replace limited habitat
- Sustainability of habitat function
- Type of habitat replacement
- Timing of implementation

Evaluation criteria for use in selecting restoration sites at the Lower Columbia River Estuary in Washington and Oregon, USA (Borde et al., 2004 - NOAA)

General Criteria

- Habitat connectivity
- Areas of historical habitat loss
- Linkages to reference sites
- Passive habitat restoration over creation
- Monitoring and evaluation
- Community support and participation

Specific Criteria

Existing conditions

- size
- complexity
- accessibility
- habitat connectivity

Potential conditions

- potential to conform to natural habitat structure, processes and functions
- potential for self-maintenance
- potential benefit to nearshore
- dependant threatened and endangered species
- potential to substantially improve ecosystem functions

Gulf of Maine Association: project planning for saltmarshes

See Project Planning - Salt Marshes

Site selection

A proposed saltmarsh restoration project should (1) be consistent with the geography and land-use patterns of the study area, (2) avoid or minimise negative impacts on nearby aquatic and terrestrial habitats, including plants, animals, and historic resources, (3) address the local community's concerns and desires, and (4) comply with federal, state, and local regulatory agency requirements and policies.

Defining project goals and objectives

Projects that lack clear goals and objectives are less likely to be successful, and it may be impossible to gauge success in the absence of a clearly defined project plan.

Baseline data collection

Detailed site characterisations are needed to formulate site-specific restoration plans and to develop success criteria for individual projects.

Funding opportunities

The cost of a restoration project depends on site-specific conditions and the proposed restoration and monitoring activities. Gulf of Main Association notes federal, state and private sources available.

Permitting and regulating considerations

Saltmarsh restoration projects require a variety of permits before construction begins. This includes permits from Government agencies prior to the scheme / project implementation. Early engagement is encouraged through contacting local, county, state, provincial, federal and tribal authorities. In Maine, the construction of any structure in, over, or under any navigable water of the U.S., the excavating or dredging from or depositing of material in such waters, or the accomplishment of any other work affecting the course, location, condition, or capacity of such waters comes under the General Permits issued by the New England District of USACE.

Restoration techniques

Restore tidal flow, removal of dredged material from marsh surface, invasive species removal.

Design consideration

geomorphic, hydrologic, and biotic factors should be considered during the design phase of a saltmarsh restoration project.

Potential obstacles to restoration

Invasive species are difficult to eradicate, contaminated sediments, destruction of new plants from animals, conflicts with surrounding land use.

Equipment sources and contacts

The Gulf of Maine Association have literature reviews and technical manuals to assist practitioners in project planning and note that several companies specialise in the manufacture and sale of environmental monitoring equipment to assist in baseline and monitoring studies.

New York State Saltmarsh Restoration and Monitoring Guidelines

A document for the New York State Department of State Division of Coastal Resources and New York State Department of Environmental Conservation Division of Fish, Wildlife and Marine Resources was published in 2000 to guide voluntary restoration projects (Niedowski, 2000). The guidance document has been designed to provide a comprehensive, accessible, and understandable source for current technical information on saltmarsh restoration and ecology, to increase the quality of restoration project planning. The guidelines attempt to provide a framework for saltmarsh restoration activities, including planning, design, implementation and monitoring. The process and consideration for restoration projects detailed in the guidance list the following:

- Planning and design phase
    - Define goals and objectives
      Ecological, economic, public benefit
    - Develop specific and quantifiable performance criteria
      Define time and spatial scale, determine targets species/habitat and ecosystem function
    - Research restoration site
      Historical condition, degree of alteration, landscape setting, hydrology, seed sources
    - Refine objectives based on-site research
    - Plan restoration project
      Cost, schedule, site constraints and technology requirements and legal restrictions
    - Obtain required permits
    - Develop a Contingency Plan for unexpected outcomes
    - Engineering designs
- Construction phase
    - Consider the effect on resources
    - Consider seasonality
    - Monitor construction activities and work plan compliance
- Assessment phase
    - Collect minimum standard baseline data
    - Tailor monitoring programme to project goals and objectives
    - Adjustments if and when required during the development
- Documentation and communication phase
  Keep records accessible and share results

Gulf of Maine Association: project planning for eelgrass

See Project Planning - Eelgrass

Site selection

It is essential to carefully consider and prioritize potential sites for eelgrass restoration. The site selection process should generate a list of sites that offer the chance for success in terms of acreage restored and the degree of habitat function restored.

Defining project goals and objectives

As with the restoration of other coastal habitats, eelgrass restoration project goals and objectives must be clearly defined and consistent. Projects that lack clear goals and objectives are less likely to be successful, and it may be impossible to gauge success in the absence of a clearly defined project plan.

Baseline data collection

Detailed site characterisations are needed to formulate site-specific restoration plans and to develop success criteria for individual projects.

Funding opportunities

The cost of a restoration project depends on site-specific conditions and the proposed restoration and monitoring activities. The Gulf of Main Association notes federal, state and private sources available.

Permitting and regulating considerations

Eelgrass restoration projects require a variety of permits before construction begins. This includes permits from Government agencies prior to the scheme / project implementation. Early engagement is encouraged through contacting local, county, state, provincial, federal and tribal authorities. In Maine, General Permits are issued by the New England District of U.S. Army Corps of Engineers.

Restoration techniques

Eelgrass beds can be restored by encouraging natural recolonization or by actively transplanting. Seeding can be used alone or in combination with transplant techniques – natural recolonisation, transplanting and or seeding.

Design consideration

transplant spacing, light attenuation, and patterns of current flow in the vicinity of the transplant site.

Potential obstacles to restoration

grazing by waterfowl, bioturbation by crabs, direct damage (dredging, aquaculture and propeller scarring), cultural sites (historic and cultural resources)

Equipment sources and contacts

The Gulf of Maine Association have literature reviews and technical manuals to assist practitioners in project planning and note that several companies specialise in the manufacture and sale of environmental monitoring equipment to assist in baseline and monitoring studies.

The Gulf of Maine Association also recognises the importance of ecological monitoring in habitat restoration. A combination of pre-and post-restoration monitoring allows an accurate assessment of a project's success. Post-restoration monitoring documents any ecological changes at the site after restoration is completed.

Coastal Restoration Trust of New Zealand Dune Restoration

The Coastal Restoration Trust has identified guidelines for dune restoration. These include consideration of impacts of carrying out dune restoration such as wind erosion or modification stabilising dune vegetation from anthropogenic activities or via animal grazing. The common elements between dune restoration projects including site consideration; plant and/or enhancement of foredune and/or backdune vegetation; earthworks; weed and pest control; and monitoring and maintenance. The guidance notes that dune restoration / management should only be considered in areas where dunes are or where historically a natural element of the coastline and there is sufficient space for the sea and anthropogenic infrastructure (e.g. roads).

Dune restoration can have a wide range of management objectives and many of these are site-specific, however, there are two broad objectives:

- Design and implement appropriate dune restoration and management works; and
- Promote a dune care ethic within the wider community, through increased community awareness and participation.

Global Peatland Restoration Manual

The Global Peatland Restoration Manual (Schumann & Joosten, 2008) provides some guidance on aspects to consider when designing a restoration monitoring scheme and noted the need for adaption depending on the individual characteristics of each project (see Table 3 below).

The Manual also provides a list of information required for restoration projects:

- Define the problem and acquire a general understanding.
- Collect sufficient baseline data to identify problems and to estimate success chances.
- Use the support of qualified technical experts, agencies, and organisations for planning.
- Identify goals and objectives.
- Focus on the restoration of a possibly self-sustaining ecosystem.
- Clarify budget issues.
- Clarify legal requirements on a local, regional, national and international level.
- Identify and engage in private or official stakeholders.
- Enable public participation.
- Consider possible risks and uncertainties.
- Establish a consensus about the mission of the project.
- Identify measurable indicators to verify project performance.
- Design monitoring and management plans (see Table 3 below).
- Test critical procedures in small scale experiments to minimize risks of failure.
- Realize the operational availability of the site.
- Organize trained supervision of work.
- Employ well-trained operators and workers.
- Implement restoration measures.
- Follow safety regulations.
- Stick to timescale.
- Check if the expected objectives can be achieved.
- Correct emerging problems.
- Modify unattainable objectives.
- Document intermediate project stages.
- Check the adequacy of the monitoring program.
- Investigate the extent to which project goals and objectives are achieved.
- Consider if critical peatland components and functions have been restored.
- Analyse ecological, economic, and social benefits realized by the project.
- Identify future management and maintenance requirements.
- Organise management and maintenance.

- Share learned lessons with interested parties on:
    - duration of each project phase and the total project,
    - costs and cost-effectiveness of each project phase, and
    - total costs of the project.

Aspect	Description
Site history	• What is the actual level of degradation (this is provided as a peatland degradation matrix table within the Manual)? • Did the site support the target habitat in recent years? • Did the site contain target species (condition of the seed bank)?
Site location	• Where are the sources for spontaneous recolonisation (target species)? • Where are disturbances (human activities, waste, pollutants, and problem species)? • How does the site interfere with its surrounding?
Site situation	Depending on the size, zonation and complexity of the site an adequate number of monitoring areas have to be established (e.g. sloping sites will show different development in the upper than in the lower parts).
Applied methods	• Will natural revegetation take place or was initial support of the establishment applied? • Were there changes in the site's hydrology? • Are there management or maintenance requirements (e.g. to maintain a certain water level by pumping of water or by adjusting weirs)?
Project aims	• What is the project focusing on? • What is the appropriate scale of monitoring (the whole catchment; focal areas of the site) and where should sampling plots be located (along transects, as nested plots, in regular or stochastic design)? • How long should the monitoring take place for and how intensive should it be (e.g. to assess fluctuations during an adequate period)? • Is it possible to optimise the monitoring by modelling selected parameters?

Description of aspects considered in the Global Peatland Restoration Manual (Schumann, & Joosten, 2008)

ANNEX 3: Case Study Inventory

Provides a selected list of case studies considered to inform the review / framework. Note this is not a database of all schemes. Those marked with an asterisk in the first column have been fully reviewed and provided in **ANNEX 4**: Detailed Case Study Review.

No.	Name	Location	Organisation(s)	Scheme Type *(e.g. restoration; enhancement; translocation etc.)*	Protected Areas; legislation; management etc.	Comments

No.	Name	Location	Organisation(s)	Scheme Type *(e.g. restoration; enhancement; translocation etc.)*	Protected Areas; legislation; management etc.	Comments
1*	DEEP	Dornoch Firth	The Glenmorangie Company, Heriot-Watt University and the MCS	Restoration and enhancement	Dornoch Firth & Loch Fleet SPA and SSSI; Dornoch Firth & Morrich More SAC; and adjacent to Moray Firth SAC.	–
2*	Loch Craignish Native Oyster Restoration Project	Loch Craignish, Argyll	Seawilding, CROMACH, Ardfern Yacht Centre, Heart of Argyll Wildlife Organisation, Stirling University and SAMS.	Restoration	Currently not designated, however, the local community would like the loch to be a designated MPA.	–
3*	The Wild Oysters Project	Firth of Clyde, River Conwy and, Tyne and Wear	ZSL, BLUE and British Marine	Restoration	Inner Clyde Estuary SPA; Menai Strait & Conwy Bay / Y Fenai a Bae Conwy SAC; Northumbria Coast SPA	–
4	Lochaline Native Oyster Project	Loch Aline, Sound of Mull	CAOLAS, Fauna & Flora International, local partners, and community groups.	Restoration / reintroduction	-	–
5	Restoration Forth	Firth of Forth	WWF, RBGE, Project Seagrass, Heriot-Watt University and three community groups.	Restoration	Outer Firth of Forth & St Andrews Bay Complex SPA; Firth of Forth SPA and Complex management, within the harbour	No funding to date.

No.	Name	Location	Organisation(s)	Scheme Type *(e.g. restoration; enhancement; translocation etc.)*	Protected Areas; legislation; management etc.	Comments
6	N/A	Lock Ryan	Loch Ryan Oyster Company in association with DEEP	Enhancement	Protected under the Water Environment (Shellfish Water Protected Areas: Designation) (Scotland) Order 2016	–
7	The Wales Native Oyster Restoration Project	Milford Haven, South Wales	NRW and ABPmer (other partners to be confirmed)	Restoration and enhancement	Pembrokeshire Marine/ Sir Benfro Forol SAC	–
8	The Humber Aquaculture Partnership (HAP)	The Humber Estuary	The University of Hull and the Yorkshire Wildlife Trust.	Translocation from Loch Ryan.	Nature Reserve	–
9	Essex Native Oyster Restoration Initiative (ENORI)	Blackwater, Roach, Crouch and Colne Marine Conservation Zone (MCZ)	ZSL, The Nature Conservancy, Native Oyster Network, University of Essex, University of Edinburgh, Natural England, Cefas, Environment Agency, The Tollesbury & Mersea Native Oyster Fishery Company Ltd., Essex Wildlife Trust, River Roach Oyster Company, BLUE, Colchester Oyster Fishery and Kent & Essex IFCA.	Restoration and Translocation (at early stages)	Blackwater, Crouch, Roach & Colne Estuaries MCZ, SAC, SPA, SSSI and Ramsar designations. Fisheries management plan and Marine Licence for restoration activities.	–

No.	Name	Location	Organisation(s)	Scheme Type *(e.g. restoration; enhancement; translocation etc.)*	Protected Areas; legislation; management etc.	Comments
10	Solent Oyster Restoration Project	Solent	BLUE, MDI Marinas, Southern IFCA, University of Plymouth, University of Southampton, Portsmouth University and the National Trust.	Restoration	Solent Maritime SAC; Solent & Southampton Water SPA, Solent & Dorset Coast SPA.	–
11*	Borkum Reef Ground Oyster Pilot Project	Borkumse Stenen, Netherlands	Ark Natuurontwikkeling, WWF Netherlands, Wageningen Marine Research and Bureau Waardenburg	Restoration	Natura 2000 and MPA	–
12*	Maryland and Virginia Oyster Restoration (Eastern oyster)	Chesapeake Bay, USA	NOAA, Virginia Institute of Marine Science (VIMS), Maryland Department of Natural Resources (DNR), Virginia Marine Resources Commission (VMRC), CBF, Oyster Recovery Partnership, Horn Point Oyster Hatchery (University of Maryland), Restore America's Estuaries, the National Fish and Wildlife Foundation (NFWF), and USACE.	Restoration	N/A	Longest, best, scaled
13	Galway Bay Oyster Restoration Project	Galway Bay, Ireland	Marine Institute, Cuan Beo Environmental CLG and Bord Iascaigh na Mhara (The Irish Seafood Development Industry)	Restoration	Galway Bay Complex SAC	Early stages

No.	Name	Location	Organisation(s)	Scheme Type *(e.g. restoration; enhancement; translocation etc.)*	Protected Areas; legislation; management etc.	Comments
14	Flat Oyster REcoVERy (FOREVER)	Brittany, France	CRC Bretagne, RC Bretagne Nord, IFREMER and ESITC Caen	Restoration	Management measures via a partnership with local bodies (e.g. fisheries).	–
15	Haringvliet Dream Fund Project	Voordelta, Netherlands	Ark Natuurontwikkeling and WWF Netherlands, in collaboration with the Native Oyster Consortium – POC (Bureau Waardenburg, Wageningen Marine Research and Sas Consultancy)	Enhancement and Restoration (Borkum Reef Ground Oyster Pilot Project)	Voordelta is protected under Natura 2000	–
16	Project RESTORE I (2016-2019)	North Sea, Germany	AWI - Helmholtz Centre for Polar and Marine Research, BfN, Bremerhaven–Helgoland – Sylt	Restoration	MPA.	–
17	Project RESTORE II (2019-2023)	North Sea, Germany	AWI - Helmholtz Centre for Polar and Marine Research, BfN, Bremerhaven–Helgoland – Sylt	Restoration	MPA.	–

Table 4. Details of case studies on native oyster

No.	Name	Location	Organisation(s)	Scheme Type *(e.g. restoration; enhancement; translocation etc.)*	Protected Areas; legislation; management etc.	Comments

No.	Name	Location	Organisation(s)	Scheme Type *(e.g. restoration; enhancement; translocation etc.)*	Protected Areas; legislation; management etc.	Comments
18*	Seagrass Ocean Rescue project	Dale Bay, Pembrokeshire, Wales	Project Seagrass, Sky Ocean Rescue, University of Swansea, WWF and Pembrokeshire Coastal Forum	Restoration – seed-based. 2 ha pilot-study.	Pembrokeshire Marine / Sir Benfro Forol SAC	Ran 2019 to March 2021.
19	LIFE Recreation ReMEDIES Project	Plymouth Sound SAC and Solvent Maritime SAC	Natural England, Ocean Conservation Trust, MCS, Plymouth City Council, Royal Yachting Association	Restoration – planting seedlings and seeds	Plymouth Sound SAC and Solvent Maritime SAC	Not yet operational)
20	N/A	North Wales	N/A	Enhancement, using seed	N/A	To repair mooring scars
21	Restoration Forth	Firth of Forth	WWF, RBGE, Project Seagrass, Heriot-Watt University and three community groups.	Restoration	Complex management, within the harbour	No funding to date

No.	Name	Location	Organisation(s)	Scheme Type *(e.g. restoration; enhancement; translocation etc.)*	Protected Areas; legislation; management etc.	Comments
22*	ZORRO (ZOsteRa RestOration)	West coast, Sweden	The University of Gothenburg, Swedish Agency for Marine and Water Management, Country Administrative Board of Västra Götaland, Stockholm University, University of Southern Denmark, Aarhus University, University of Groningen, Radboud University Nijmegen, NIOZ Royal Netherlands Institute for Sea Research and Åbo Akademi University	Restoration, translocation and management	Swedish Seagrass Restoration Handbook. The Växjö District Court is also looking into seagrass compensation measures associated with anthropogenic impacts.	Ongoing
23*	NOVAGRASS	Jutland, Denmark	University of Southern Denmark, VIMS, Aarhus University, University of Copenhagen, Radboud University Nijmegen, University of Gothenburg, DHI Water, Mulitdyk, The Danish Nature Agency, KC Denmark A/S, SEGES and Green & Blue Tech.	Restoration and translocation	N/A	Very successful

No.	Name	Location	Organisation(s)	**Scheme Type** ***(e.g. restoration; enhancement; translocation etc.)***	**Protected Areas; legislation; management etc.**	Comments
24*	Eelgrass Restoration Project	Eastern Shore, Virginia, USA	VIMS, The University of Virginia, The Nature Conservancy, VMRC, USACE and the Virginia Coastal Zone Management (CZM) Program	Restoration	Virginia Coast Reserve and a Long Term Ecological Research (LTER) site.	Most successful
25*	Submerged Aquatic Vegetation (SAV) Program	Chesapeake Bay, Virginia and Maryland, USA	Chesapeake Bay Program, Maryland DNR, Maryland Department of Environment, University of Maryland, St. Mary's College of Maryland, VIMS, Virginia Department of the Environmental Quality, VMRC, Virginia CZM Program, Old Dominion University, Department of Energy and Environment (District of Columbia), NOAA, USACE, U.S. Environment Protection Agency, U.S. Fisheries and Wildlife Service, U.S. Geological Survey and the Smithsonian Environmental Research Centre.	Restoration (seed-based) and translocation	N/A	Best example overseas, see Orth et al., 2020

No.	Name	Location	Organisation(s)	Scheme Type ***(e.g. restoration; enhancement; translocation etc.)***	**Protected Areas; legislation; management etc.**	Comments
26*	Cornell Cooperative Extension Eelgrass Program	Several projects located within Long Island Sound, New York, USA	Cornell University, Suffolk County, NFWF, the Peconic Estuary Program, Natural Resources Conservation Service, Save the Sound, STIDD systems, Long Island Community Foundation, New York State Environmental Protection Fund and Local municipalities	Enhancement, Restoration and Monitoring	Long Island Sound Management Plan	–
27	Nearshore Habitat Program	Puget Sound, Washington, USA	The Pacific Northwest National Laboratory and the Washington Department of Natural Resources (lead).	Restoration and translocation	Seagrass monitoring in greater Puget Sound via the Submerged Vegetation Monitoring Program	Jeff Gaeckle – Program Manager

Table 5. Details of case studies on seagrass

No.	Name	Location	Organisation(s)	Scheme Type ***(e.g. restoration; enhancement; translocation etc.)***	**Protected Areas; legislation; management etc.**	Comments
28*	Green Shore Salt Marsh Program	Dornoch Firth, Eden Estuary and Tay Estuary	Green Solutions, St. Andrews University partnership, Dornoch Academy	Restoration, translocation	-	–

No.	Name	Location	Organisation(s)	**Scheme Type** *(e.g. restoration; enhancement; translocation etc.)*	Protected Areas; legislation; management etc.	Comments
29*	The Nigg Bay Coastal Realignment Project	Nigg Bay, Cromarty Firth	RSPB (and NatureScot indirectly)	Restoration / realignment of defence	Nature Reserve	–
30	Skinflats Tidal Exchange Project (STEP Forth)	Firth of Forth	RSPB, funded by Heritage Lottery Fund through the Inner Forth Landscape Initiative and EcoCo Life	Managed realignment / enhancement	Firth of Forth SPA and RSPB Skinflats Nature Reserve	–
31	The Kennet Pans Managed Coastal Realignment	Firth of Forth, Kincardine	Transport Scotland	Managed realignment / restoration	Firth of Forth SPA	–
32*	Paull Holme Strays Managed Realignment	Paull Holme Strays, Humber Estuary	Environment Agency	Enhancement / realignment of defence	Flood Risk Management Scheme, Nature Reserve, European site, UK legislation	–
33*	Wallasea Island Wild Coast Project	Wallasea Island, Rochford, Essex	RSPB, Environment Agency and Crossrail	Managed realignment and regulated tidal exchange	Crouch and Roach Estuaries (Mid-Essex Coast Phase 3) SPA, Outer Thames Estuary SPA, Essex Estuaries SAC, Blackwater, Crouch, Roach and Colne Estuaries MCZ and Ramsar site.	–

No.	Name	Location	Organisation(s)	Scheme Type *(e.g. restoration; enhancement; translocation etc.)*	Protected Areas; legislation; management etc.	Comments
34*	Medmerry Managed Realignment Scheme	West Sussex Coast	Environment Agency and RSPB	Managed realignment / restoration	-	–
35*	Steart Coastal Management Project	Parrett Estuary, Bristol	Environment Agency Advice and site management by Wildfowl and Wetlands Trust	Managed realignment	Severn Estuary SPA and Severn Estuary/ Môr Hafren SAC	–
36	Northey Island	Blackwater Estuary, Essex	National Trust	Managed realignment	Blackwater Estuary Ramsar site, Blackwater Estuary SPA, SAC and SSI and Blackwater, Crouch Roach and Colne Estuaries MCZ	Demonstration / Pilot study
37	Tidal Wetland Restoration Project	Long Island Sound, Connecticut, USA	Connecticut Department of Environment Protection	Restoration	-	–
38	Cheverie Creek Salt Marsh Restoration Project	Bay of Fundy, Nova Scotia, Canada	Nova Scotia Department of Natural Resources, the Department of Fisheries and Oceans, Mt. Allison University, the Nova Scotia Museum of Natural History, and the Ecology Action Centre	Restoration	-	–

Table 6. Details of case studies on saltmarsh

No.	Name	Location	Organisation(s)	Scheme Type *(e.g. restoration; enhancement; translocation etc.)*	Protected Areas; legislation; management etc.	Comments
39*	West Sands Dune Restoration Project	West Sands Beach, St. Andrews	The West Sands Partnership, Fife Coast and Countryside Trust, St. Andrews Links Trust, NatureScot, University of St. Andrews, Fife Council and local landowners	Restoration	SAC, SSSI and European site	–
40*	Sand Dune Restoration Project	Morrich More, Tain	FLS	Restoration	Morrich More SSSI, Dornoch Firth and Loch Fleet SPA, Dornoch Firth and Morrich More SAC, and adjacent to Moray Firth SAC	Trial site
41	Uist Resilience Enhancement	Uist, Outer Hebrides	NatureScot and partners	Enhancement	North Uist Machair SAC, South Uist Machair SAC	Not yet commenced: strategy in place – awaiting funding.
42	Fylde Sand Dunes Project	Fylde Coast	Lanchashire Wildlife Trust, Manchester Wildlife Trust, North Merseyside Wildlife Trust, Environment Agency, Flyde Council and Blackpool Council	Enhancement		–

No.	Name	Location	Organisation(s)	**Scheme Type** *(e.g. restoration; enhancement; translocation etc.)*	Protected Areas; legislation; management etc.	Comments
43*	Sands of LIFE	Ten separate locations around Wales including, Kenfig, Bridgend and Newborough Warren, Anglesey	NRW, Dunes2Dunes, Carmarthen Bay Dunes, DuneLIFE Dynamic Dunescapes, UK Sand and Shingle Network.	Enhancement and Restoration	Kenfig, Nature Reserve, Newborough National Nature Reserve and Forest	–
44	DuneLIFE	Eight sites around England, with key sand dune sites in Cornwall, Cumbria, Devon, Dorset, Lincolnshire and Merseyside	Natural England, Cornwall Trust for Nature Conservation, Cumbria Wildlife Trust, Lincolnshire Wildlife Trust, the National Trust and Plantlife International.	Enhancement and Restoration	SACs and seven Annex I sand dune habitats.	–
45*	Coastal Dune Restoration Project	Point Reyes California, USA	Point Reyes National Seashore, National Park Service	Enhancement and Restoration	United Nations Educational, Scientific, and Cultural Organization (UNESCO) - designated Golden Gate Biosphere Reserve and contains a Ramsar site.	–
46*	Backdune Restoration Project	Nationwide, New Zealand	Coastal Restoration Trust, Ministry for the Environment, Coastal Care groups, iwi Trust, Department of Conservation and Councils.	Restoration	Guidance and management	–

No.	Name	Location	Organisation(s)	Scheme Type *(e.g. restoration; enhancement; translocation etc.)*	Protected Areas; legislation; management etc.	Comments
47	Merimbula Beach Dune Restoration	Bega Valley Shire, New South Wales, Australia	Bega Valley Shire Council and New South Wales Government's Coastal Management Program (CMP).	Restoration	New South Wales Government's CMP	50% of funding provided by CMP

Table 7. Details of case studies on sand dunes

ANNEX 4: Detailed Case Study Review

Using the list of selected projects in the UK and globally, provided in **ANNEX 3**: Case Study Inventory, a detailed review of 20 selected case studies has been carried out. This was based on a proforma for each case study, as provided below.

1. Name	**Dornoch Environmental Enhancement Project**
Feature	Native Oysters
Location	Dornoch Firth, Scotland
Scheme type	Restoration and Enhancement
Timescales	2014 – 2025. 300 initial oysters in March 2017, increased to 20,000 between October 2018 and Spring 2021, with an aim of 200,000 oysters over subsequent 3 years and then 1 million a year until project achieves 4 million oysters.
Objectives	It aims to reintroduce the native oyster (Ostrea edulis) into the Dornoch Firth, Ross and Cromarty (40 ha) to enhance biodiversity and improved water quality.
Organisation structure	Heriot-Watt University, The Glenmorangie Company and the Marine Conservation Society
2. Ecology	Objectives, habitat suitability, benefits, short term and long term risks (genetics, biosecurity, climate change, etc.), scheme and site selection, maximising success
Strengths	Habitat suitability through literature, fisheries and archaeological records, and shell material. Suitable environmental characteristics established, water quality / nutrients. The DEEP project also conducted a survivability study with 300 oysters to determine site suitability, prior to increasing to a large deployment.

1. Name	**Dornoch Environmental Enhancement Project**
Novelty	The DEEP project has developed novel biosecurity protocols and pioneered site selection and feasibility work
Weaknesses	Presence of parasite *Bonamia ostreae* at a shellfish farm on the west of Scotland. Scottish Government's Fish Health Inspectorate (FHI) conducted an epidemiological investigation and has confirmed presence of the parasite at: • Sgeir Liath (Lochnell Oysters) • Lamb Holm (Orkney Shellfish Hatchery (OSH) Ltd) – stock culled. • Dornoch Firth West (Heriot Watt University - DEEP Oyster Restoration) • John Muir Building (Heriot Watt University) – stock culled. • Initial Designation Notice [Presence suspected] • Dornoch Firth East (Heriot Watt University - DEEP Oyster Restoration).
Challenges	Limited broodstock numbers. Limited supply chain for oysters. Limited suitable substrate – required waste shells material for larval settlement and regulator approvals process. Requirement for high rigor in biosecurity. Limitations of disease screening tools.
Gaps	Oyster restoration – does it become self-sustaining? Do the oyster larvae in water column get dispersed over a wider distance or do they find their way back to natal bed? Habitat type does not exist anymore so knowing what the oyster reef should look like is difficult due to very few examples left.
3. Structure	Site community cohesion, timing, funding, drawing on other programmes
Strengths	The project is working with micro-enterprise partners OSH to improve survival rates of spat and to ensure biologically clean product. Working with Maorach Beag to develop supply chain.
Novelty	DEEP and OSH are working on a joint proposal for a Knowledge Transfer Partnership through Innovate UK to investigate optimal hatchery techniques.
Weaknesses	NA
Challenges	Long process, restoration is decadal in duration. Lack of mature oysters available – 10g oysters to escape predation – a year to find 20,000 oysters. Need to energise the supply chain at the hatchery and on-growing level. Develop circular economy via shell waste product, new standards for re-use.
Gaps	NA
4. Regulation	Site / regional / national regulation, licensing, formal engagement and timing
Strengths	Conducted archaeological and historic research to demonstrate the presence of the native oyster at that site. Working with government agencies and regulatory bodies to ensure compliance and create a mechanism for licensing for re-introduction and re-use of shell.
Novelty	The DEEP project may provide a methodology for future restoration in other areas and help government achieve efficiencies in licensing processes.

1. Name	Dornoch Environmental Enhancement Project
Weaknesses	NA
Challenges	Issues for aquaculture permitting in relation to restoration, this has been highlighted by the aquaculture industry. Issues in effort required in HRA process.
Gaps	NA
5. Monitoring	Actual benefits, measuring success, communicating outcomes
Strengths	Researching and monitoring the water quality, blue carbon and biodiversity impacts of the developing oyster reefs. Monitoring the oyster every six months. Engage with communities in recognising the value of clean coastal water. Regularly updates via Glenmorangie and updates of the project through conferences and webinars.
Novelty	New monitoring methods developed to suit tidal sites.
Weaknesses	NA
Challenges	Dynamism of site and access to study area can be a constraint.
Gaps	NA
6. Socio-economic	Benefits planned, maximising success, benefits realised
Strengths	The DEEP project is strengthening the aquaculture supply chain, which will benefit other restoration projects by creating a supply of disease and INNS -free oysters, spat, on-grown and broodstock; and benefit native oyster aquaculture by improving methodologies for hatchery and for on-growing. Strong advocates of oyster supply chain as economic engine in the rural economy.
Novelty	The DEEP project is enabling access to markets, providing an alternative market for native oysters earlier than food markets, and assisting in increasing productivity of both hatcheries and on-growers.
Weaknesses	NA
Challenges	Restoration programmes need to place orders with supply chain well in advance to ensure oysters are available at the point of requirement and this often does not match planning and funding cycles well.
Gaps	NA
7. Source	References

1. Name	**Dornoch Environmental Enhancement Project**
References	CREW. 2019. Towards an Economic Value of Native Oyster Restoration in Scotland: Provisioning, Regulating and Cultural Ecosystem Services. Centre of Expertise For Waters. Sanderson, W.G. & Lee, H. 2021. The DEEP project: Progress and challenges in oyster restoration. MASTS Webinar [online]. The Scottish Parliament Questions (2020). [online] Available at: https://www.festivalofpolitics.scot/home/chamber-and-committees/written-questions-and-answers/question?ref=S5W-27330. Accessed 04 February 2021.

Case study A1 Dornoch Environmental Enhancement Project: brief summary, ecology, structure, regulation, monitoring, socio-economic benefits and sources

1. Name	**Loch Craignish Native Oyster Restoration Project**
Feature	Native Oysters
Location	Loch Craignish, Ardfern, Argyll, Scotland
Scheme type	Restoration
Timescales	Spring 2019 - 5-year project
Objectives	Primary aim is to restore the native oyster beds once widespread at Loch Craignish, Argyll. This will result in improved water quality and enhance biodiversity and address the degradation of the loch caused by scallop dredging, fish farm activity, anchoring and effluent from recreational boating.
Organisation structure	Seawilding, CROMACH, Ardfern Yacht Centre, Heart of Argyll Wildlife Organisation, Stirling University and SAMS
2. Ecology	Objectives, habitat suitability, benefits, short term and long term risks (genetics, biosecurity, climate change, etc.), scheme and site selection, maximising success
Strengths	Identified several relic populations (no more than a few hundred individuals) of native oysters in the loch. In the summer of 2020 surveys of the seabed sites were conducted prior to the release of oysters. No additional cultch has been required as there is an abundance of cockle, oyster and horse mussel shell on the seabed.
Novelty	Select four restoration sites within the loch, not just one area. Conducting genetic research to ensure resilience in the stock. Genotyping the oysters to assess genetic variability as well as resistance to disease. This pioneering research will be useful to all native oyster restoration projects in Europe.

1. Name	**Loch Craignish Native Oyster Restoration Project**
Weaknesses	Presence of parasite *B. ostreae* at a shellfish farm on the west of Scotland. Scottish Government's FHI conducted an epidemiological investigation and has confirmed presence of the parasite at: • Sgeir Liath (Loch Nell Oysters) - Donated a proportion of stock. • Loch Craignish Native Oyster Restoration Project [to be revoked]
Challenges	Fundraising to conduct a programme of environmental DNA testing to detect problems such as parasites and INNS. Aim to create a unique dataset on the health of the loch over time.
Gaps	Lack of historical scientific data.
3. Structure	Site community cohesion, timing, funding, drawing on other programmes
Strengths	Obtained 60,000 oysters from Morecambe Bay Hatchery and grew them from 2g to 8-15g prior to release. Another 1000,000 oyster juveniles are at the nursery.
Novelty	Pioneering floating nursery system (first in the UK), to grow juveniles at the southern end of the loch.
Weaknesses	NA
Challenges	Community-led with fund-raising is main source of funding. It has been grant-aided by Sea-Changers and supported by Lochnell Oysters which has donated a proportion of the oysters and helped with equipment and stock.
Gaps	NA
4. Regulation	Site / regional / national regulation, licensing, formal engagement and timing
Strengths	NatureScot approved site selection survey protocol. Working closely with NatureScot to ensure biodiversity protocols are followed.
Novelty	NA
Weaknesses	NA
Challenges	Possible future aim to have Loch Craignish designated as an MPA for community-led habitat restoration and regenerative aquaculture.
Gaps	NA
5. Monitoring	Actual benefits, measuring success, communicating outcomes

1. Name	**Loch Craignish Native Oyster Restoration Project**
Strengths	Narwhal Expeditions team aid in the surveying the site prior to release, with the survey protocols considered acceptable by NatureScot. The project therefore has a valuable and growing dataset to inform the baseline of the project. This in turn will enable the determination in changes to the loch over time in regards to the native oyster population and biodiversity. During release representative quadrats surveys were taken. 90% survival to date.
Novelty	Care and monitoring of juveniles has been conducted by CROMACH in conjunction with primary school pupils.
Weaknesses	NA
Challenges	NA
Gaps	NA
6. Socio-economic	Benefits planned, maximising success, benefits realised
Strengths	Communicating with locals and regular visitors about the project, building engagement, increasing knowledge and awareness of marine conservation and the importance of native oysters.
Novelty	The first community-led native oyster restoration project in Scotland. Potential to become a sustainable oyster fishery, which in turn will create local jobs
Weaknesses	NA
Challenges	NA
Gaps	NA
7. Source	References
References	<u>Seawilding newsletter Winter 2020</u>. [online]. The Scottish Parliament Questions (2020). [online] Available at: https://www.festivalofpolitics.scot/home/chamber-and-committees/written-questions-and-answers/question?ref=S5W-27330. Accessed 04 February 2021.

Case study A2 Loch Craignish Native Oyster Restoration Project: brief summary, ecology, structure, regulation, monitoring, socio-economic benefits and sources

1. Name	**The Wild Oysters Project**

1. Name	**The Wild Oysters Project**
Feature	Native Oysters
Location	Firth of Clyde (Scotland), River Conwy (Wales) and Tyne & Wear (England)
Scheme type	Restoration
Timescales	2020 - 2023
Objectives	The aim of the project is for the UK seas to have self-sustaining populations of native oysters which provide clean water, healthy fisheries, and plentiful biodiversity.
Organisation structure	Zoological Society of London (ZSL), Blue Marine Foundation (BLUE) and British Marine
2. Ecology	Objectives, habitat suitability, benefits, short term and long term risks (genetics, biosecurity, climate change, etc.), scheme and site selection, maximising success
Strengths	The project will work together with local partners to commence the restoration of the 20,000 km^2 of oyster reefs that have been lost from around the coastline of Britain. This will be done by creating oyster rehabilitation hubs (caged oysters), 130 nationally. Oysters are known to provide a variety of ecological benefits e.g. improving water quality, providing nursery grounds for important sea food species and capturing carbon.
Novelty	By partnering with British Marine (a membership group for recreational and small commercial boating) provides access to high value distribution and settlement surfaces at marinas.
Weaknesses	NA
Challenges	NA
Gaps	NA
3. Structure	Site community cohesion, timing, funding, drawing on other programmes
Strengths	The project will be using methods developed through the Solent Oyster Restoration Project and carrying out seabed restoration, including baseline surveys and cultch deployment, building on work carried out by the Essex Native Oyster Restoration initiative. The project has the potential to release nine billion native oyster larvae into the ocean creating oyster nurseries in UK waters. Delivering an extensive public outreach and biological sciences education programme at both a primary and secondary level with the aim of reach 12000 students as well as 38000 members of the general public through further work. ZSL have developed a handbook for native oyster restoration to aid other projects.
Novelty	£1,180,000 raised by players of People’s Postcode Lottery and awarded as part of the Dream Fund giving charities the opportunity to bring a dream project to life.

1. Name	The Wild Oysters Project
Weaknesses	NA
Challenges	Community outreach programmes are difficult at the moment due to COVID-19 but the project has created some online resources and events to engage people in the projects.
Gaps	Aims to have extensive community engagement project however very few details of what this will entail are available, also no info on how this has been impacted by COVID-19.
4. Regulation	Site / regional / national regulation, licensing, formal engagement and timing
Strengths	The nurseries were not placed at protected sites and were instead attached to private infrastructure; therefore it was important to gain permissions from the yachting clubs.
Novelty	NA
Weaknesses	NA
Challenges	NA
Gaps	NA
5. Monitoring	Actual benefits, measuring success, communicating outcomes
Strengths	The project hopes to have citizen science as part of its monitoring and reporting regime.
Novelty	NA
Weaknesses	Potentially by using private infrastructure this will prevent the benefits of the project being realised by the pubic and limit the engagement opportunities.
Challenges	NA
Gaps	Nurseries have recently been deployed; mention has been made of recording the biodiversity benefits, but no clear monitoring strategy could be sourced as part of this review.
6. Socio-economic	Benefits planned, maximising success, benefits realised

1. Name	The Wild Oysters Project
Strengths	The economic benefits of restoring native oyster beds includes provisioning (e.g. seafood), regulating (e.g. water filtration), habitat (e.g. bioengineering, species protection) and cultural (e.g. sense of place and research) ecosystem services. Research has also highlighted the particular benefit of oyster beds at removing pollution from water. The project is also looking to employ local people to help with the project to install the nurseries, engage with the public and lead citizen science.
Novelty	One of few projects trying to demonstrate that wildlife can be cultivated in enclosed, leisure environments.
Weaknesses	NA
Challenges	NA
Gaps	NA
7. Source	References
References	NORA. 2017. England The Wild Oysters Project – NORA. [online]. Yacht Havens. 2020. Largs Superheroes. [online]. BBC News. 2020. Oyster "maternity ward" to boost native oysters in River Conwy. [online]. Ireland, U., Preston, J., Gamble, C., Debney, A., Helmer, L. & Hancock, B. 2020. European Native Oyster Habitat Restoration Handbook. [online]. Zoological Society of London (ZSL). 2019. Million-pound boost for Britain's native oyster population.

Case study A3 Wild Oysters Project: brief summary, ecology, structure, regulation, monitoring, socio-economic benefits and sources

1. Name	Borkum Reef Ground (BRG) Oyster Pilot Project
Feature	Native Oysters
Location	Borkum Reef Ground, North of Borkum Island (Germany)
Scheme type	Restoration
Timescales	2018-2019 Installation of beds in May 2018, interim monitoring in July 2018 and final monitoring occurring 16 months later between 9-11 September 2019.

1. Name	**Borkum Reef Ground (BRG) Oyster Pilot Project**
Objectives	To determine if it is possible to restore oyster beds in the deeper parts of the North Sea and identifying the key factors for success or failure for active restoration of structure forming shellfish beds in deep North Sea.
Organisation structure	WWF Netherlands, Ark Natuur, Wageningen University and Research, Bureau Waardenburg, Flat Oyster Consortium
2. Ecology	Objectives, habitat suitability, benefits, short term and long term risks (genetics, biosecurity, climate change, etc.), scheme and site selection, maximising success
Strengths	Suitable habitat as 30% of Dutch North Sea floor used to be covered in epibenthic shellfish reefs, especially flat oysters and that BRG falls within the historical distribution. Survival and growth (weight and length) were both measured to assess the success of the scheme.
Novelty	This project is the first study into restoration of oyster beds in the deeper parts of the North Sea (23 m at low tide).
Weaknesses	Oyster survival inhibited after 16 months because they were found to be too big for their holding towers which prevented effective breathing and feeding behaviour in some cases.
Challenges	NA
Gaps	The potential impacts of predators e.g. common starfish, on larval recruitment. Unknown effect of storms to move oysters from pilot site, potential risk with increase in storm frequency due to climate change.
3. Structure	Site community cohesion, timing, funding, drawing on other programmes
Strengths	The feasibility of this project was assessed by previous research which suggested a successful outcome. This project has the support of local conservation groups as well as universities which opens up the possibility for more research in the future.
Novelty	NA
Weaknesses	NA
Challenges	NA
Gaps	NA
4. Regulation	Site / regional / national regulation, licensing, formal engagement and timing

1. Name	Borkum Reef Ground (BRG) Oyster Pilot Project
Strengths	Shellfish reef restoration is supported by Dutch and EU policy e.g. Marine Strategy Policy paper 3, Marine Framework Directive. Flat oyster beds are a priority marine habitat for protection in European MPAs. The Natura 2000 area Borkum Reef Ground (BRG) is one of three MPAs in the German Exclusive Economic Zone (EEZ) of the North Sea, which have been declared as nature conservation areas (NCAs) according to national legislation. The objectives of this site include the restoration of habitats where necessary.
Novelty	The first study of its kind; it could inform future studies in a similar environment
Weaknesses	NA
Challenges	NA
Gaps	NA
5. Monitoring	Actual benefits, measuring success, communicating outcomes
Strengths	Monitoring identified the reef to be growing, reproducing, and recruiting, surviving beyond the initial oysters introduced.
Novelty	-
Weaknesses	Reliance on divers for assessing recruits on the seabed inhibited the collection of quantitative oyster measurements and biodiversity data.
Challenges	Adverse weather conditions caused a change to the timing of monitoring.
Gaps	NA
6. Socio-economic	Benefits planned, maximising success, benefits realised
Strengths	Employment of local boat services and diving volunteers to complete the project. This project has attracted long term monitoring funding as part of the North Sea reef vitalization for ecosystem services 4-year scientific project which hopes to contribute to our knowledge of the biodiversity and ecosystem services provided by native oyster reefs.
Novelty	NA
Weaknesses	NA
Challenges	NA
Gaps	NA

1. Name	**Borkum Reef Ground (BRG) Oyster Pilot Project**
7. Source	References
References	Didderen, K., Lengkeek, W., Bergsma, J.H., van Dongen, U., Driessen, F.M.F. & Kamermans, P. 2020. WWF & ARK Borkum Reef Ground Oyster Pilot. [online]. Pogoda, B., Merk, V., Colsoul, B., Hausen, T., Peter, C., Pesch, R., Kramer, M., Jaklin, S., Holler, P., Bartholomä, A., Michaelis, R. & Prinz, K. 2020. Site selection for biogenic reef restoration in offshore environments: The Natura 2000 area Borkum Reef Ground as a case study for native oyster restoration. *Aquatic Conservation Marine and Freshwater Ecosystems*, 30(11), pp.2163–2179. Didderen, K. 2020. Biodiversity of North Sea Native Oyster Reefs: Notes From The Netherlands – NORA. [online].

Case study A4 Borkum Reef Ground (BRG) Oyster Pilot Project: brief summary, ecology, structure, regulation, monitoring, socio-economic benefits and sources

1. Name	**Maryland and Virginia Oyster Restoration Project**
Feature	Native Oysters
Location	Chesapeake Bay, USA
Scheme type	Restoration
Timescales	Spring 2019 - 5-year project
Objectives	2009 - Long-term project (20+ years) USACE began to assess the potential for oyster restoration in the Chesapeake Bay in 1995 and 2000, with aims to restore an abundant self-sustaining oyster population that performs important ecological functions such as providing reef community habitat, nutrient cycling, spatial connectivity, and water filtration and contributes to an oyster fishery. Ecological aims were as follows • Long-range: Restore self-sustaining oyster sanctuary populations. • Near-term- Habitat for oysters: Restore oyster abundances. Focus on restoring and maintaining habitat and in low salinity regions, broodstock. • Near-term- Habitat for reef community: Restore bar/reef characteristics similar to undegraded oyster habitat. • Near-term-Ecological services: Restore native oyster populations that provide ecological services typical of undegraded oyster habitat. • Fisheries Management: Restore oyster spawning/habitat sanctuaries in multiple tributaries that export larvae outside the sanctuary boundaries and provide a larval source to harvest grounds.

1. Name	**Maryland and Virginia Oyster Restoration Project**
Organisation structure	National Oceanic and Atmospheric Administration (NOAA), Virginia Institute of Marine Science (VIMS), Maryland Department of Natural Resources, Virginia Marine Resources Commission, Chesapeake Bay Foundation (CBF), Oyster Recovery Partnership, Horn Point Oyster Hatchery (University of Maryland), Restore America's Estuaries, the National Fish and Wildlife Foundation, the USACE.
2. Ecology	Objectives, habitat suitability, benefits, short term and long term risks (genetics, biosecurity, climate change, etc.), scheme and site selection, maximising success
Strengths	The USACE Masterplan noted data obtained from modelling, fossil shell survey, historic records, bathymetry, water clarity, salinity, dissolved oxygen, chlorophyll, oyster sanctuaries. Also information on oyster biology, disease and reproduction (including influences, fecundity, larval development and recruitment). Assessment of exiting broodstock populations. NOAA provides habitat mapping and assessment using multi-beam sonar equipment to inform oyster restoration site selection and for project monitoring. Rotating broodstock to avoid genetic narrowing.
Novelty	Large-scale restoration, over 20 sites each with varying restoration targets in acres.
Weaknesses	NA
Challenges	Loss of habitat, oyster disease (derno, *Perkinsus marinus* and MSX, *Haplosporidium nelsoni*), predation, water quality degradation, commercial harvesting. Lack of oyster shells for reef effort – CBF set up a recycling program ‘Save Oyster Sheel’ where individuals and restaurants donated empty oyster shells to be used in oyster restoration projects. Critical aspects of oyster biology, such as larval transport, were only just starting to be understood. Hatchery stock used to produce the spat-on-shell will need to be managed so that genetic diversity is maintained in the restored populations.
Gaps	NA
3. Structure	Site community cohesion, timing, funding, drawing on other programmes
Strengths	CBF established the Maryland Oyster Restoration Centre in 2002, which contains several tanks for producing spat. In Virginia, CBF has conducted works from the Oyster Restoration Centre at VIMS but is also now using a barge (Prudence H. & Louis F. Ryan Mobile Oyster Restoration Center) for much of the oyster setting work – which increases efficiency and reduces travel time. NOAA - funds oyster research and community-based oyster restoration projects.
Novelty	Oyster Gardens - Community members in Maryland and Virginia grow oyster alongside their docks, which aids CBF to plant the oysters on sanctuary reef sites. The oysters provided are sprat on the shells provided by the ‘Save Oyster Shell’ program. NOAA Chesapeake Bay developed an Oyster Data Tool to help plan oyster restoration and aquaculture – it includes bathymetry, sediment type, salinity and temperature, sanctuaries, oyster survey locations and results.
Weaknesses	NA

1. Name	**Maryland and Virginia Oyster Restoration Project**
Challenges	Lesson learned from past restoration: efforts have been scattered throughout the Bay and have been too small in scale to make a system-wide impact.
Gaps	NA
4. Regulation	Site / regional / national regulation, licensing, formal engagement and timing
Strengths	The Water Resources Development Act (WRDA) of 2020 will direct important resources to ecosystem restoration projects, water conservation, and natural infrastructure projects. USACE is authorized by Section 704(b) of the WRDA of 1986, as amended by Section 505 of WRDA 1996, Section 342 of WRDA 2000, Section 113 of the Fiscal Year 2002 Energy and Water Development Appropriations Act, Section 126 of the Fiscal Year 2006 Energy and Water Development Appropriations Act, and Section 5021 of WRDA 2007, to construct oyster restoration projects "to conserve fish and wildlife" for ecosystem restoration and can include sanctuaries and harvest reserves. Private oyster leasehold system for spat-on-shell production.
Novelty	In 2009 President Barack Obama issued Executive Order 13508, Chesapeake Bay Protection and Restoration. The “Strategy for Protecting and Restoring the Chesapeake Bay Watershed” was developed in response. Chesapeake Bay Oyster Restoration importance noted by the U.S. Senate in 2018, with aquaculture priorities to be included in the WRDA.
Weaknesses	At start of project all proposed restoration to be constructed within permanent sanctuary, with the exception of spat-on-shell production areas.
Challenges	Political and public support over an extended period, decades.
Gaps	NA
5. Monitoring	Actual benefits, measuring success, communicating outcomes
Strengths	Monitoring and rehabilitation of existing sanctuary reefs. Monitoring will determine when enough habitat has been constructed to reach restoration goals.
Novelty	NA
Weaknesses	NA
Challenges	NA
Gaps	USACE undertook additional investigations into the costs and benefits of sanctuaries and harvest reserves.
6. Socio-economic	Benefits planned, maximising success, benefits realised

1. Name	**Maryland and Virginia Oyster Restoration Project**
Strengths	CBF is focused on improving public awareness and knowledge of the value of oysters to the Bay, providing the public hands-on involvement in restoration, developing partnerships, and promoting education and scientific research.
Novelty	NA
Weaknesses	NA
Challenges	CBF acknowledges that oyster restoration is a long-term process that will require the participation and commitment of federal and state agencies and citizens alike for many years.
Gaps	NA
7. Source	References
References	Chesapeake Bay – Oyster Restoration. [online]. U.S. Army Corps of Engineers 2012. Chesapeake Bay Oyster Recovery: Native Oyster Restoration Master Plan. Final. U.S. Army Corps of Engineers – Baltimore and Norfolk District, Virginia Marine Resources Commission and Maryland Department of Natural Resources.

Case study A5 Maryland and Virginia Oyster Restoration Project: brief summary, ecology, structure, regulation, monitoring, socio-economic benefits and sources

1. Name	**Seagrass Ocean Rescue Project**
Feature	Seagrass
Location	Dale Bay, Pembrokeshire, Wales
Scheme type	Restoration (Seed based)
Timescales	2017-Present
Objectives	The objective is to restore 20,000 m^2 of the marine plant in west Wales. The project also aims to demonstrate how communities and conservation can work in harmony.
Organisation structure	Project Seagrass, Sky Ocean Rescue, WWF, Swansea University, and Pembrokeshire Coastal Forum.

1. Name	**Seagrass Ocean Rescue Project**
2. Ecology	Objectives, habitat suitability, benefits, short term and long term risks (genetics, biosecurity, climate change, etc.), scheme and site selection, maximising success
Strengths	Site selection based on previous history of seagrass as well as abiotic factors which determine habitat suitability such as water depth, sufficient light intensity, and shelter from storms. 1,200,000 seeds planted to date with dense growth in some patches. Proven site for restoration prior to project based on local site trials.
Novelty	First large-scale deployment of Bags of seagrass seed line (BOSSline) method for cheap and effective deployment of seeds.
Weaknesses	Some patches in the planted area are performing poorly possibly due to winter seed storage (resulting from extended stakeholder engagement) and probable anchor impacts. Germination has been slower than expected. Problems overcome with further planting and investment in visitor moorings.
Challenges	Late stakeholder engagement issues have pushed back the planting schedule.
Gaps	Studies preceding this large-scale effort highlight a need for greater understanding of germination and development.
3. Structure	Site community cohesion, timing, funding, drawing on other programmes
Strengths	Stakeholder engagement is a key part of the consultation for the project with care taken to accommodate recreation and commercial uses. Timing critical due to extent of decline of seagrass across the UK (92% gone). National volunteers used to collect seagrass seeds from across the UK and local volunteers e.g. school children and divers involved at the site. Creation of a lot of guidance for future projects.
Novelty	Methods inspired by success of Chesapeake Bay study (Virginia, USA).
Weaknesses	Limited engagement from the Crown Estate
Challenges	Enabling boat mooring structures in the same vicinity as seagrass planting, key stakeholder issue but potentially damaging to plants.
Gaps	NA
4. Regulation	Site / regional / national regulation, licensing, formal engagement and timing
Strengths	Natural Resources Wales will be the regulator for the project, granting the partners a licence to plant seagrass
Novelty	Pembrokeshire Marine/ Sir Benfro Forol SAC providing international protection which already contains specification for seagrass.

1. Name	Seagrass Ocean Rescue Project
Weaknesses	NA
Challenges	Site is in an SAC so has protection as a feature of the SAC but working on agreement with local fishermen to prevent them from disturbing the site also
Gaps	NA
5. Monitoring	Actual benefits, measuring success, communicating outcomes
Strengths	FAQ document produced outlining benefits such as improved biodiversity which improves fishing grounds as well as improving water quality for water sports. Formation of Dale Seagrass Stakeholder group to communicate to local people news from the site. Successive dives to assess the status of the planting beds alongside continuous monitoring of biodiversity and carbon intake as a measure of benefits. Project based on 3 years of trials at the site. Availability of volunteer divers able to take part in monitoring work.
Novelty	Novelty as first UK seagrass restoration project. This was seen as a pilot project.
Weaknesses	Benefits are not always visible making it more difficult for stakeholders to engage. Monitoring shows that some of the planted lines have been dragged out of position reducing effectiveness.
Challenges	Ensuring renewed interest in the project for the future.
Gaps	Investigating and instigating ways to directly measure some of the unseen benefits of seagrass beds e.g. fisheries
6. Socio-economic	Benefits planned, maximising success, benefits realised
Strengths	As a young seagrass bed benefits not yet reached full potential e.g. acting as a fish nursery or maximising biodiversity. Latest stakeholder information suggests agreement by the community to add protections such as marker buoys / new moorings to prevent seagrass disturbance and to visit the site. Suggested these include a voluntary donation to fund children’s environmental activities.
Novelty	As the first project of its kind this will enhances the media presence of the area with particular benefit in the advertising of Dale as an environmental conscious area. Creation of a pilot Sensitive Ecosystem responsible Fisher Award in collaboration with local fishers
Weaknesses	NA
Challenges	NA
Gaps	NA

1. Name	**Seagrass Ocean Rescue Project**
7. Source	References
References	Pembrokeshire Coastal Forum (PCF). 2020. Restoring Seagrass in Dale - PCF. [online]. Unsworth, R.K.F., Bertelli, C.M., Cullen-Unsworth, L.C., Esteban, N., Jones, B.L., Lilley, R., Lowe, C., Nuuttila, H.K. & Rees, S.C. 2019. Sowing the Seeds of Seagrass Recovery Using Hessian Bags. *Frontiers in Ecology and Evolution*, 7. Pembrokeshire Coastal Forum. 2019. FAQs Seagrass Ocean Rescue Project. [online].

Case study B1 Seagrass Ocean Rescue Project: brief summary, ecology, structure, regulation, monitoring, socio-economic benefits and sources

1. Name	**ZORRO (ZOsteRa RestOration) Program**
Feature	Seagrass
Location	West coast, Sweden
Scheme type	Restoration, translocation and management
Timescales	2011 - ongoing
Objectives	To improve the environmental conditions of shallow coastal ecosystems through the development of new methods for the management and restoration of eelgrass habitats in Sweden. The research within Zorro is focused on: • Ecological causes of eelgrass loss and lack of recovery in NW Sweden. • Legal causes and ecological consequences for eelgrass of small-scale coastal exploitation in NW Sweden. • Economic valuation of eelgrass ecosystem services in NW Sweden. • Deficiencies in the Swedish legal management system of eelgrass and other coastal ecosystems and how it could be improved. • Developing methods and policies for compensatory mitigation to avoid net-losses of eelgrass affected by exploitation. • Developing cost-effective methods and guidelines for large-scale restoration of eelgrass in Sweden.
Organisation structure	University of Gothenburg, in collaboration with Swedish Agency for Marine and Water Management and Country Administrative Board of Västra Götaland. Partners include Stockholm University, University of Southern Denmark, Aarhus University, University of Groningen, Radboud University Nijmegen, NIOZ Royal Netherlands Institute for Sea Research and Åbo Akademi University.
2. Ecology	Objectives, habitat suitability, benefits, short term and long term risks (genetics, biosecurity, climate change, etc.), scheme and site selection, maximising success

1. Name	ZORRO (ZOsteRa RestOration) Program
Strengths	Focus on ecological causes of eelgrass loss and lack of recovery in North-west Sweden. Understanding for seagrass losses and historical habitats through extensive studies. Mapped historic areas of seagrass (determined through field surveys, remote sensing, drones and satellite imagery), where restoration is most likely to be successful. Used drones to determine area estimations of seagrass beds. Using divers/snorkelers to determine seagrass species and to avoid filamentous algal mats and perennial macro algae mats. Assessment of physical conditions – water depth and clarity - using light-loggers and waves and currents – and sediment samples. Conducted test-planting prior to large scale restoration – best method is a single shoot. Donor meadow with similar physical exposure sediment type and depth as the receiving site.
Novelty	Provided detailed technical guidelines on seagrass restoration. This includes site selection, harvest, planting and evaluation of the results.
Weaknesses	NA
Challenges	Finding an area suitable for restoration, water quality conditions have deteriorated in many areas where large historical meadows have been lost. Methods for eelgrass restoration using seeds have also been developed for Swedish conditions. However, seed methods cannot presently be recommended due to very high and variable losses of seeds, and high costs. Seed method also has a higher risk of failure and take two additional years to obtain a functional eelgrass meadow - estimated to cost two to three times more with available methods.
Gaps	NA
3. Structure	Site community cohesion, timing, funding, drawing on other programmes
Strengths	Perform large scale restorations of eelgrass and develop new measures that can improve the environment locally and facilitate restoration of eelgrass. Funding of the research program includes self-funding through the University of Gothenburg, the Swedish Agency for Marine and Water Management, Swedish EPA, County Administrative Board of Västra Götaland and through several research grants from the Swedish Research Council FORMAS.
Novelty	NA
Weaknesses	Both harvest and planting is done by hand, the method will likely limit the size of possible restoration projects to less than 10 hectares per year, which is a very small amount in comparison with the 1000s of hectares that has been lost along the Swedish west coast since the 1980s.
Challenges	General challenge of restoration work recognised as labour intensive, expensive and the results are many times uncertain
Gaps	Some of the methods may also be appropriate for the southern part of the Baltic Sea, but complementary studies will be needed before they could be recommended also for this area.

1. Name	**ZORRO (ZOsteRa RestOration) Program**
4. Regulation	Site / regional / national regulation, licensing, formal engagement and timing
Strengths	Aim to improve the protection of eelgrass in Västra Götaland Region. In 2015, the Växjö District Court ordered the Port of Gothenburg to compensate for the ecological consequences of their expansion in the harbour. The Port will plant a minimum of 1.7 hectares of eelgrass using scientific methods. Test planting began in 2016 and aim to finish in 2023. The progress will be reported to the court and to the Swedish Agency for Marine and Water Management (Green Maritime Transport, 2016).
Novelty	The handbook provides detailed technical guidelines for eelgrass restoration in Scandinavian waters and includes all important steps in the restoration process, from site selection and permit processes to harvest and planting of eelgrass, and monitoring and evaluation of results. The handbook forms part of the action program for Marine Environment Directive (Measures 29, 30 and 31; Marine and Water Authority) report 2015: 30). Developing cost-effective methods and guidelines for large-scale restoration of eelgrass in Sweden.
Weaknesses	NA
Challenges	To improve management of seagrass, as there as issues with applying legislation, where small impacts on eelgrass do not mediate a sufficient consideration.
Gaps	NA
5. Monitoring	Actual benefits, measuring success, communicating outcomes
Strengths	The research has resulted in both scientific publications as well as reports, guidelines and suggestion of policies for management and restoration of eelgrass in Sweden. Conducted test-planting prior to large scale restoration and monitored results. Visited after one month, two and a half months and eleven months the following Spring to allow for the effect of winter mortality to be included in the assessment. Long-term storage of nutrients and carbon are not fully obtained until 10 years or more after restoration and therefore should be monitored for at least 10 years. Measure shoot density and leaf morphology, as they are non-destructive variables.
Novelty	In addition to the handbook, there is also a four-part video available to support the guidelines available on YouTube to help with visualisation of restoration. Determined area extent of the meadow via drone, to monitor the development of the transplantation. At end of first and second grow season a few transplanted seagrasses are harvested to measure the growth of the individual. Counted side shoots and measured biomass – estimation of growth, which was used to determine expansion of planted meadow.
Weaknesses	NA
Challenges	NA
Gaps	NA

1. Name	**ZORRO (ZOsteRa RestOration) Program**
6. Socio-economic	Benefits planned, maximising success, benefits realised
Strengths	Project deliverables include the provision of estimates of the economic value derived from eelgrass ecosystem services in Sweden. Another is to recommend on how the Swedish legal system can be developed to further support a sustainable management of shallow coastal ecosystems. Informed locals of the restoration work to help prevent swimmers and boats form disturbing newly transplanted seagrass. The 2016 Handbook recommended that the administration focus on protecting the remaining eelgrass beds, and only as a last measure allows compensation restoration as a solution in exploitation – see Port of Gothenburg.
Novelty	NA
Weaknesses	NA
Challenges	Large-scale restoration of eelgrass in the Marstrand area can not presently be recommended due to the strong feedbacks preventing eelgrass growth. Therefore, new methods need to be developed, which could include harvesting or fencing off perennial algal mats, dampening the wave energy or stabilizing the sediment with artificial structures, or sand capping to decrease sediment resuspension (Moksnes et al., 2018).
Gaps	NA
7. Source	References
References	Green Maritime Transport. 2016. Eelgrass – the new key player. [online]. Eriander, L. 2016. Restoration and management of eelgrass (*Zostera marina*) on the west coast of Sweden. Doctoral Thesis. University of Gothenburg. Department of Marine Sciences. Moksnes, P-O., Gipperth, L., Eriander, L., Laas, K., Cole, S. & Infantes, E. 2016. Handbook for restoration of eelgrass in Sweden - Guidance. Swedish Maritime Administration, Report number 2016, 9, 146 (in Swedish). Moksnes, P-O., Eriander, L., Infantes, E. & Holmer, M. 2018. Local Regime Shifts Prevent Natural Recovery and Restoration of Lost Eelgrass Beds Along the Swedish West Coast. *Estuaries and Coasts*, 41, 1712-1731. ZORRO YouTube Channel 2017. [online]. ZORRO – Interdisciplinary research about management and restoration of eelgrass in Sweden. [online].

Case study B2 ZORRO (ZOsteRa RestOration) Program: brief summary, ecology, structure, regulation, monitoring, socio-economic benefits and sources

1. Name	**Eelgrass Restoration Project (seaside heritage program)**

1. Name	**Eelgrass Restoration Project (seaside heritage program)**
Feature	Seagrass
Location	Eastern Shore, Virginia, US
Scheme type	Restoration
Timescales	1997 – ongoing (long-term project)
Objectives	To understand why seagrass habitat was declining and how to restore seagrass population within the bay.
Organisation structure	VIMS, The University of Virginia, The Nature Conservancy, Virginia Marine Resources Commission, USACE and the Virginia Coastal Zone Management Program.
2. Ecology	Objectives, habitat suitability, benefits, short term and long term risks (genetics, biosecurity, climate change, etc.), scheme and site selection, maximising success
Strengths	Focus on history of the species and importance of habitat within the bays of Virginia's Eastern Shore. Habitat suitability models and historical records show that the eelgrass currently occupies only a fraction of its estimated historical distribution in these coastal lagoons. Importance of seagrass in playing role in mitigating the impacts of climate change. A patch of seagrass was discovered in 1997, this was used to determine that conditions in the bay were optimum for recovery of the seagrass. Numerous papers have been published in relation to work within this restoration project including work on genetic diversity, seedling establishment, turbidity and sediment suspension and modelling effects of climate change.
Novelty	VIMS invented a new approach for harvesting and distributing eelgrass seeds. The first blue-carbon feasibility study, which provides the potential for future implementation of a long-term carbon credit project. Identified from research that the best seeds are those that fall fast in the tanks; created a flume to separate seeds from those that were less favourable.
Weaknesses	Despite the success of eelgrass seeding efforts, many young seedlings fail to develop into adult plants.
Challenges	Limited resilience to increases in water temperature predicted from current climate change models.
Gaps	1) Understanding how different physical factors influence seedling establishment at different restoration sites; and 2) Investigating the potential importance of high-density, repeated seeding at promising restoration sites.
3. Structure	Site community cohesion, timing, funding, drawing on other programmes

1. Name	**Eelgrass Restoration Project (seaside heritage program)**
Strengths	Harvest seagrass during a 10-day window in Spring, using 40-60 volunteers. Volunteers have been used since 1999. Seeds are released into the bay in October, before they germinate in mid-November. Grants funded by numerous agencies, Coastal Programs of the Virginia Department of Environmental Quality, the Virginia Recreational Fishing License Fund, the American Recovery and Reinvestment Act, The Nature Conservancy, the USACE, the Virginia Department of Transportation, and private grants from the Allied-Signal Foundation, Norfolk-Southern, and the Keith Campbell Foundation for the Environment.
Novelty	NA
Weaknesses	NA
Challenges	Initially finding funding was challenging as prospective donor did not full appreciate the project aims / ambition and that these could infact be accomplished.
Gaps	NA
4. Regulation	Site / regional / national regulation, licensing, formal engagement and timing
Strengths	Located within the Nature Conservancy’s Volgenau Virginia Coast Reserve and within a Long Term Ecological Research (LTER) site.
Novelty	NA
Weaknesses	NA
Challenges	NA
Gaps	NA
5. Monitoring	Actual benefits, measuring success, communicating outcomes
Strengths	VIMS and The Nature Conservancy have since broadcast more than 72 million seeds into 600 acres to help accelerate the natural spread of eelgrass, which now covers almost 9,000 acres. Long-term monitoring of Virginia's restored eelgrass. At the early stages of the project transplants were used to test various hypothesis regarding the influence of environmental factors. The success of this restoration stems directly from the large-scale seeding efforts over time and indirectly through positive feedbacks that promoted resilience and recovery (Orth et al., 2020). Ongoing baseline studies by LTER scientists in the absence of eelgrass set the stage for understanding the subsequent ecological benefits of restoring eelgrass as a dominant species.

1. Name	**Eelgrass Restoration Project (seaside heritage program)**
Novelty	Generated a number of research papers on the findings and created guidelines for success which could be replicated elsewhere: • Transplanting eelgrass using shoots • Mechanised and manual transplanting of eelgrass • Mechanical seed planter for transplanting eelgrass • Innovative techniques for large scale seed based eelgrass restoration.
Weaknesses	NA
Challenges	NA
Gaps	Restoration is far from complete, and seeding is now focusing on bays where seagrass is currently not present.
6. Socio-economic	Benefits planned, maximising success, benefits realised
Strengths	Increase in seagrass habitat has resulted in commercial fish species appearing within the bay. Restoration of eelgrass to the coastal bays has led to recovery of key ecosystem services, including increased capture of solar energy and subsequent transfer up the food chain, greater removal of polluting nutrients, and more trapping of suspended sediments.
Novelty	The restored meadows are now self-sustaining. Project aims to co-restore scallops within the bay with support of local recreational fishermen.
Weaknesses	NA
Challenges	NA
Gaps	NA
7. Source	References
References	Malmquist, D. 2012. Eelgrass restoration aids overall recovery of coastal bays. VIMS. [online]. Orth, R.J., Bieri, J., Fishman, J.R., Harwell, M.C., Marion, S.R., Moore, K.A., Nowak, J.F. & van Montfrans, J. 2006. *A Review of Techniques Using Adult Plants and Seeds to Transplant Eelgrass (Zostera marina L.) in Chesapeake Bay and The Virginia Coastal Bays. Conference*. Seagrass Restoration: Success, Failure, and the Costs of Both. March 11, 2003. Sarasota, Florida. Orth, R.J., Lefcheck, J.S., McGlathery, K.S., Aoki, L., Luckenbach, M.W., Moore, K.A., Oreska, M.P.J., Snyder, R., Wilcox, D.J. & Lusk. B.2020. Restoration of seagrass habitat leads to rapid recovery of coastal ecosystem services. *Science Advances*, 6: eabc6434. VIMS. 2020. SAV: Restoring our Underwater Prairies [online].

Case study B3 Eelgrass Restoration Project: brief summary, ecology, structure, regulation, monitoring, socio-economic benefits and sources

1. Name	**Submerged Aquatic Vegetation (SAV) Program**
Feature	Seagrass
Location	Eastern Shore, Virginia, USA
Scheme type	Restoration (seed-based) and translocation.
Timescales	1984-2025 (long-term)
Objectives	Sustain and increase the habitat benefits of SAV in the Chesapeake Bay. Achieve and sustain the ultimate outcome of 185,000 acres of SAV Bay-wide necessary for a restored Bay. Progress toward this ultimate outcome will be measured against a target of 90,000 acres by 2017 and 130,000 acres by 2025.
Organisation structure	Chesapeake Bay Program in partnership with Maryland Department of Natural Resources, Maryland Department of environment, University of Maryland Center for Environmental Science, St. Mary's College of Maryland, VIMS, Virginia Department of the Environmental Quality, Virginia Marine Resources Commission, Virginia Coastal Zone Management Program, Old Dominion University, Department of Energy and Environment (District of Columbia), NOAA, USACE, U.S. Environment Protection Agency, U.S. Fisheries and Wildlife Service, U.S. Geological Survey and the Smithsonian Environmental Research Centre.
2. Ecology	Objectives, habitat suitability, benefits, short term and long term risks (genetics, biosecurity, climate change, etc.), scheme and site selection, maximising success
Strengths	Tracking advancements in the scientific understanding of underwater grass biology, ecology, genetics, restoration and other related topic. Encouraging local, state and federal partners to manage INNS that are detrimental to underwater grasses. Identified available and appropriate models for selecting restoration sites and reviewed historic records and photographic evidence. Aimed to plant or seed SAV each year in areas of the Bay deemed likely for success, this will in turn provide future seed sources and improve physical conditions for further SAV recruitment. Identified importance of protecting existing and recovering SAV.
Novelty	NA
Weaknesses	NA
Challenges	Climate change, shoreline hardening and stressors that reduce water clarity will continue to impact restoration success.
Gaps	Climate change research—assessing the potential impacts of climate change (e.g. sea level rise) as well as the influence of these impacts on SAV (e.g. how will sea level rise affect SAV?). Research is being conducted. Uncertainty around shallow-water use - conflicts and impacts from climate change and how these effect the Bay specific SAV restoration goals.

1. Name	**Submerged Aquatic Vegetation (SAV) Program**
3. Structure	Site community cohesion, timing, funding, drawing on other programmes
Strengths	NA
Novelty	NA
Weaknesses	SAV research is limited by funding availability.
Challenges	Efforts to monitor and restore underwater grasses cannot be sustained without continued support from funders.
Gaps	There is limited capacity to restore SAV and accelerate restoration goal attainment without engagement of additional organizations to assist with the effort.
4. Regulation	Site / regional / national regulation, licensing, formal engagement and timing
Strengths	Maryland, Virginia and the District of Columbia all have at least some regulations in place that protect existing SAV from harmful practices, including dredging and filling, nearshore construction and commercial fishing. SVA protection under Section 404 of the Clean Water Act (33 U.S.C. 1341-1987) and Section 10 of the Rivers and Harbors Act (33 U.S.C. 403). Potential impacts on Special Aquatic Sites, such as SAV, are considered in the permit review process. In the permit review and approval processes, special consideration is made for the protection and preservation of SAV.
Novelty	NA
Weaknesses	NA
Challenges	Enhance existing laws and regulations that protect underwater grasses in the Chesapeake Bay.
Gaps	Existing regulations may not be effective at protecting SAV as the resource recovers in the Chesapeake Bay. New threats and conflicts are emerging that may deem the current regulations ineffective, such as aquaculture, climate change impacts, and harvesting.
5. Monitoring	Actual benefits, measuring success, communicating outcomes
Strengths	Monitor submerged aquatic vegetation throughout the Chesapeake Bay and its tidal tributaries. Ariel Photography, ground surveys, mapping (and entered into GIS). The project has mapped 66,387 acres of SAV in 2019, which is 51% of the Chesapeake Bay Program's 2025 restoration target of 130,000 acres and 36% of the partnership's 185,000-acre goal. Convene annual, in-person meetings of the Submerged Aquatic Vegetation Workgroup to discuss priorities, review status updates and implement work plan actions.

1. Name	Submerged Aquatic Vegetation (SAV) Program
Novelty	Currently Developing “Small-scale SAV Restoration in Chesapeake Bay: A Protocol and Technical Guidance Manual” to promote collaborative restoration efforts throughout the Bay.
Weaknesses	The aerial survey cannot differentiate epiphytic algae on submersed vascular plants or differentiate many benthic marine algae species. Although the 66,387 acres mapped in 2019 is a 70% increase from the 38,958 acres observed during the first survey in 1984, it is a 17% decrease from the preceding 10-year average of 79,738 acres and a 38% decrease from 2018 when it was estimated that the Bay may have supported up to 108,078 acres of underwater grasses
Challenges	Many factors prevented complete mapping of SAV acres in 2018 which resulted in an estimate calculated by combining mapped acreage (99,511 acres) with 2017 data (8,567 acres) for the region that was not mapped to estimate the acreage in the Bay.
Gaps	NA
6. Socio-economic	Benefits planned, maximising success, benefits realised
Strengths	Use restoration activities to engage and educate citizen volunteers and further understanding of site selection criteria. Supported efforts to determine the economic value of the ecosystem services underwater grasses provide. Continuous seed bank restoration and planting will encourage the expansion of SAV propagule production facilities, increase expertise among restoration practitioners and provide opportunities for citizen and student engagement. Encouraged local, state and federal partners to consider and promote the habitat benefits and ecosystem services of underwater grasses, especially when handling nearshore and shallow-water use conflicts.
Novelty	Developed the Chesapeake Bay SAV Watchers Program, a monitoring program for volunteers and community scientists.
Weaknesses	NA
Challenges	The public perception of underwater grasses as a nuisance must be transformed if our restoration and protection efforts are to succeed. Effective communication could better engage this audience.
Gaps	Chesapeake Bay SAV Watchers Program has a limited number of watershed organisations involved and the program is primarily being conducted in Maryland. There are no groups in Virginia using the protocol.
7. Source	References
References	Chesapeake Bay Program: Submerged Aquatic Vegetation (SAV) [online]. Chesapeake Bay Program. Biennial Strategy Review System. 2020-2021 SAV Logic and Action Plan [online].

Case study B4 Submerged Aquatic Vegetation (SAV) Program: brief summary, ecology, structure, regulation, monitoring, socio-economic benefits and sources

1. Name	**Cornell Cooperative Extension Eelgrass Program**
Feature	Seagrass
Location	Several projects located within Long Island Sound, New York, USA
Scheme type	Enhancement, Restoration and Monitoring
Timescales	2004 – ongoing (several projects completed as part of the ongoing program)
Objectives	Main purpose is to restore and monitor eelgrass. To track the extent and monitor the health of existing eelgrass meadows as well as the historic distribution of meadows throughout Long Island. To conduct proactive restoration at appropriate sites around Long Island. To develop alternative sources of eelgrass planting propagules including seeds, transplants and nursery grown material. To develop innovative planting methods to restore eelgrass using both seeds and transplants. To conduct a limited amount of applied research on eelgrass ecology and restoration.
Organisation structure	Cornell Cooperative Extension's Suffolk County Marine Program. Cornell University, Suffolk County, National Fish and Wildlife Foundation, the Peconic Estuary Program, Natural Resources Conservation Service, save the Sound, STIDD systems, Long Island Community Foundation, New York State Environmental Protection Fund and Local municipalities.
2. Ecology	Objectives, habitat suitability, benefits, short term and long term risks (genetics, biosecurity, climate change, etc.), scheme and site selection, maximising success
Strengths	Restoration efforts in Long Island try to minimise impacts to remaining meadows and source adult shoots from those that are free-flowing or beach cast shoots which have washed up onshore. Collection of these "beach cast" shoots for restoration purposes is a low-cost and low-impact source of eelgrass transplants. There are several meadows around Long Island where eelgrass are uprooted by the combination wave energy and crab burrowing. Large numbers of viable plants can be collected that would otherwise end up drifting onto the adjacent beach or out into the open water. Surveys of the sound consisted of ariel photography, combined with field inspections to verify eelgrass presence and extent and gather information on the health of the bed. Site conditions throughout site need to be suitable for eelgrass, this includes using temperature loggers and light meters. Sediment samples were also taken at each site to identify the sediment types that support eelgrass. Project starts with a small test planting and then follows throughout a spring or autumn season, or ideally a full year overwinter.
Novelty	A modification of the free-planting method has been developed for the high energy environment of the Long Island Sound and some exposed areas in the eastern Peconic Estuary. In these areas, available rocks have been used to hold down small groups of adult shoots until they become rooted. The BuDS system developed by Cornell Cooperative Extension enables flower shoots to be taken directly from the field to the restoration site, where the flower shoots can drop naturally over time as they develop. New system of restoration using biodegradable discs of burlap so that volunteers can help with restoration to assemble planting units.

1. Name	**Cornell Cooperative Extension Eelgrass Program**
Weaknesses	NA
Challenges	Historic seagrass acreage in New York has not been documented. Identifying suitable seabed for restoration, identified muddy seabed conditions were not suitable.
Gaps	Approach to climate change and increased storm occurrence on restoration efforts.
3. Structure	Site community cohesion, timing, funding, drawing on other programmes
Strengths	Program notes to date the most successful method of planting eelgrass on the east coast of the US involves transplanting adult shoots. Seed collection during summer months through the use of scuba divers or snorkelers. Used similar methods to VIMS Eelgrass Restoration Project. Distribution of the seeds occurs in early fall by broadcast seeding via boat or by wading through the water. Funding for volunteer workshop provided by Atlantic Coastal Fish Habitat Partnership. National Fish and Wildlife foundation funding has been key expansion of eelgrass restoration activities.
Novelty	Opportunities for public involvement in the restoration of our local marine meadows through participation in Marine Meadows Program Workshops. The workshops provide an opportunity to understand the importance of marine meadows and gives an opportunity for members of the public to be involved in restoration.
Weaknesses	Abandoned a project in Hallock's Bay, Orient. Cornell Cooperative Extension had tried several times to restore broadcast eelgrass seeds there. Each time, the grass grew strongly and steadily until the hot weather of mid-summer caused the young shoots to all die.
Challenges	Funding for the program through public donations and fundraising.
Gaps	NA
4. Regulation	Site / regional / national regulation, licensing, formal engagement and timing
Strengths	New York State Seagrass Task Force established from 2006 legislation. Long Island Sound Conservation and Management Plan (2015) sets long term targets for the Sound, including an eelgrass extent target and improve water quality by 2035 to support healthy eelgrass. The eelgrass extent target is to restore and maintain 2,000 additional acres of eelgrass by 2035 from a 2012 baseline of 2,061 acres. Also, to continue eelgrass abundance surveys and promote eelgrass management. Long Island Sound Conservation and Management Plan includes a monitoring programme lead by the US Fish and Wildlife Service of eelgrass with periodic surveys to determine extent and health of vegetation every 3-5 years since 2002.
Novelty	Information from the ongoing program fed into the 2009 Taskforce Report to the Governor and Legislature, which led to the Seagrass Protection Act in 2012.
Weaknesses	NA

1. Name	**Cornell Cooperative Extension Eelgrass Program**
Challenges	NA
Gaps	NA
5. Monitoring	Actual benefits, measuring success, communicating outcomes
Strengths	Long-term eelgrass monitoring on Long Island began in 1997 to establish baseline data for eelgrass in the Peconic Estuary and monitor trends in eelgrass parameters for management and restoration activities. This includes, water quality and temperature, eelgrass health and shoot density to allow for comparisons between successive years Several of the projects as part of the restoration program is in the monitoring phase. The program also noted baseline monitoring to determine the health of existing eelgrass. Monitoring of planting units on a monthly basis for the first season to determine what has happened to the eelgrass if restoration is not successful. Website, newsletters and access to presentations, posters and research associated with the eelgrass program.
Novelty	Cornell's Eelgrass Program has developed an entire website that has become world renowned for information on eelgrass biology, ecology, restoration and importance.
Weaknesses	Time and resource for monitoring is dictated by funding.
Challenges	Population dynamics of eelgrass vary with the estuary in which they reside, the monitoring protocols may need to be modified slightly to accommodate the differences encountered.
Gaps	NA
6. Socio-economic	Benefits planned, maximising success, benefits realised
Strengths	Set up community outreach program to participants who are trained how to weave eelgrass shoots into biodegradable burlap planting discs. Previous project has combined seagrass restoration with scallop restoration.
Novelty	Volunteer-based water quality monitoring benefits all those involved, filling in data gaps and helping to identify areas in need of further study for scientists while increasing environmental stewardship, interest and knowledge to those who volunteer.
Weaknesses	NA
Challenges	NA
Gaps	NA
7. Source	References

1. Name	**Cornell Cooperative Extension Eelgrass Program**
References	Cornell Cooperative Extension Marine Program. 2020. [online]. Cornell Cooperative Extension of Suffolk County. n.d. Seagras.LI – Long Island Seagrass Conservation Website [online]. Long Island Sound Study. 2015. Comprehensive Conservation and Management Plan [online]. Riverhead News-Review. 2012. Eelgrass project abandoned, shellfishing spot to re-open [online].

Case study B5 Cornell Cooperative Extension Eelgrass Program: brief summary, ecology, structure, regulation, monitoring, socio-economic benefits and sources

1. Name	**Green Shore Salt Marsh Program**
Feature	Saltmarsh
Location	Dornoch Firth, Eden Estuary and Tay Estuary
Scheme type	Restoration and translocation
Timescales	2017 – 2020
Objectives	To investigated soft engineering materials combined with direct saltmarsh planting as a natural and cost-effective alternative to traditional coastal defences.
Organisation structure	Green Solutions, St. Andrews University partnership, Dornoch Academy
2. Ecology	Objectives, habitat suitability, benefits, short term and long term risks (genetics, biosecurity, climate change, etc.), scheme and site selection, maximising success
Strengths	Sites chosen by need for erosion control, proximity to donor site or currently as salt marsh habitat. Used a combination of donor and grown plants to increase survival rate/limit damage to donor site. Variety of species chosen for transplanting increasing biodiversity.
Novelty	First study to use bio-rolls to try and improve salt marsh restoration success. Created a dedicated coastal plant hub to supply the project.
Weaknesses	A number of risks involved with planting in the tidal zone e.g. plants being washed away or undergoing wave stress. Bio-rolls did not consistently increase transplanting success.
Challenges	Bio-rolls logistically difficult to install and maintain.

1. Name	**Green Shore Salt Marsh Program**
Gaps	Lack of evidence on ways to improve the survival rate of plantations whether that is part of the planting process or before. Make use of evolving technical expertise in soft engineering.
3. Structure	Site community cohesion, timing, funding, drawing on other programmes
Strengths	Preliminary studies in the Eden estuary to restore salt marshes which highlighted the need for soft engineering protection. Site selection also considered the protection of important resources e.g. golf course, municipal waste site, airfield. 300 volunteers invited to help including local schools and clubs. Strong government links with funding from the ministry of defence.
Novelty	Bio-rolls pioneered by Florida State University and similar strategy used for the restoration of UK riverbanks.
Weaknesses	NA
Challenges	Organising large amounts of volunteer work (9,000 hours) is very time consuming and should require a dedicated role to organise the effort. Locations often remote and hard for volunteers to reach.
Gaps	NA
4. Regulation	Site / regional / national regulation, licensing, formal engagement and timing
Strengths	Project works within the bounds of the UK Biodiversity Action Plan which highlights coastal saltmarshes as a priority habitat.
Novelty	Located within Eden Estuary SSSI and Local Nature Reserve which prioritises its saltmarsh habitats.
Weaknesses	NA
Challenges	NA
Gaps	NA
5. Monitoring	Actual benefits, measuring success, communicating outcomes
Strengths	Contributing to evidence base on the impact of soft engineering to improve habitat restoration. Bio-rolls contributed to sediment retention and stabilisation which could aid future planting schemes.
Novelty	Large volunteer base spreads the message about the importance of salt march restoration through the community

1. Name	Green Shore Salt Marsh Program
Weaknesses	NA
Challenges	Given decadal variations in weather patterns and estuary dynamics, a longer-term approach will be required to measure saltmarsh restoration success.
Gaps	The limited success of the project meant a large-scale long-term monitoring strategy was not developed.
6. Socio-economic	Benefits planned, maximising success, benefits realised
Strengths	Plans to continue planting these areas involves improvements to the original strategy e.g. allowing plants to mature more in polytunnels to increase resilience, removing summer and winter algal growth at the sites and repairing trampling damage.
Novelty	NA
Weaknesses	Long term benefits of flood defence will not be seen for a decade if initial planting survives at a high enough rate.
Challenges	Requires more experimental style work to find the most effective method of saltmarsh restoration before tangible benefits can be seen.
Gaps	NA
7. Source	References
References	Green Shores. 2020. Saltmarsh Creation for Natural Flood Defence in the Tay & Eden Estuaries & the Dornoch Firth.

Shore Salt Marsh Program: brief summary, ecology, structure, regulation, monitoring, socio-economic benefits and sources

1. Name	The Nigg Bay Coastal Realignment Project
Feature	Saltmarsh
Location	Nigg Bay, Cromarty Firth
Scheme type	Restoration
Timescales	February 2003 - present

1. Name	**The Nigg Bay Coastal Realignment Project**
Objectives	To allow the tide to re-establish saltmarsh habitat in the area to replace habitat lost in the past and prepare for future losses as a result of sea level rise.
Organisation structure	RSPB and SEPA (and NatureScot indirectly)
2. Ecology	Objectives, habitat suitability, benefits, short term and long term risks (genetics, biosecurity, climate change, etc.), scheme and site selection, maximising success
Strengths	A range of monitoring studies were undertaken to describe ecological development of site (i.e. surveys of overwintering waterbirds, benthic invertebrates, vegetation and sedimentation/erosion patterns) as well as impacts to saltmarsh habitats and benthic invertebrate communities outside the breached area. Very little saltmarsh has been lost outside the managed realignment site so any negative impact of the work has been small. Site selection was based on the area previously having salt marsh, largely undisturbed apart from draining which was abandoned and rough grazing. This location is also internationally important for wintering birds which has declined 36% between 1950 and 1997.
Novelty	NA
Weaknesses	Overall species diversity initially decreased with the reintroduction of saline conditions, but the number of saltmarsh species increased.
Challenges	NA
Gaps	NA
3. Structure	Site community cohesion, timing, funding, drawing on other programmes
Strengths	Funding sources included the Heritage Lottery Fund, NatureScot, SEPA, RSPB and the Miss EMP Scott Will Trust. Consultations with local communities and statutory bodies were undertaken.
Novelty	Scotland’s first ever managed coastal realignment, a 25 ha field known locally as ‘Meddat Marsh’ on the edge of Nigg Bay, was reconnected to the sea for the first time since the 1950s.
Weaknesses	NA
Challenges	Determining how best to breach the original sea wall while creating minimal impact on surrounding habitat.
Gaps	No studies of realignment had been undertaken in Scotland prior to this project.
4. Regulation	Site / regional / national regulation, licensing, formal engagement and timing

1. Name	The Nigg Bay Coastal Realignment Project
Strengths	Located within a Nature Reserve. Permissions sought and granted in relation to a variety of regulation e.g. through the Wildlife and Countryside Act 1981 for the alteration of a SSSI. A “design and impacts” study was undertaken to determine how the work would impact the surrounding environment. A full environmental impact assessment was not required by the authorities in this instance.
Novelty	As the first of its kind in Scotland there was no experience of the consents required, or the processes required for securing those consents, under the Scottish system.
Weaknesses	NA
Challenges	Determining which regulations where applicable to the site.
Gaps	NA
5. Monitoring	Actual benefits, measuring success, communicating outcomes
Strengths	A programme of monitoring the site has taken place for 15 years from before the breach to the present day creating a long-term data set. All monitoring plots, bar one, were saltmarsh 9 years after the breach. This colonisation has been quicker than expected and the new saltmarsh is now of the same composition as the surrounding areas.
Novelty	NA
Weaknesses	Monitoring largely undertaken by students as part of PhD’s and master’s projects. Duties not passed on once student projects were finished.
Challenges	After this initial 4-year period of monitoring, the frequency of monitoring was reduced due to lack of resources and requirement, monitoring that did occur largely consisted of winter bird surveys.
Gaps	NA
6. Socio-economic	Benefits planned, maximising success, benefits realised
Strengths	Over the past 10 years sedimentation has built up and a saltmarsh creek system have developed which are acting as better sea defences than the previous sea wall. Improving the quality and diversity of habitat in the nature reserve brings additional recreational and educational benefits, especially where it pertains to activities such as bird watching. This project has also brought economic savings as the previous sea wall (now breached) was eroded and would have required more regular maintenance, whereas the sea wall behind the marsh now is in good condition.
Novelty	NA

1. Name	**The Nigg Bay Coastal Realignment Project**
Weaknesses	NA
Challenges	NA
Gaps	NA
7. Source	References
References	Elliot, S. 2015. Coastal Realignment at RSPB Nigg Bay Nature Reserve. RSPB, September 2015, pp. 29. Elliot, S. 2017. Nigg Bay Coastal Realignment [online].

Case study C2 Nigg Bay Coastal Realignment Project: brief summary, ecology, structure, regulation, monitoring, socio-economic benefits and sources

1. Name	**Paull Holme Strays Managed Realignment**
Feature	Saltmarsh
Location	Paul Holme Strays, Humber Estuary (East Riding of Yorkshire)
Scheme type	Enhancement
Timescales	2003 – 2014
Objectives	Provide cost effective flood risk management for the area. Create intertidal habitat to compensate for that lost through implementation of this and other flood defence schemes in the middle estuary. Address additional habitat losses arising from coastal squeeze.
Organisation structure	Environment Agency
2. Ecology	Objectives, habitat suitability, benefits, short term and long term risks (genetics, biosecurity, climate change, etc.), scheme and site selection, maximising success

1. Name	**Paull Holme Strays Managed Realignment**
Strengths	The site was chosen due to its proximity to multiple nationally and internationally valuable sites which are important for waterbirds. The saltmarsh development appears to have been successful to date, with 29 of the 36 monitoring sites in the new saltmarsh supporting vegetation by 2007. Accumulation of sediment is such that in the future the elevation could be enough to extend this area. The Paull Holme Strays site has met its initial targets for supporting a wader population equal to or greater than that lost through direct land claim and coastal squeeze arising from flood defence works in the middle estuary.
Novelty	NA
Weaknesses	It is possible long-term development of the new mudflat into saltmarsh is likely to reduce the available habitat for certain benthic invertebrates and foraging birds.
Challenges	NA
Gaps	NA
3. Structure	Site community cohesion, timing, funding, drawing on other programmes
Strengths	Costing a total of £7,400,000 which is being funded by the Environment Agency. The project has created 80 ha of intertidal habitat, as of 2010 approximately 40 ha of mudflat and 30 ha of saltmarsh are on the site. The site is inundated on approximately 80% of tides.
Novelty	NA
Weaknesses	The area around the larger breach is silting up rapidly.
Challenges	NA
Gaps	NA
4. Regulation	Site / regional / national regulation, licensing, formal engagement and timing
Strengths	This project is part of the Humber Flood Risk Management Scheme which is using a combination of natural and man-made strategies to handle the issue. The site also is part of a Local Nature Reserve under UK legislation, and has multiple European designations including SPA and Ramsar protection.
Novelty	Site designated as an SAC after the conclusion of the project.
Weaknesses	NA
Challenges	NA

1. Name	**Paull Holme Strays Managed Realignment**
Gaps	NA
5. Monitoring	Actual benefits, measuring success, communicating outcomes
Strengths	A five-year monitoring programme began late 2003 to monitor accretion and erosion at the site, and to assess the development of intertidal habitat and associated assemblages, particularly benthic invertebrates, birds and vegetation. A subsequent five-year bird and benthos survey programme has been undertaken in a second phase, but at a reduced frequency. Three species have been recorded nationally, and in some instances internationally, important numbers in the managed realignment site, and the populations are regularly present at a level considered to be of importance within the context of the Humber Estuary SPA assemblage. Ongoing bird and mammal surveys occurring in the area.
Novelty	NA
Weaknesses	Potential impact from hikers and dog walking, assessed with a recreation disturbance study.
Challenges	The Paull Holme Strays site originally included areas within the lower tidal range, the rapid sediment accretion already experienced within the site suggests that over time, tidal inundation patterns and associated site function will alter changing the function of the site.
Gaps	NA
6. Socio-economic	Benefits planned, maximising success, benefits realised
Strengths	The new intertidal habitats (80 ha) within the managed realignment site are substantially larger than those of intertidal habitat expected to be lost in the short to medium term at a wider estuary level. Natural flood defence system which requires minimal maintenance once established, with ecosystem services such as, ‘flood water storage’ and ‘dissipation of tidal and river energy’. Natural flood defence can also improve water and sediment quality and reduce sedimentation in the main channel, which in turn reduces dredging requirements. It also provides ‘opportunities for recreation and tourism’ through becoming a tourist and bird watching attraction.
Novelty	NA
Weaknesses	NA
Challenges	NA
Gaps	NA
7. Source	References

1. Name	**Paull Holme Strays Managed Realignment**
References	Hemingway, K.L., Cutts, N.C. & Pérez-Dominguez, R. 2008. Managed Realignment in the Humber Estuary, UK. Institute of Estuarine & Coastal Studies (IECS), University of Hull, UK. Report produced as part of the European Interreg IIIB HARBASINS project. Mander, L., Cutts, N.D., Allen, J. & Mazik, K. 2007. Assessing the development of newly created habitat for wintering estuarine birds. *Estuarine, Coastal and Shelf Science*, 75(1-2), 163–174. Mazik, K., Musk, W., Dawes, O., Solyanko, K., Brown, S., Mander, L. & Elliott, M. 2010. Managed realignment as compensation for the loss of intertidal mudflat: A short term solution to a long-term problem? *Estuarine, Coastal and Shelf Science*, 90(1), 11–20. Sanders, K. & Davy, T. 2009. Humber River Management Scheme: Combined Annual Report. [online] Available at: http://humbernature.co.uk/admin/resources/annual-report-20082009.pdf. Accessed 11 February 2021.

Case study C3 Paull Holme Strays Managed Realignment: brief summary, ecology, structure, regulation, monitoring, socio-economic benefits and sources

1. Name	**Wallasea Island Wild Coast Project**
Feature	Saltmarsh
Location	Wallasea Island, Rochford, Essex
Scheme type	Managed realignment and regulated tidal exchange
Timescales	2006 - 2012
Objectives	To create new mudflat and saltmarsh in compensation for losses of similar coastal habitats following port developments. To enhance the coastal protection afforded the island, because its north bank was at risk of natural and unmanaged seawall breaching.
Organisation structure	RSPB, Environment Agency, Defra, CJT Ecology and Crossrail
2. Ecology	Objectives, habitat suitability, benefits, short term and long term risks (genetics, biosecurity, climate change, etc.), scheme and site selection, maximising success
Strengths	The project attempted to return the island back to being a mosaic of mudflat marshes and lagoons - as it had once been in the 14th Century, and to create a huge expanse of habitat for wildlife and birds, whose existing habitats are being damaged and lost because of climate change. A total of £750,000 on studies to prove that the project is feasible and acceptable both socially and environmentally.

1. Name	**Wallasea Island Wild Coast Project**
Novelty	Wallasea Island Wild Coast' is an RSPB flagship project and the most ambitious marine wetland restoration in Europe. The habitats are designed be reminiscent of those found in Mediterranean salinas (biodiverse coastal lakes used historically for salt production). These new habitats are designed to provide a suitable environment for more southerly bird species that are less common in the UK.
Weaknesses	The impact assessment has assessed the scheme to be of moderate beneficial significance to the ecological status of the area, including negligible to minor adverse effects on protected species. The only major ecological benefit is to shore birds.
Challenges	NA
Gaps	The scheme has very broad aims and is largely focussed on creating habitat for birds without true consideration as to how these habitats will be formed and how to make sure value is maximised.
3. Structure	Site community cohesion, timing, funding, drawing on other programmes
Strengths	Particular attention was paid to ensuring that the breaches would be stable over time and that the project would not cause major erosion within or outside the realigned area. Public consultations with Local Authorities, Yacht Clubs and local communities have helped develop the design and many of the suggestions were incorporated into the final design.
Novelty	This project involved raising the islands landforms which was done using material from London's Crossrail project (>3 million tonnes).
Weaknesses	Logistical issues with material handling equipment.
Challenges	£70 million to undertake the whole project which included multiple sites and large scale landform change.
Gaps	NA
4. Regulation	Site / regional / national regulation, licensing, formal engagement and timing
Strengths	Site is located within the Crouch and Roach Estuaries (Mid-Essex Coast Phase 3) SPA, Outer Thames Estuary SPA, Essex Estuaries SAC, Blackwater, Crouch, Roach and Colne Estuaries MCZ and within a Ramsar due to its wetland of international importance. This work was allowed within the SPA due to its benefit to increasing habitat for overwintering birds.
Novelty	In 2018 this restored habitat became officially designated when it was included within the Crouch and Roach Estuaries SPA and Ramsar wetland area.
Weaknesses	This project had more regulation to go through due to the infilling that was required to raise the land level of the site. The site required meeting the Essex waste plan and standards for construction waste as the material was sourced from Crossrail digging.

1. Name	**Wallasea Island Wild Coast Project**
Challenges	NA
Gaps	NA
5. Monitoring	Actual benefits, measuring success, communicating outcomes
Strengths	A five-year monitoring scheme was put in place to describe the ecological development of the site and to confirm if it meets compensation targets. Ecological surveys included overwintering waterbirds, benthic invertebrates, saltmarsh vegetation growth. An interim report published in 2010 preceded the release of the main report and suggested positive outcomes for benthic invertebrates (rapid colonisation), birds (relatively high overwintering numbers), and saltmarsh plants (100% plant coverage by 2010). In January 2020, a standard Wetland Bird Survey (WeBS) of this site showed that it supported 19,056 birds.
Novelty	NA
Weaknesses	NA
Challenges	NA
Gaps	Due to the focus not primarily being on saltmarsh restoration no monitoring of saltmarsh species colonisation has been commissioned.
6. Socio-economic	Benefits planned, maximising success, benefits realised
Strengths	Innovative new design elements should provide high value at low cost. The project is hoping to create a new hub for bird watching in the area including multiple hides and a visitors centre.
Novelty	By mirroring habitats already available in France and Spain, the project is anticipating the movement of more southern species into regions like Wallasea Island due to the impacts of climate change. The site is located near one of the world’s most important estuaries and one of Europe’s largest economic regeneration zones, the Thames Gateway. This project therefore offers a unique opportunity to restore natural habitats in a heavily commercialised region.
Weaknesses	NA
Challenges	NA
Gaps	NA
7. Source	References

1. Name	**Wallasea Island Wild Coast Project**
References	ABPmer. n.d. Non-Technical Summary. [online]. Coastal Management. 2016. Wallasea Island Wild Coast project (UK). [online]. Institution of Civil Engineers (ICE). 2012. Wallasea Island Wild Coast Project. [online]. Omreg.net. 2015. Jubilee Marsh (Wallasea). [online]. Omreg.net. 2018a. Dynamic Lagoons (Wallasea). [online]. Omreg.net. 2018b. Allfleet's Marsh (Wallasea). [online]. The RSPB. 2020. Wallasea Island Wild Coast Project. [online].

Case study C4 Wallasea Island Wild Coast Project: brief summary, ecology, structure, regulation, monitoring, socio-economic benefits and sources

1. Name	**Medmerry Managed Realignment Scheme**
Feature	Saltmarsh
Location	Medmerry (North of Selsey), West Sussex Coast
Scheme type	Managed realignment / restoration
Timescales	2012-2013
Objectives	The project aimed to provide coastal flood protection and to create a large expanse of coastal habitat.
Organisation structure	Environment Agency and RSPB (principal contractor was Team Van Oord and Jacobs carried out design)
2. Ecology	Objectives, habitat suitability, benefits, short term and long term risks (genetics, biosecurity, climate change, etc.), scheme and site selection, maximising success
Strengths	The site was selected due to it being natural mudflats before the embankment was built. The project has improved connectivity between this new reserve and Pagham Harbour nature reserve, as well as providing a stepping-stone between Pagham Harbour and Langstone and Chichester Harbours. A total of 183 ha of intertidal habitat, including mudflat, saltmarsh and transitional grassland was delivered. Water voles were translocated to the site to boost local populations. Improved/newly created habitat for birds, small mammals and fish.

1. Name	Medmerry Managed Realignment Scheme
Novelty	A pair of Black-winged Stilts bred successfully in 2014, only the third ever in the UK. The arrival of a large shoal of Smooth-hound Sharks was possibly unprecedented on the south coast. During 2014 and 2015 Medmerry had a fish 'index of diversity' comparable to Chichester Harbour, Pagham Harbour and Rye Harbour, despite being less than three years old.
Weaknesses	NA
Challenges	NA
Gaps	NA
3. Structure	Site community cohesion, timing, funding, drawing on other programmes
Strengths	The creation of the stakeholder group Medmerry Stakeholder Advisory Group (MStAG), and extensive wider community engagement the Medmerry project has given local people the opportunity to influence the creation and development of this reserve. The Group was involved in decision-making, agreeing project objectives and messages, as well as designing access routes, viewpoints and car parking facilities. The project team has worked with local voluntary groups and universities, to involve students in long-term monitoring of the habitat and species establishment. The evaluation of the site also identified several key archaeological finds from as early as the bronze age.
Novelty	It is the only open-coast managed realignment in the UK and remains (as of January 2020) the only such project to involve deliberately creating a breach through a mobile shingle barrier.
Weaknesses	NA
Challenges	NA
Gaps	NA
4. Regulation	Site / regional / national regulation, licensing, formal engagement and timing
Strengths	By creating intertidal habitat to compensate for European site loss elsewhere around the Solent, mitigated for the loss of freshwater SSSI and protects sensitive species and many different habitats, ensuring legislation is upheld. An EIA and Health Impact Assessment (HIA) where conducted. The project accomplished the goals of two major local government schemes: • The North Solent Shoreline Management Plan; and • South East Region Habitat Creation Programme.
Novelty	NA
Weaknesses	NA
Challenges	Anticipated future designation as SPA and SAC.

1. Name	**Medmerry Managed Realignment Scheme**
Gaps	NA
5. Monitoring	Actual benefits, measuring success, communicating outcomes
Strengths	The RSPB have set up a five-year rolling management plan that will ensure the scheme habitat and mitigation objectives are met, with an overall aim of maximising biodiversity across the site.
Novelty	The scheme has been designed to be resilient to sea level rise for at least 100 years. A genetic monitoring programme, undertaken in partnership with Brighton University, will provide valuable information about how well the founder population of water voles establishes itself.
Weaknesses	NA
Challenges	NA
Gaps	NA
6. Socio-economic	Benefits planned, maximising success, benefits realised
Strengths	The natural water storage of the saltmarsh prevents erosion and flooding (it will provide a higher standard of protection to 348 properties in Selsey, as well as key infrastructure). These natural methods require much less maintenance than the hard structures (£300,000 each year for its upkeep). Further social and health benefits have been found from using the area as a public access area. Natural beauty also attracts an increase in green tourism. Farmers have found that cows which graze on salt marsh grasses have a higher percentage of salt which is favoured by consumers, with meat attracting a high price. The fish nursery will help sustain the local fishing fleet. £90 million direct benefit.
Novelty	NA
Weaknesses	NA
Challenges	NA
Gaps	NA
7. Source	References

1. Name	**Medmerry Managed Realignment Scheme**
References	BBC Bitesize. 2021. Managed realignment – Medmerry, Sussex - Managing our coastlines – WJEC - GCSE Geography Revision - WJEC - BBC Bitesize [online]. Environment Agency. 2016. Medmerry Managed Realignment - Monitoring Update: Summer 2016. [online]. Gilham, A. (2014).Medmerry Managed Realignment Scheme SCOPAC Field Visit. [online]. Institution of Civil Engineers (ICE). 2012. Managed realignment at Medmerry, Sussex. [online]. Omreg.net. 2013. Medmerry. [online].

Case study C5 Medmerry Managed Realignment Scheme: brief summary, ecology, structure, regulation, monitoring, socio-economic benefits and sources

1. Name	**Steart Coastal Management Project**
Feature	Saltmarsh
Location	Parrett Estuary, Bristol
Scheme type	Managed realignment / restoration
Timescales	2012-2014
Objectives	To create intertidal wetland which can act as a flood defence and benefit the communities as a space for recreation and education.
Organisation structure	Environment Agency with advice and site management by Wildfowl and Wetlands Trust (WWT) (50-year site management lease). Designed and supervised by CH2M Hill, Construction was carried out by Team Van Oord.
2. Ecology	Objectives, habitat suitability, benefits, short term and long term risks (genetics, biosecurity, climate change, etc.), scheme and site selection, maximising success
Strengths	The project opened a (200m-wide) breach to the Parrett Estuary creating 262 ha of intertidal habitat, with 2.5 km of internal channels to allow for effective flooding and draining. The intertidal area extensive modelling was undertaken to evaluate the tidal inundation characteristics and assess the impacts on the surrounding estuary.
Novelty	

1. Name	Steart Coastal Management Project
Weaknesses	This site was largely chosen due to its potential for flood defence and being large enough to accommodate a large portion of the offsetting needed for developments elsewhere.
Challenges	Undergoing work where protected species were already inhabited permanently as well as disrupting the connectivity local habitats.
Gaps	No specific species or ecological community identified to benefit from this programme, largely the ecology of the plan is not communicated.
3. Structure	Site community cohesion, timing, funding, drawing on other programmes
Strengths	Instead of putting up fences to keep people away from the construction site the risks were communicated directly to the residence and visitors.
Novelty	This managed realignment forms part of one of the largest coastal wetland creation projects in the UK, the 'Steart Coastal Management Project'.
Weaknesses	Disrupted public access to the area when under construction as well as contending with local farming. Difficult to move worker and materials across such as large site.
Challenges	£20 million cost overall. Significant archaeological finds were identified on site which needed to be excavated with care and properly identified before further work could commence. Also, a problem with UXO was identified on the site.
Gaps	NA
4. Regulation	Site / regional / national regulation, licensing, formal engagement and timing
Strengths	Located within or in proximity to the Severn Estuary SPA and Severn Estuary/ Môr Hafren SAC. Local stakeholder engagement was undertaken from the start of the project to alleviate concerns. Furthermore, one of the key ways the community contributed was by creating a "community vision" for peninsula's marshland through engagement with community groups, technical groups and specialist volunteers. This helped eliminate potential objections. The project also made close links with the local councils to keep on top of planning permissions.
Novelty	NA
Weaknesses	NA
Challenges	Parts of the peninsula lie within the Severn Estuary SSSI, SPA, Ramsar Site and SAC all of which must be safeguarded. High value ecological and environmental interests meant that a close working relationship with Natural England was essential.
Gaps	NA

1. Name	**Steart Coastal Management Project**
5. Monitoring	Actual benefits, measuring success, communicating outcomes
Strengths	The site is meant to develop into a mosaic of different intertidal, brackish and freshwater habitats through natural erosion which will benefit a diverse variety of organisms. Throughout delivery, the project team offered regular updates to local people, and monthly progress meetings took place to ensure concerns and questions could be addressed.
Novelty	NA
Weaknesses	NA
Challenges	NA
Gaps	No studies or monitoring have been undertaken to identify if saltmarsh species are colonising the area with any particular success.
6. Socio-economic	Benefits planned, maximising success, benefits realised
Strengths	This project offered added flood protection to 83 homes, an important pylon line to Hinkley nuclear power station and Steart Drove, and the only road that links Steart village with surrounding communities. The natural defence also resulted in a financial saving on flood management.
Novelty	An attempt has been made to quantify the benefits of the site, based largely on habitat provision, education, recreation and tourism, food, and regulating services = £491000 - £913000
Weaknesses	
Challenges	Making compensation for a reduction of farming in the area.
Gaps	NA
7. Source	References

1. Name	Steart Coastal Management Project
References	da Silva, L.V. 2012. Ecosystem Services Assessment at Steart Peninsula, Somerset, UK. MSc Thesis, Imperial College London. Environment Agency. 2013. Steart Coastal Management Project: Update to South West Regional Coastal Monitoring Programme's Annual Partner's Meeting. [online] Available at: https://southwest.coastalmonitoring.org/wp-content/uploads/2016/02/Steart-presentation-to-SW-Coastal-Group-8-Oct-13.pdf. Accessed 18 February 2021. Institution of Civil Engineers (ICE). 2012. Managed realignment at Steart, Somerset. [online]. Omreg.net. 2014. Steart Marsh. [online]. Scott, J., Pontee, N., McGrath, T., Cox, R. & Philips, M. 2016. Delivering Large Habitat Restoration Schemes: Lessons from the Steart Coastal Management Project. *Coastal Management*. WWT. 2014. Steart Coastal Management Project completed. [online] Available at: https://wwtonline.co.uk/news/steart-coastal-management-project-completed. Accessed 18 February 2021.

Case study C6 Steart Coastal Management Project: brief summary, ecology, structure, regulation, monitoring, socio-economic benefits and sources

1. Name	Dune Restoration Project
Feature	Sand Dunes
Location	West Sands Beach, St. Andrews
Scheme type	Restoration
Timescales	2010 - ongoing
Objectives	Natural flood management approaches to manage erosion and flood risk within the dune system.
Organisation structure	The West Sands Partnership, Fife Coast and Countryside Trust, St. Andrews Links Trust, NatureScot, University of St. Andrews, Fife Council and Local landowners
2. Ecology	Objectives, habitat suitability, benefits, short term and long term risks (genetics, biosecurity, climate change, etc.), scheme and site selection, maximising success

1. Name	Dune Restoration Project
Strengths	Defined and mapped the sediment patterns and grain size distributions within the dunes and intertidal area in order to determine long term viability and success of the project. A donor site was identified that could withstand periodic sediment extraction without suffering long term consequences. Tens of thousands of tons of sand sourced from this donor site were used to re-profile the West Sands dunes and eroded sections of dune were re-instated. Access routes were re-laid, and sand fencing was installed. Volunteers planted marram grass to stabilize the dune system in the longer term. Fife Coast and Countryside Trust arranged days for volunteers to visit West Sands and transplant marram grass from other areas of the dunes in order to help stabilise the new sand deposits.
Novelty	As part of restoration the 'New Dunes from Old Trees' project uses old Christmas trees to temporarily stabilise restore sand dunes.
Weaknesses	NA
Challenges	NA
Gaps	NA
3. Structure	Site community cohesion, timing, funding, drawing on other programmes
Strengths	In 2010, a large-scale dune restoration project was completed at the Swilcan section, with tens of thousands of tonnes of sand used to re-profile the dunes. The natural processes of deposition and erosion within the dune system will continue to take place and the recharged dune areas will re-supply sediments back to the foreshore where they will eventually be returned to the donor site. From 2018 new sand dunes have been placed at three larger access points through the dunes in such a position to shield and protect back dune and infrastructure from direct tidal flooding. The original funding for this work was via the INTERREG Sustainable Coastal Development in Practice fund. Ongoing funding is provided by local council budgets; however, the key input continues to be provided by St. Andrews Links Trust. Volunteer groups spend time assisting with tasks, e.g. planting lyme and marram grass and removing INNS. Funding has also been provided from The Open Legacy project.
Novelty	In 2012 The West Sands Partnership agreed and published the Management Plan for the West Sands, St Andrews, from 2012-2025.
Weaknesses	NA
Challenges	NA
Gaps	NA
4. Regulation	Site / regional / national regulation, licensing, formal engagement and timing

1. Name	Dune Restoration Project
Strengths	Part of the Eden Estuary SSSI, the Firth of Tay and Eden Estuary SAC and European site; all work had to ensure conservation objectives were met. The Fife Coast and Countryside Trust have secured a licence to take sand from the beach at low tide to link the edges of blowouts together. This will allow sand to build behind them and the dunes to repair themselves. Agreement from Marine Scotland to allow the Links Trust to harvest a larger quantity of sand for the purpose of recharging the large blow out holes in the dune system. Received support from NatureScot on consents to Marine Scotland. Consent was requested and obtained for INNS (plants) removal along the West Sands dune system. Liaison with SEPA and NatureScot. [Note: Blow-outs are increasingly seen as a positive feature in most dune systems (depending on local context). They can locally rejuvenate decalcified systems, and provide valuable habitat for dune specialist species dependent on bare sand. Therefore, stabilisation of blow-outs should only occur where they threaten property, or a principal line of coastal defence.]
Novelty	To prevent damage to the dunes, fires and fireworks are normally prohibited on West Sands and permission should be sought from Fife Council.
Weaknesses	NA
Challenges	NA
Gaps	NA
5. Monitoring	Actual benefits, measuring success, communicating outcomes
Strengths	Monitoring carried out by Fife Coast and Countryside Trust has shown that since mechanical beach cleaning stopped Ringed Plovers have been breeding successfully at Outhead for the first time since 2005. Conservation grazing sheep herd provided since 2013 by local farmer. Site condition monitoring has also been undertaken by NatureScot, and noted dunes were ‘recovering’. Some management is required for the long-term sustainability of the restoration work, however the project has been designed to be as self–sustaining as possible. Project partners have accepted that dune restoration is part of the site management in the mid to longer term.
Novelty	Monthly visitor surveys as part of the West Sands Management Plan.
Weaknesses	NA
Challenges	NA
Gaps	NA
6. Socio-economic	Benefits planned, maximising success, benefits realised

1. Name	**Dune Restoration Project**
Strengths	Access to the dunes is now managed, with sensitive paths closed off, and there are now boardwalks and signed dune paths, providing access to the beach from the car park. Manual litter picking has replaced mechanical beach cleaning which means that the top layer of sand, including seaweed is left behind. This change in practice helps to preserve the nests of ground nesting birds, and provide natural obstacles around which sand can deposit, grasses colonize and ultimately new dunes develop. Local volunteers provided their time to replant the Swilcan section under the supervision of Fife Coast and Countryside Trust.
Novelty	Work in 2010 highlighted in the BBC's Countryfile programme. In 2019, 4000 Christmas trees were donated to the project from across Fife, Perth, Kinross and Tayside. The project involves more than 50 volunteers and staff.
Weaknesses	Using Christmas trees to temporarily stabilise blown sand can help to maintain vulnerable sections of leading dune ridge until sand-binding vegetation establishes, but should not be considered as a long-term measure.
Challenges	COVID-19 has resulted in the 'New Dunes from Old Trees' project being postponed to 2021.
Gaps	NA
7. Source	References
References	Natural Flood Management Network Scotland. n.d. Case Studies. West Sands Beach, St Andrews [online]. NatureScot. 2015. West Sands dunes transformed by unique partnership. News Releases. [online].

Case study D1 Dune Restoration Project: brief summary, ecology, structure, regulation, monitoring, socio-economic benefits and sources

1. Name	**Sands of Life Project**
Feature	Sand Dunes
Location	10 separate sites across Wales in Anglesey & Menai Strait, Meirionyddshire, Carmarthen Bay and Bridgend.
Scheme type	Conservation and Restoration
Timescales	2018 - 2022
Objectives	The aim of the project is to revitalise sand dunes across Wales.

1. Name	**Sands of Life Project**
Organisation structure	Natural Resources Wales
2. Ecology	Objectives, habitat suitability, benefits, short term and long term risks (genetics, biosecurity, climate change, etc.), scheme and site selection, maximising success
Strengths	The project will restore over 2400 hectares of sand dunes. This project contributes to the most at-risk habitat in Europe. Largely the aim is to remobilise the sand dunes so that their behaviour is more natural as well as removing invasive vegetation (sea buckthorn) and restore natural species. The increased management of the dunes hoped to remove the invasive non-native species, this will be done by people but also grazing by cows, ponies, and rabbits. Increases the habitat for Britain's rarest lizard, the sand lizard.
Novelty	The project will return the sites to favourable environmental status.
Weaknesses	Restoring the system to mobile conditions prevent the dunes contributing to carbon sequestration.
Challenges	NA
Gaps	NA
3. Structure	Site community cohesion, timing, funding, drawing on other programmes
Strengths	Restoring the sand dunes has many benefits such as acting as hotspots of biodiversity (especially for rare species), natural flood defences and supporting pollinators. 75% of the £4 million of funding is from the LIFE Programme of the European Union, with the Welsh Government providing 25% match funding. This project is working with partners to share its findings, partners include Dune LIFE Dynamic Dunescapes. At each site the project will be working with local partners and landowners. Public engagement will consist of 20 guided walks (2 at each site), 30 meeting (3 per site) as well as attending local events such as fairs.
Novelty	The project hopes to engage more than 3500 key members of the public through various media and engage at least 50 professionals from at least 10 partner organisations in dune ecology.
Weaknesses	Due to the scale of the project keeping all interested groups thoroughly informed is difficult, face to face contact is limited, largely a focus on digital communication.
Challenges	Removal of UXO.
Gaps	NA
4. Regulation	Site / regional / national regulation, licensing, formal engagement and timing

1. Name	Sands of Life Project
Strengths	The project will work within 4 separate SAC areas and numerous SSSIs which will require permission from the local authority to do the work. The outcomes of this project will help deliver objective 2 of the nature recovery plan of Wales as well as fulfilling responsibilities under the Conservation of Habitats and Species Regulations 2010. Strong government support.
Novelty	The plans submitted to the EU funding body had a section dedicated to how the project would limit its carbon footprint.
Weaknesses	NA
Challenges	NA
Gaps	NA
5. Monitoring	Actual benefits, measuring success, communicating outcomes
Strengths	Regular updates on the work including the impact of COVID-19 are available on the government website, including detail on what works are happening in each season. A large-scale before and after monitoring programme was built into the project, with work being undertaken by JBA & UKCEH to establish the ecological and physical characteristics of the site before and after the restoration including surveys of plants, invertebrates, and soil. Also, aerial 3D LIDAR imaging was taken of the site to establish the water level and dune shapes. Pre- and post- restoration monitoring are built-in to the project.
Novelty	A Citizen Science App has been developed in partnership with Plantlife and a similar large-scale restoration scheme operating in both England and Wales (Dynamic Dunescapes) to allow the public to assist with monitoring of multiple dune features after restoration takes place.
Weaknesses	NA
Challenges	Maintenance/updates on the project website only ensured up to 5 years after the project, possibility potential for neglect after the project finishes.
Gaps	No long-term monitoring in place, relying on unconfirmed support from universities or local authorities.
6. Socio-economic	Benefits planned, maximising success, benefits realised
Strengths	This project contributes to the Welsh Wellbeing Goals including enabling more people to enjoy the dunes, training new environmental managers, creating new economic opportunities and supporting traditional farming. Improving the sites will hopefully bring more visitors to the site boosting local businesses (surveys set up to assess this).
Novelty	By reinstating dune mobility and natural ways of grazing this should make the dunes mostly self-sustaining in terms of management.

1. Name	**Sands of Life Project**
Weaknesses	NA
Challenges	NA
Gaps	NA
7. Source	References
References	Natural Resources Wales. 2019. Sands of LIFE. [online].¶ LIFE Nature and Biodiversity. 2019. Technical Application Form. [online] Available at: https://gov.wales/sites/default/files/publications/2019-01/181017atisn12633doc2.pdf.

Case study D2 Sands of Life Project: brief summary, ecology, structure, regulation, monitoring, socio-economic benefits and sources

1. Name	**Coastal Dune Restoration Project**
Feature	Sand Dunes
Location	Point Reyes California, USA
Scheme type	Enhancement and restoration
Timescales	Started in 2015 and used spot spraying herbicides in Autumn 2016.
Objectives	To improve and restore 600 acres of coastal sand dunes to benefit species listed as threatened or endangered under the Endangered Species Act and remove INNS plants such as ice plant and European beachgrass on the Point Reyes Beach and along the Limantour Split. **Primary objectives:** • Remove non-native, invasive plant species from dune habitat where they interfere with natural physical processes such as sand movement and hydrology. • Remove non-native, invasive plant species from dunes to create conditions under which native species can flourish. • Minimize potential for non-native species reinvasion of restored habitat. • Increase potential coastal dune habitat for target threatened and endangered species affected by non-native, invasive plant species. **Secondary objectives – goals the park would like to achieve.** • Increase visitor understanding of natural dune processes. • Use adaptive management to inform and improve subsequent dune restoration efforts. • Increase opportunities for research into understanding the restoration of coastal California dunes.
Organisation structure	Point Reyes National Seashore, National Park service

1. Name	**Coastal Dune Restoration Project**
2. Ecology	Objectives, habitat suitability, benefits, short term and long term risks (genetics, biosecurity, climate change, etc.), scheme and site selection, maximising success
Strengths	Plan to eliminate carpets of ice plant and beachgrass with a combination of mechanical removal, manual removal, and spot spraying of herbicides. This combination should restore more dune area with less damage than the other options previously studied by Point Reyes National Seashore. Have previously restored 400 acres of dunes with varying methods and results, using lessons learned from for this restoration project. Restoring coastal sand dunes should make Point Reyes National Seashore more resilient to climate change and sea level rise. Restoration efforts would be focused within three coastal dune system areas as they are considered high priority for restoration. History of habitat and threated species from INNS plants. Noted that the dunes cannot naturally migrate due to INNS, making them most susceptible to climate change. Project also noted knowledge of the biology of INNS plants including rooting system. Mapping of current invasive plant boundaries and verifying boundaries of wetlands and special status plant species populations within proposed project areas. The park would coordinate planning efforts with ranchers to ensure the least amount of impact to ranch operations from implementation activities such as access, staging, and removal. Restoration of backdune areas would occur in a more phased approach that would allow more time for native vegetation to recruit into restored areas and, thereby, minimize potential for sand movement. Restoration of coastal dune habitat will aid in supporting threatened or endangered species such as the Western snowy plover, Myrtle’s Silverspot butterfly, Tidestrom’s lupine and Beach layia. Restoration option selected involves mechanical and limited herbicide treatment of INNS plants. Uses targeted herbicide control methods to remove these species.
Novelty	Used restoration experience of Abbotts Lagoon Restoration Project (2011-2015) within the Point Reyes to determine best methods. Project had to provide a variety of alternative restoration options for the Environmental Statement, the option selected was based on the greatest benefit with the least impact to park ranches and coastal resources.
Weaknesses	Attempt to remove INNS, rather than restore habitat, as Point Reyes National Seashore, recognises a return to historic conditions would be most likely infeasible given the number of changes in the ecosystem.
Challenges	Concerns on the use of glyphosate herbicide and the project's effects on nearby ranches. European beachgrass decomposes slowly.
Gaps	NA
3. Structure	Site community cohesion, timing, funding, drawing on other programmes
Strengths	Chemical control only occurred during appropriate weather conditions (i.e. low winds and fog during non-rainy days) with protective buffers established adjacent to wetlands, rare plants, nesting areas, and organic pastures and involved only a very controlled application of herbicide to target species using backpack sprayers with calibrated wands. Restoration timing was compared to important life cycle phases for both animals and plants.

1. Name	**Coastal Dune Restoration Project**
Novelty	Work during seasons, days, and times that won't harm sensitive plants, wildlife, and visitors. Lessons learned from pervious restoration project within Point Reyes noted herbicide treatment was very effective compared to mechanical removal, enabling survival of existing native plants.
Weaknesses	NA
Challenges	Monitoring of project will only continue for as long as funding allows. The Park Service relies on Federal appropriations to fund its core activities through base funding, although there is increasing use of alternative revenue sources, such as private monies and grants, to fund specific projects. Funding agencies typically prefer to award monies to projects that can show considerable benefit for reasonable costs. As a result, restoration project are limited in size due to funding constraints.
Gaps	NA
4. Regulation	Site / regional / national regulation, licensing, formal engagement and timing
Strengths	UNESCO designation Golden Gate Biosphere Reserve. Also contains a Ramsar designated Wetland of International Importance. Point Reyes is a National Seashore protected by the National Forest Service, allowing the continued operation of the 26 ranches established in the area. It is also the most recent site to be added to the University of California Reserves in partnership with the U.S. National Park as of August 2017. Any restoration work would be accomplished within the constraints imposed by laws, policies and sound management practices including environmental protection measures. Issued a Finding of No Significant Impact for the Environmental Assessment, which was prepared for this project in compliance with National Environmental Policy Act and released to the public for review under National Park Service Management policies. The Environmental Assessment was circulated to permitting agencies and other parties to review and comment on. Consultation with the U.S. Fish and Wildlife Service, California Coastal Commission, the USACE and the San Francisco Bay Regional Water Quality control Board.
Novelty	As the project required an Environmental Assessment, members of the public were able to comment on the Environmental Assessment including the proposed restoration methodology, and associated alternatives, and highlight any concerns e.g. ranchers and use of herbicides.
Weaknesses	NA
Challenges	The use of herbicides, mechanical equipment, and prescribed burning must conform to Occupational Health and Safety Act regulations, USEPA standards, California Department of Pesticide Regulation, and local air quality management district regulations. Impact avoidance and minimisation measures include closures of work areas; noticing of closures; strict weather restrictions on spraying and prescribed burning.
Gaps	NA

1. Name	Coastal Dune Restoration Project
5. Monitoring	Actual benefits, measuring success, communicating outcomes
Strengths	In the case of herbicide treatments, sprayed areas are surveyed during and immediately after work is performed to ensure that more than 99% of plants appear to have been treated based on the visible evidence of blue dye on the leaves. Park Service personnel inspect hand removal work while being performed to ensure that the proper amount of belowground roots and rhizomes are being removed. Plants installed in the backdune plots adjacent to ranch lands would be monitored to assess mortality of plantings and overall species establishment. Monitoring on the number of rare plants, western snowy plover nesting sites, induing nesting success and health of each plover, and presence of Myrtle's silverspot butterfly population. All restoration efforts require long-term follow-up to reduce INNS plant cover at less than 1%. The re-treatment approaches acknowledge that annual follow-up will be necessary for a number of years. Point Reyes National Seashore routinely adopts a long-term adaptive management program for its restoration efforts, continuing to look for ways to improve the efficacy of restoration efforts in future years.
Novelty	Monitoring of existing restoration projects, which Point Reyes National Seashore has worked on would continue as funding allows to determine the success in determining level of re-treatment necessary, as well as success in restoring native vegetation communities and progress toward recovering listed and rare species.
Weaknesses	NA
Challenges	Note it is often difficult to obtain separate funding for follow-up maintenance, but the project has emphasised maintenance of previously restored areas in its annual work plans and funding proposals.
Gaps	NA
6. Socio-economic	Benefits planned, maximising success, benefits realised
Strengths	Restore natural conditions and promote visitor understanding of coastal dune functions demonstrate a concerted commitment to an applied research-resource stewardship program. Public information measure by posting notices on the Point Reyes National Seashore website, at the Visitor Centre, and at trailheads.
Novelty	Restoration efforts are being coordinated closely with adjacent ranchers to ensure that dune restoration efforts have no or minimal impacts on ranch operations. Park staff consulted with ranch operators bordering the dune project areas to discuss pasture protection measures.
Weaknesses	NA
Challenges	Where dunes border active ranch lands dune restoration may be limited to the current dune extent and possibly even only the "oceanward" portion of dunes.
Gaps	NA

1. Name	**Coastal Dune Restoration Project**
7. Source	References
References	Point Reyes National Seashore. 2015. Coastal Dune Restoration Environmental Assessment. [online]. Point Reyes National Seashore. 2015. Finding of No Significant Impact. [online].

Case study D3 Coastal Dune Restoration Project: brief summary, ecology, structure, regulation, monitoring, socio-economic benefits and sources

1. Name	**Backdune Restoration Project**
Feature	Sand Dunes
Location	Nationwide, New Zealand
Scheme type	Restoration
Timescales	2011 – 2014
Objectives	To enhance the capacity of local communities and councils to undertake restoration of indigenous biodiversity in coastal backdune environments through: • extensive review of existing knowledge and experience • setting up demonstration areas and monitoring sites • providing practical guidelines for coastal groups, iwi, managing agencies and the wider community. The aim of this project is to produce and communicate guidelines that will empower communities to successfully design and undertake restoration of backdune environments.
Organisation structure	Coastal Restoration Trust (CRT), Ministry for the Environment, Coastal Care groups, iwi Trust, Department of Conservation and Councils.
2. Ecology	Objectives, habitat suitability, benefits, short term and long term risks (genetics, biosecurity, climate change, etc.), scheme and site selection, maximising success

1. Name	**Backdune Restoration Project**
Strengths	Understanding of ecology, complex ecosystems and awareness of coastal pressures and modifications e.g. human induced, grazing animals and INNS (plants). Project also acknowledges importance of dunes in climate change. A review of existing monitoring guidelines used in other ecosystems was completed and information was used in the development of a dunes monitoring system. A range of other monitoring methods used at the science and large-scale survey level were also reviewed. For assessing dune condition including vegetation cover, dune profiles, and impacts of users and pest animals, a Step-Point Method was developed, and field tested at demonstration sites. Restoration using seedlings and planting juvenile plants, and conducted trial transect planting. Following the planting every seedling was measured including height, crown spread and plant vigour. Plant protectors used to inhibit grazing, plants with protectors shown to have higher survival than those without.
Novelty	Produced a Coastal Restoration Handbook, which includes background information on dunes, planting practices and guidelines on monitoring. Restoration movement nationwide at eleven different locations.
Weaknesses	Trialled planting in high exposure sites which did not survive, some project sites recorded drought in the first two years of the project following planting which had a big impact on plant health and subsequent death.
Challenges	Almost a complete absence of useful guidance for restoration of backdune areas and this is an urgent need. INNS plants provided challenges and learning opportunities for transitioning from exotic to native vegetation communities. As the project is nationwide, each site has its own issues and a blanket approach was not suitable throughout.
Gaps	Project identified areas of drought and raises questions over species selection and finding drought resistant alternatives.
3. Structure	Site community cohesion, timing, funding, drawing on other programmes
Strengths	Considered one of the most successful community-based dune restoration programmes in the world. Planting occurs in the winter season. Funded by the Ministry for the Environment's Community Environment Fund in collaboration with local community Coast Care groups, councils, Trusts and the Department of Conservation.
Novelty	At a site in Wellington community groups were involved at establishment and monitoring or the project and groups readily participated in measuring planted seedlings and recording data. This involvement received positive feedback from the community groups.
Weaknesses	A number of projects had already started restoration works prior to the backdune restoration project. Therefore, some success may be from work undertaken using different techniques. Although for one of these sites a fire destroyed a lot of the earlier restoration work.
Challenges	Guidance reviewed were for other ecosystems and may not directly reflect dune restoration. Local community required guidelines on choice of species, selection of appropriate planting sites and methods for site preparation, planting and weed management.

1. Name	Backdune Restoration Project
Gaps	NA
4. Regulation	Site / regional / national regulation, licensing, formal engagement and timing
Strengths	Guidance and management. Field-based workshop, consultation and liaison in the development and testing of robust but user-friendly monitoring methods. Resource consent granted by local councils. The dune plantings and fencing will not require consents from councils. Permit is not required by the Department of Conservation to collect seeds and vegetative propagating material from areas that it administers under the following conditions: • That all plants raised from such collections are used solely for the purpose of restoration. • That no commercial gain is realised through the sale of plants. • The guidelines for collecting seed and taking cuttings are followed. • Biosecurity risks including weed and animal pests are managed. This means no new animal or plant pests are introduced to the site as a result of any activity associated with restoration.
Novelty	Field-based workshops with local communities and agency staff are a useful tool to review the history of a site and talk through the potential opportunities and expectations for backdune restoration.
Weaknesses	NA
Challenges	NA
Gaps	NA
5. Monitoring	Actual benefits, measuring success, communicating outcomes
Strengths	Developed user-friendly methods for measuring dune restoration initiatives including performance of plantings and effectiveness of maintenance of weed growth and pest animal control are under development. Project progress updates for newsletters and websites for CRT, Local Coast Care, councils, project partners. Monitoring comprised of trialling and reviewing at a minimum of 30 sites nationwide. Monitoring regularly over the first 1-2 years after planting by the local community to identify any issues e.g. rabbits or grazing. The backdunes project provided a template for monitoring to ensure information on species performance is maximised and the programme goals are achieved. Other monitoring techniques include beach profiles, vegetation transects and video monitoring. At many sites, monitoring consists of regular inspections of dune condition and keeping a regular photographic record of areas before and after restoration work and when there are major events (e.g. storms). A survival assessment will be carried out approximately three months following planting and a full reassessment one-year later.
Novelty	Published a scientifically robust guide in the form of two articles for the CRT Coastal Restoration Handbook aimed at: • quantifying the current status of dunes, and • determining whether restoration programmes are meeting objectives (including data storage, analysis). These were made available on the CRT and relevant management agency websites.

1. Name	**Backdune Restoration Project**
Weaknesses	As projects are located nationwide, some of the monitoring has varied between sites. Some are providing 1-2 years of data while others are providing up to five years.
Challenges	Vegetation and management issues including rabbits, sand fencing, control of INNS.
Gaps	NA
6. Socio-economic	Benefits planned, maximising success, benefits realised
Strengths	An educative process that can be used to raise community awareness of likely coastal hazards including sea-level rise and potential impacts. The project enables communities to design and undertake successful restoration of backdune environments. The work enhances natural protection against coastal hazards. Changes in beach user attitudes and behaviour, with community-based partnerships shown as highly effective in developing public understanding of the importance of health dune systems and management required to maintain it.
Novelty	Community based coastal restoration work now includes more emphasis on backdunes as well as foredunes.
Weaknesses	Project noted that efforts to educate the public on the ultimate goal of dune restoration could be improved / increased.
Challenges	NA
Gaps	NA
7. Source	References
References	Coastal Restoration Trust of New Zealand. 2011. Restoration of Coastal Sand Dunes Using Native Plants: Technical Handbook. Practical Guide for Coastal Communities Adapting to Climate Change. [online]. Coastal Restoration Trust of New Zealand. 2014. Restoration of Indigenous Biodiversity on Coastal Backdunes. Dune Restoration Trust of New Zealand [online]. Northland Regional Council. 2010. Restoration Guidelines for the Ahipara Recreation Reserve, Mapere Block. [online].

Case study D4 Backdune Restoration Project: brief summary, ecology, structure, regulation, monitoring, socio-economic benefits and sources

The marine and coastal enhancement projects within Scottish inshore waters - guidance on scoping a proposal page is available.

To download the project assessment form please go to the marine and coastal enhancement projects in Scottish inshore waters - project assessment form page.