Identifying and prioritising marine nature recovery (MNR) opportunities

A scoping report for Cornwall Wildlife Trust

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Executive Summary

This report addresses how we might spatially map and prioritise marine nature recovery (MNR) opportunities as part of an extension of the Local Nature Recovery Strategy (LNRS) to cover marine and coastal areas of Cornwall and the Isles of Scilly. It considers whether the approach adopted as part of Cornwall LNRS pilot could be applied to MNR. The approach used conservation planning tools and a natural capital framework to spatially prioritise habitat restoration opportunities.

The report finds that such an approach is indeed valid to MNR, but that its realisation faces significant challenges. These challenges reflect the dynamic and interactive nature of marine and coastal environments. There is also considerable uncertainty about the adequacy of available spatial data to capture how the costs and benefits of MNR vary across the seascape.

Any realisation of MNR requires extensive stakeholder engagement and collaboration due to the complex governance and legal framework. Many of the socioeconomic and cultural factors that influence the distribution of the costs and benefits of MNR are not readily reduced to spatial data. Nonetheless, the spatial prioritisation of MNR opportunities, as part a wider decision-making process, could bring significant benefits given the high costs and high potential benefits of MNR.

As a result of the uncertainties about the adequacy of existing data sources and methods, the reports recommends that MNR mapping is not <u>immediately</u> undertaken for the whole of Cornwall's & IoS inshore waters.

Instead, this report recommends engagement with, and steering of, current and planned activities to address many of the uncertainties associated with MNR. These activities include:

a. Natural England's marine Natural Capital Environment Assessment for Cornwall.
b. Development of the ERCCIS Marine Data Hub.
c. Delivery of the Isles of Scilly Local nature recovery strategy.
d. NERC marine research focussed on waters around the Isles of Scilly.
e. Existing marine and coastal nature recovery projects in Cornwall and the IoS.
f. Next iteration of the Local nature recovery strategy for Cornwall.

These activities will augment the available evidence base, expertise and stakeholder engagement required for successful MNR mapping and prioritisation.

The report also recommends particular attention is given to the following aspects of the evidence base to inform MNR mapping:

a. Compilation of species of conservation and economic importance.
b. Marine and coastal habitat mapping.
c. Spatial indicators of exposure to risks and pressures.
d. Methods for mapping the relative benefits of key ecosystem services.
e. Assessment of existing maps of potential habitat restoration sites.

1. Background and Purpose

1.1. Cornwall Local Nature Recovery Strategy

Local Nature Recovery Strategies (LRNS) are an England-wide system of spatial strategies, introduced by the Environment Act[1] (Defra, 2021b, section 104), that will establish priorities and map actions to drive nature's recovery and provide wider environmental benefits.

The purpose of the LNRS is to help reverse the ongoing decline of nature and biodiversity in England. To this end, the LNRS will enable the public, private and voluntary sectors to work more effectively together for nature's recovery. This work is to be focussed on where it will have the most benefit for biodiversity while also achieving wider environmental objectives.

The production of the LNRS is intended to be evidence-based, locally led and collaborative. Key elements of the LNRS are the agreement of nature recovery priorities, the mapping of existing local habitats of particular importance for biodiversity (including statutory and non-statutory protected sites) and the mapping of recovery opportunities that restore habitat, biodiversity and achieve wider environmental goals. The mapping of existing sites of high nature value together with nature recovery and restoration opportunities form the local Nature Recovery Network (NRN). In emphasizing restoration, LNRS' reflect international initiatives that include the UN decade of ocean science for sustainable development (2021-30) and the UN decade of ecosystem restoration (2021-30).

Cornwall was among five Local Nature Recovery Strategy pilots funded by Defra that ran from August 2020 to May 2021. Among the outputs of the pilot were a draft NRN and associated opportunity maps identifying priority areas for the restoration of woodland, heathland and wetland habitats. These draft outputs, and associated data layers, were made publicly available on the Lagas mapping platform[2].

1.2. LNRS and the marine and coastal zones

The statutory scope of the LNRS covers all land above the mean low water line. In response to stakeholder views, the draft Cornwall LNRS included reference to marine opportunities for nature recovery. It observed that the exclusion of these opportunities ignores how terrestrial

[1] https://www.legislation.gov.uk/ukpga/2021/30/part/6/crossheading/local-nature-recovery-strategies/enacted

[2] https://lagas.co.uk/app/

and marine environments form an inter-related continuum across the coastal zone (Christie et al., 2021).

Any extension of the Local Nature Recovery Strategy to the marine zone will need to address how existing Marine Protected Areas (**Box 1**) are managed and expanded for nature conservation, the restoration of habitats within and outside of the MPA network, restoring and expanding 'blue carbon' assets and the ecosystem services they provide, and enabling people to enjoy and understand marine nature (Christie et al., 2021).

Any attempt to map nature recovery opportunities across marine and coastal waters will need to address the unique characteristics of these zones, the availability and quality of data available and the suitability of analytical tools for the task.

1.2.1. Defining marine nature recovery opportunities

In this report, we consider the identification and prioritisation of marine nature recovery (MNR) opportunities. We assume that these opportunities will be primarily driven by biodiversity gains, but also informed by ecosystem service benefits.

Biodiversity benefit may be conceived and realised in terms of the diversity and abundance of species, the size, quality and connectivity of their habitats, or the removal of invasive species. Ecosystem services may range from carbon capture and water quality management to the provision of fishing stocks and benefits in social wellbeing.

The pervasiveness and significance of human impacts on marine ecosystems and biodiversity, means that protecting remaining biodiverse habitats or managing activities that affect them will not suffice. The realisation of MNR opportunities will require 'passive' and 'active' measures (Perrow & Davy, 2002) to restore what has been lost:

- **Passive or 'indirect' restoration** mitigates the pressures of adverse human activities and environmental 'stressors' or 'pressures' on ecosystems and improves conditions to enable and facilitate natural restoration. Mitigation may be either on-site or distant from the nature recovery site.
- **Active or 'direct' restoration** involves the re-introduction of species often combined with the restoration of hydrological and substrate conditions (Christie et al., 2021; Saunders et al., 2020). Seagrass, saltmarsh and native oyster beds are among habitats that have been successfully regenerated in areas from which they have disappeared or created at entirely new but suitable locations (Preston et al., 2020; Hudson et al., 2021; Gamble et al., 2021).

In terms of the goals of restoration, we currently lack an effective baseline or examples of biodiversity or habitats that have not been degraded by the history of human activities affecting the marine zone. The concept of an 'extinction debt' (Tilman et al., 1994) underlines how many of the impacts on biodiversity caused by historical damage and fragmentation of ecosystems are still being realised.

1.3. Purpose and scope of this Report

This desktop report builds on the Cornwall pilot LNRS (*Cornwall Nature Recovery Strategy Pilot Draft v1.5*, 2021), the *Marine Nature Recovery – first steps* report (Christie et al., 2021) and the 3Cs report on coastal partnerships (Curry, 2022) to consider how we might spatially map and prioritise marine opportunities for nature recovery. In particular, it will consider the suitability of adopting a similar approach to that taken for Cornwall's terrestrial opportunity mapping and explore what alternative approaches may be applicable.

Given the impending marine Natural Capital Ecosystem Assessment (mNCEA) for Cornwall and the Isles of Scilly to be undertaken by Natural England, the report will also consider how opportunity mapping and prioritisation can fit with a wider Natural Capital approach.

The report structure is as follows:

- Outline the approach and methodology used in the Cornwall LNRS for the prioritisation and mapping of nature recovery opportunities.
- Describe how marine opportunity mapping fits within a wider Natural Capital approach to identifying and managing marine and coastal natural assets and services.
- Consider how the characteristics of marine and coastal ecosystems differ from the terrestrial systems and the implications for marine opportunity mapping.
- Consider the sufficiency and quality of marine and coastal data, and available analytical tools, to support a spatial prioritisation of nature recovery opportunities.
- Recommendations for realising the prioritisation and mapping of marine and coastal nature recovery opportunities.

The report will consider the mapping of nature recovery opportunities for the coastal and inshore marine environments (0-12 nautical miles below MHWS) of Cornwall and the Isles of Scilly, including the relationship to the intertidal and terrestrial coastal environments. We consider opportunity mapping to include both designated Marine Protection Areas (MPAs) and the wider seas between MPAs. The report does not consider how marine recovery opportunities may be monitored or assessed.

Box 1: Marine Protection Areas (MPAs)

Approximately 34% percent of Cornwall's inshore seas currently benefit from some form of legislation that seeks to protect species and habitats from damage and disturbance. Cornwall MPAs are of the following types:

- Marine Conservation Zones (MCZ) – twenty-two sites were created within Cornwall's inshore waters (eleven around the Isles of Scilly) under the Marine and Coastal Access Act 2009 with the aim to protect nationally important marine wildlife, habitats and seabed features.
- Two types of European Marine Sites designated under EU Legislation to protect wildlife and habitats that are important at a European level:
    - Special Areas of Conservation (SACs) - seven areas in or bordering Cornwall were designated under the EU Habitats Directive,
    - Special Protection Areas (SPAs) - two areas in Cornwall were designated under the EU Birds directive and form part of the European-wide Natura 2000 network of internationally important sites.

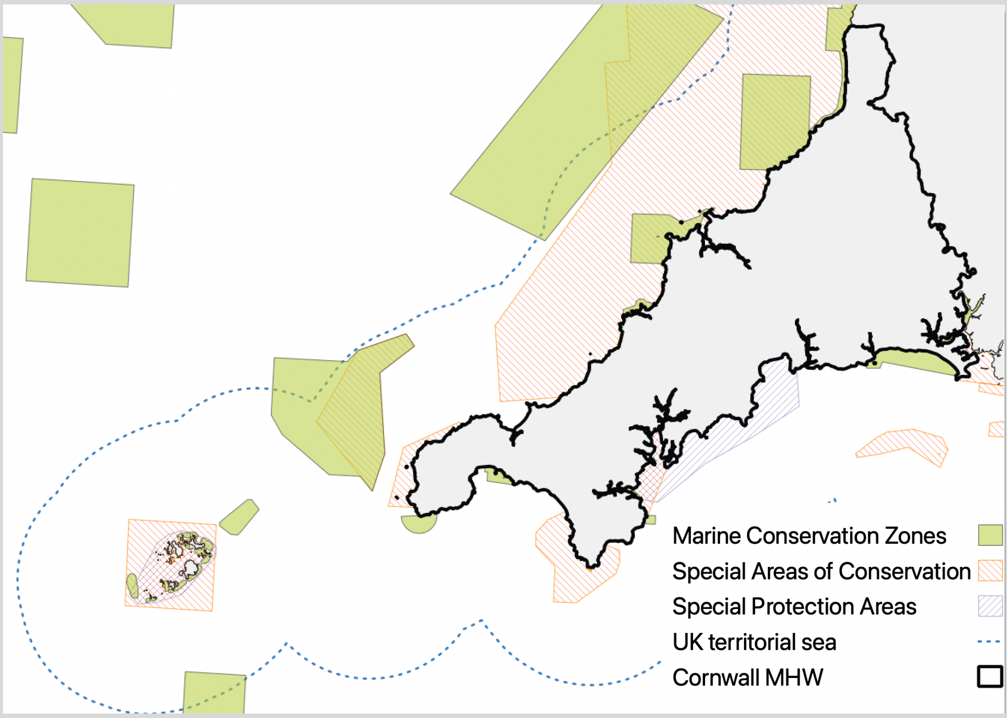

Figure 1.1: Marine Protection Areas in and around Cornwall inshore seas. Only areas below MHW shown.

2. Cornwall draft Nature Recovery Network mapping

As outlined in HM Government 25 Year Environment Plan and the UK Environment Act (Defra, 2021b), a spatially-explicit Nature Recovery Network (NRN) is an essential element of a LNRS. The purpose of the NRN is to help deliver the Lawton report 's recommendations that wildlife requires more habitat, in better condition, in bigger patches that are more closely connected (Lawton et al. 2010). NRN mapping is intended to include the following elements:

- existing statutory protected sites and specific unprotected areas of biodiversity importance[3] that form the core of the network:
- opportunities for recovering or enhancing biodiverse habitats while taking into account other environmental benefits.

In the draft Cornwall NRN these elements defined distinct strategic planning zones for use with Cornwall Council's Net gain and Biodiversity off-setting planning tool. These zones comprised an "Existing Nature Network", identifying the most important protected and non-protected areas of Cornwall in terms of biodiversity and the provision of key ecosystem services, and "Habitat opportunity maps" of areas of mainland Cornwall for the restoration of key habitats (**Figure** 2.1).

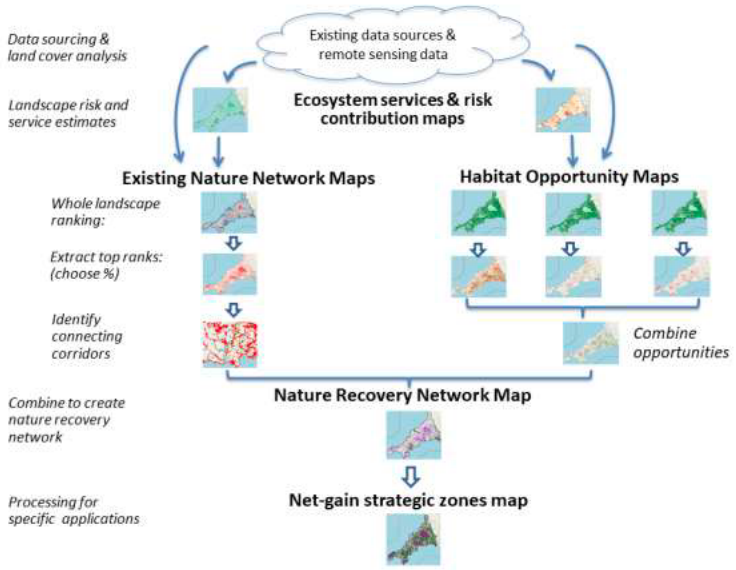

Figure 2.1: Outline of the work-flow for mapping the nature recovery network and the relationship between different mapping products viewable on Lagas.

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[3] Currently restricted to County Wildlife Sites and areas of 'irreplaceable habitats' as defined by the National Planning Policy Framework (Defra, 2023)

A conservation planning approach was used for the mapping of the existing nature network and habitat restoration opportunities. The mapping of restoration opportunities involved:

- **(i)** Selection of the types of habitat for restoration.
- **(ii)** Identification of spatially varying characteristics that affect suitability, likely costs or benefits of restoration.
- **(iii)** Definition of the size, extent, resolution and parameters of the spatial prioritization.
- **(iv)** Spatial prioritisation of potential restoration sites for each chosen habitat.

Additional analyses were performed to assign overlapping opportunity areas to a single opportunity type (based on their respective prioritization) and definition of strategic zones.

2.1. Selection of habitat types

Woodland, heathland and wetland habitats were selected based on the potential biodiversity gains, ecosystem service provision, and a theoretical basis and practical means to perform spatial prioritisation. A theoretical basis was provided when the costs or benefits of habitat restoration are known to be determined by multiple, spatially varying factors. Such factors might be abiotic conditions, demand for ecosystem services or existing habitats and landcover. A practical means depended upon the availability of suitable spatial data to describe variation in these same factors. Therefore, seminatural grasslands were not included among the chosen habitats because of a lack of sufficient, spatially varying criteria and data that could be used to prioritise and map opportunities.

2.2. Identification of spatially varying factors

Data sources, or methods to calculate, key factors affecting the suitability of restoration opportunities were identified for:

- Existing areas of the selected and associated habitats (landscape context) that determine potential benefits from greater connectivity or size of habitats.
- Relative indicators of the value of spatially varying ecosystem service benefits.
- Other spatially varying factors that facilitate or constrain habitat restoration by affecting the cost, time or likelihood of success.

Decisions on which factors to include were also informed by the role of opportunity mapping within the wider decision-making process. Therefore, most opportunity costs were excluded as many of these factors, such as potential use of the site for agriculture or development, would be captured by the wider decision-making framework.

2.3. Definition of the parameters of the spatial prioritisation.

The extent and resolution of prioritisation analysis was largely determined by the resolution of available data informing the prioritisation and strategic goals of the mapping. A weighting was attributed to each benefit, facilitating and constraining factor identified in step (ii) as a reflection of their relative importance in determining suitability. Weightings reflected expert opinion on the importance of factors and the reliability of the underlying data.

2.4. Spatial prioritization of potential restoration sites

The entire potential landscape for habitat restoration was ranked using Zonation conservation planning software (Moilanen et al., 2005). The ranking reflected trade-offs between the potential benefits of restoration, facilitating and constraining factors. Higher rankings were generally associated with locations that provided multiple benefits or were characterised by multiple facilitating factors.

2.5. Reflections and lessons-learnt

A review (Defra, 2021c) of all pilot LNRS schemes identified a number of challenges to the delivery of NRNs. To these can be added some additional issues encountered during Cornwall's pilot NRN mapping.

- **Stakeholder engagement** - the review of pilot schemes (Defra, 2021c) states that the mapping of opportunity areas should be a transparent process with the participation of local partners. However, it also acknowledges that the outputs of more complex methods and modelling can help generate initial proposals for discussion. Likewise, the pilot NRN for Cornwall was envisaged as indicative rather than prescriptive, offering a starting point for consultation on nature restoration opportunities. Nevertheless, wider consultation with stakeholder groups could have informed many steps of Cornwall's NRN mapping; from the identification of restoration priorities to identification and weighting of the factors affecting the suitability of sites for restoration. The benefits of wider consultation, however, need to be weighed against time and resource implications.
- **Data availability** - presents a major challenge to analytical approaches to NRN mapping. Cornwall's pilot NRN approach focussed on broad habitat types as there was limited data describing species distributions or the location and quality of certain habitats such as seminatural grassland. The site characteristics considered were primarily abiotic factors affecting restoration suitability, with no consideration of

biotic interactions that might affect success. The spatial mapping of ecosystem service benefits was also restricted to a few key services due to the complexity of the processes involved. Given appropriate data and/or models describing species distributions, the prioritisation could be driven by habitat requirements of multiple species and incorporate species-specific connectivity benefits and biotic interactions as appropriate.

- **Site characteristics and landscape context** – although most of the criteria informing opportunity prioritisation were site characteristics, a conservation planning approach can capture potential benefits of restoration to existing habitat areas and their connectivity. Methods used to calculate ecosystem service benefits also captured benefits spatially distant from the potential restoration site. Nevertheless, not all the effects of the wider landscape are readily captured. The value of flood or water pollution mitigation for a given site, for example, will be affected by significant habitat change or restoration elsewhere within the same catchment. Opportunities that address an entire catchment, for example, might be better considered as an ensemble of inter-dependent measures.
- **Prioritisation can only indicate potential suitability –** particularly when considering broad habitat types, there is an assumption that the type of habitat and methods of restoration will be adapted to the conditions of any given location. Many of the factors determining the most appropriate method of restoration are unlikely to be captured by available spatial data or the chosen resolution of prioritisation.

2.6. Summary points

- Production of Cornwall's draft NRN demonstrated the application of a conservation planning approach to spatially prioritise habitat restoration opportunities.
- The approach captured the effects of site characteristics and aspects of the wider landscape context that determine suitability and potential benefits.
- Key challenges to the approach are the adequacy of spatial data and representing how the value of ecosystem services can vary across the landscape.
- The outputs of the approach need to be integrated within a wider decision-making framework and process of stakeholder engagement.

3. Nature Recovery within a Natural Capital Framework

In the 25-year Environment Plan the UK government expressed the intent to use a 'natural capital' approach as a tool to help make key choices and long-term decisions (Defra, 2018).

A natural capital approach provides a common framework to consider scientific, social and economic evidence about the value of the natural environment to inform decision-making. In its guidance on a natural capital approach (Defra, 2021a) describes it as "*thinking of nature as an asset, or set of assets that benefit people. The ability of natural capital assets to provide goods and services is determined by their quality, quantity and location. These in turn can be affected by background pressures, management practices and drivers of demand*".

In principle, a natural capital approach can help address growing human demands for ecosystem services, without compromising biodiversity and future ecosystem service provision (Seppelt et al., 2013).

Fundamental to any natural capital assessment is the identification of key and vulnerable natural assets, the value of the ecosystem services they provide and the pressures or risks to these assets (see **Box 2**). Although predominantly applied to terrestrial systems, recent years have seen assessments of coastal and marine zones (Churn, 2022; Rees et al., 2022; Watson et al., 2020). There is a growing resource and evidence base to inform marine assessments, including the allocation of ecosystem services to different habitat classes (Galparsoro et al., 2014) and habitat correspondence tables (JNCC, 2018) to enable the translation of habitat maps to maps of ecosystem sensitivity or services.

The UK government Natural Capital and Ecosystem Assessment (NCEA) was established to "*collect data on the extent, condition and change over time of England's ecosystems and natural capital, and the benefits to society*" (Defra, 2022) with a dedicated marine programme to develop best practice and a "*suite of analytical tools to support more effective policy making for marine decision makers at all scales*".

BOX 2: Key concepts of natural capital approach

Natural Assets or Stocks – are sources of ecosystem functions and services. They are commonly identified with individual, or assemblages of, species or habitats. Natural assets are typically selected due to their ecological importance, the value of the services they provide and their vulnerability to change, but also the availability of information about their quantity, quality and location.

Ecosystem Services – are provided by natural assets, with different assets providing different services. In practice, only a small number of the services provided by assets are considered in any natural capital assessment, typically based on their relative importance, value or vulnerability to change. Increasing the quantity or quality of natural assets will increase the provision of the services they provide, but the **value** of these services can be affected by wider issues unrelated to the health of the environment.

Values or benefits of services – are realised through human mediation, whether in the form of fishing and agriculture or a demand for flood mitigation and carbon sequestration services. As a result, the value of a service can vary over time and geography, and between different stakeholders, communities and socioeconomic groups. The value of services can be realised locally or distant to the location of the natural asset, as exemplified by the value of flood mitigation services being realised downstream of their providing assets.

The valuation of a service may be expressed in monetary terms, but also by other metrics reflecting relative value. The sum value of the services of a given asset should not be identified with the inherent value of the asset itself.

Risks – sometimes termed ‘pressures’ or ‘stressors’ they are usually the direct or indirect results of human activity which affect the long term sustainability or quality of a natural asset and the services it provides. In many cases, risks are the result of human activities to realise the value of ecosystem services. Such effects are exemplified by the effects of fishing and recreational use on the quantity, quality and sustainability of natural assets. It is important that the collective pressures of realising the value of multiple services as well as risks from other activities, (*e.g.* terrestrially derived pollution), do not compromise natural assets and the services they provide.

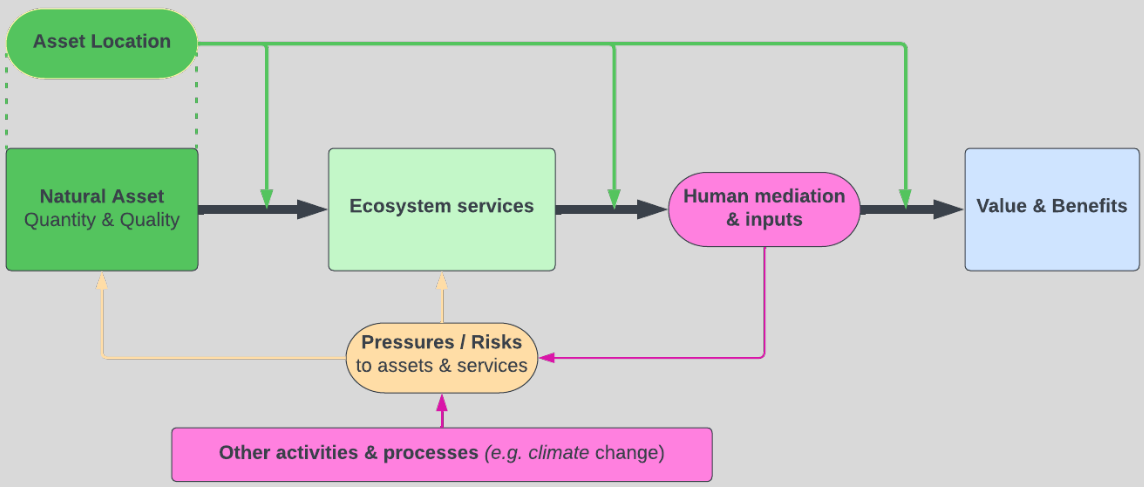

Figure 3.1: Relationship between natural assets, ecosystem services, values (or benefits) and risks. Asset location may affect the provision of services, the cost and feasibility of realising service benefits (human mediation & inputs) and the demand for service benefits which determine value.

3.1. Natural capital assessments and opportunity mapping

Natural capital assessments can help inform the mapping of nature recovery opportunities by providing an evidence base on the extent and condition of assets, the type and value of ecosystem services and risks to those same assets and services.

These assessments, however, rarely account for how the supply and value of ecosystem services provided by natural assets, and the risks to those services and assets, spatially vary across the area of the assessment. In particular, the use of fixed service values per area of a natural asset, such as a habitat type, does not account for how service value or exposure to risks vary across the land or seascape. As a result, many natural capital assessments cannot directly inform a spatial prioritization of restoration opportunities.

Various methods have been used to map spatially disaggregated ecosystem service values and risks. The draft Cornwall NRN mapped the relative value of a small number of ecosystem services that included flood mitigation and water pollution risks and carbon storage and sequestration. There remain, however, no 'standard methods' for doing so as methodologies and the available evidence base continue to evolve.

The benefits (or value) of ecosystem services (per unit area) may vary as a function of varying demand for the service. The draft Cornwall NRN mapping of flood mitigation services, for example, adjusted relative service values by the amount of downstream infrastructure at risk of flooding. Conditions that affect habitat quality or function can also affect service provision. For example, the amount of nitrogen and phosphorous removed by coastal habitats in the Solent (Watson et al., 2020) is estimated to vary by a factor of two or more as a result of variation in water quality and the effects of eutrophication.

Despite shortcomings, natural capital assessments can provide a valuable evidence base to inform the selection of nature recovery priorities, even if a process of spatial prioritisation requires greater detail than is provided by most assessments.

An additional benefit of a natural capital assessment prior to mapping opportunities is early engagement with stakeholders in the processes of data collection and interpretation (Curry, 2022). Early involvement can broaden understanding of the data used and the benefits and limitations of any spatial prioritisation. The process can be invaluable in highlighting issues concerning opportunity costs, the diversity of ecosystem services and who these services benefit. Most stakeholders will be directly affected by only some of the costs and benefits of any nature recovery activity. An understanding of the distribution of costs and benefits may be required to effectively prioritise between options and is often indicative or stakeholder attitude, resistance and engagement.

Table 3.1: Example of an Asset:Service matrix (from Rees et al., 2022) including indications of confidence in the contribution values based on the source of evidence. Where asset contribution to service indicated by colour (significant, moderate, low or negligible) and source of evidence by number (1: Expert opinion, 2: Grey / overseas, 3: UK peer review).

Natural capital asset		Ecosystem Service				
		Food	Climate	Sea defence	Clean water & sediment	Tourism
Saltmarsh	Saltmarsh	3	3	3	3	3
Intertidal reef	Intertidal rock & hard substrata.	3	2	1		1
Subtidal reef	Shallow rock & other hard substrata	3	2	1		1
	Deep rock & other hard substrata	1		1		1
Intertidal sediments	Sand and muddy sand	1	2	3		1
	Mud	3	3	3	3	1
Biogenic reef	Intertidal biogenic reefs	2	1	2	2	1
Subtidal sediment	Coarse sediment	2		3	3	
	Sand	2		3	3	
	Mud	2		3	3	
	Mixed sediments	2		3	3	

3.2. Summary points

- A natural capital assessment quantifies the relationships between natural assets, their ecosystem services, the value of the services, and risks to both assets and services.
- As a result, it helps the identify priority assets and services requiring protection and restoration.
- An additional benefit of a natural capital assessment is stakeholder engagement and involvement that can in turn inform spatial prioritisation of recovery opportunities.
- However, an assessment does not spatially disaggregate information about ecosystem services values and the risks to services and assets, as is required for the spatial prioritisation of nature recovery opportunities.

4. Challenges to marine and coastal nature recovery

4.1. Awareness of marine nature restoration

For terrestrial ecosystems, the importance of restoring as well as protecting species and ecosystems is reflected in policy goals. Restoration (or 'recovery') may be achieved through the mitigation of risks or stressors to ecosystems allowing the 're-wilding' or natural recovery of habitats and ecosystem functions. Alternatively, more 'active' restoration measures may include the modification of environmental conditions, such as drainage or river flow, the (re-) introduction of key species, or the creation and management of entirely new habitats by tree planting or wetland creation.

In reality, these two approaches reflect the spectrum of measures that can help realise nature recovery. In many cases a combination of mitigating risks, modifying the abiotic conditions and reintroducing key species will be required to ensure the sustainable restoration of biodiversity and ecosystem functions and services.

The history of agriculture and forestry practices provides numerous examples of the large-scale creation, restoration and destruction of entire terrestrial ecosystems. An awareness of how landscapes have changed over time, is important in accepting the need for the creation or restoration of terrestrial ecosystems. In contrast, there is far less awareness of the history of human marine and coastal management (Saunders et al., 2020), such as the cultivation of aquaculture (Smith et al 2019, Levin et al 2017) for millennia or the extensive use of saltmarshes for coastal reclamation in Europe as early as the 13th century (Waddenarchieven, 2010).

Marine ecological restoration (MER) approaches offer an alternative to a reliance on protection-based conservation measures. Although the importance of MER continues to be debated (Abelson et al 2020; Saunders et al 2020; Bayraktarov et al 2020), there are now many examples of successful large-scale restoration of entire marine ecosystems that have proved sustainable, cost effective and beneficial. Among the habitats successfully restored at scale are saltmarsh, mangroves, seagrass meadows, oyster reefs, kelp beds and coral reefs(Saunders et al., 2020). As for terrestrial systems, protection and restoration of marine ecosystems are not exclusive, but represent mutually beneficial approaches to marine conservation (Possingham et al 2015).

4.2. Unique challenges to marine and coastal nature restoration

Coastal and marine restoration is faced by many of the same challenges as terrestrial restoration but also unique challenges of its own. These challenges reflect the nature of the marine and coastal environment, the methods used for marine habitat mapping, the interactions between coastal, marine and terrestrial systems, the costs of restoration activities, and the complexity of the organisational and legal framework governing marine and coastal areas.

4.2.1. Marine and coastal environments

Marine and coastal conditions vary spatially and temporally much more than most terrestrial systems. The marine zone has an inherently three-dimensional nature (Venegas-Li et al., 2018), with distinct surface, pelagic and benthic ecosystems. These ecosystems are characterised by differing biotic and abiotic conditions, provide distinct ecosystem services and are exposed to different risks and pressures. All of these systems are affected by the dynamism of the marine environment in terms of the transport of nutrients, larvae and contaminants. The effect of tides, wind and currents on the connectivity and interactions between habitats and populations is often more important than simple proximity. The complexity, temporal variability and three-dimensional nature of marine environments all add to the challenge of obtaining suitable data to inform restoration planning and prioritisation.

4.2.2. Marine Habitat Mapping

Marine Habitat Mapping (MHM) integrates physical sampling, satellite, aircraft, and shipboard remote sensing data, surface water analysis, and pelagic and benthic observations (Cogan et al., 2009). A key element of MHM is the choice of Habitat Classification Schemes (HCS) which combine environmental and biological information to define distinct habitat classes. Different HSCs were developed for different applications and their suitability for nature restoration planning can vary in terms of how well they map habitats of high biodiversity or ecosystem service importance. As with terrestrial habitats, the level of classification will reflect the spatial resolution of mapping, with 'broader' habitat classes representing habitat mosaics.

For example, the EUNIS[4] habitat classes - based on the JNCC Marine Habitat Classification for Britain and Ireland (Connor et al., 2004) – cover the entire seabed from the intertidal zone

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[4] https://www.eea.europa.eu/data-and-maps/data/eunis-habitat-classification-1

into deeper, subtidal areas as well as some broad-scale pelagic habitats. However, EUNIS is less developed for offshore habitats, particularly those occurring on hard substrates and less readily applied using data from remote video techniques (Strong et al., 2019).

In certain cases, habitat classifications will be based solely on physical and environmental features of the seafloor to infer the distribution of benthic communities. As a result, marine habitat maps often present a mixture of "realized" and "potential" habitats (Strong et al., 2019); the latter lacking any direct sampling or measurement of the biota. Any estimation of habitat quality often also relies on indirect indicators such as exposure to activities detrimental to quality or the spatial boundaries of management measures, such as MPAs or fishery byelaws, indicative of the intensity of such activities.

4.2.3. Restoration costs and benefits

Marine and coastal restoration projects are generally more costly per unit area than many terrestrial restoration activities (Bayraktarov et al 2016). On the other hand, the potential cost to benefit ratios are often much higher when account is taken of the many ecosystem services they can provide. Careful selection of suitable restoration sites and capturing the range of potential benefits and services provided by nature recovery opportunities is often essential to justify investment in marine habitat restoration.

As a result of the dynamism of marine environments and ecosystems, the benefits of restoration are often spatially distant from the site and costs of restoration activity than for many terrestrial systems. Sustaining stocks and biodiversity of fishing waters, for example, can require the protection or restoration of spatially distant spawning and nursery grounds (Beck et al., 2001). The interdependence between different marine and coastal restoration activities can also be significant. The off-shore restoration of bivalve reefs, for example, can reduce wave energy and water turbidity thereby facilitating the restoration or in-shore seagrass meadows or saltmarsh (Gillis et al., 2014).

4.2.4. Shared services and risks across terrestrial and coastal ecosystems

This interdependence of many intertidal and subtidal habitats extends to the terrestrial environment. Coastal squeeze, caused by terrestrial infrastructure, presents a key risk to many intertidal habitats. Conversely, marine habitats can also mitigate the risks of coastal erosion and flooding to terrestrial ecosystems. Such interactions are particularly evident for estuarine environments which are susceptible to both upstream and marine sources of risk. Equally, estuaries also benefit from both marine and terrestrial habitat restoration or mitigation of environmental risks such as pollution. There is no simple way of capturing such codependencies by a spatial prioritisation approach, although a mapping of key risks to different ecosystems can help identify the sources of risk and methods of mitigation through nature restoration or other interventions.

4.2.5. Complexity of governance and legal frameworks

Most of the seabed is ownership of the Crown Estate and the legal and governance responsibilities for the use, management and protection of these environments is dispersed among multiple organisations, policies and mechanisms for delivery (Curry, 2022 and see **Box 3**). Whereas a few engaged and motivated land owners can largely realise many terrestrial restoration opportunities, no such equivalent mechanism for delivery is realistic for coastal and marine zones.

BOX 3: Key competent authorities and advisory agencies for marine and coastal planning, licensing and permissions in England.

- Marine Management Organisation – responsible for preparing marine plans, marine licensing operations and the monitoring and enforcement of MCZs.
- Crown Estate or private owners – Foreshore and seabed management, leases and permissions
- Natural England – impact assessments on protected areas, wildlife and protected species licensing
- Environment Agency – quality of estuaries and coastal waters and flood risk management
- Local Planning Authority – Regulating use of land and planning permissions above MLW.
- Cornwall Inshore Fisheries and Conservation Authority – fisheries and conservation management.
- Harbour authorities – harbour management and permissions.

A sense of shared responsibility and 'ownership' of marine and coastal environments can be beneficial as well as challenging to realising nature recovery opportunities. Collaborative working across stakeholders and organisations is essential to the success of both passive and active nature recovery projects. Carefully designed restoration schemes with community engagement can have better cost-benefit ratios, particularly in terms of any on-going enforcement and opportunity costs associated with the restoration of ecosystems.

Community engagement has a role both prior to, during and after any spatial prioritisation of opportunities. In the first place to help identify potential costs and benefits of restoration, secondly to help identify information and indicators that can inform prioritisation and mapping, and finally in the interpretation and use of results. Inadequate or stakeholder engagement around MNR opportunities has the potential to jeopardise not only a single project but also trust and engagement required for future work. The uneven distribution of the costs and benefits of nature recovery opportunities among stakeholders necessitates a comprehensive approach to their identification and engagement.

Stakeholder engagement can also be essential in identifying opportunities for restoration and/or mitigating key risks that might not be captured by an analytical approach. Changes in behaviour, equipment and practice have enormous potential for mitigating many of the key risks to maritime ecosystems and facilitating nature recovery, as exemplified by the changes to fishing gear or mooring systems (Tevi, 2020).

4.3. Summary points

- Marine nature recovery is likely to involve a combination of passive and active measures.
- The realisation of MNR faces unique challenges due to the inherent nature of marine and coastal environments and a deficit of data compared to the terrestrial environment.
- Higher costs and benefits of marine restoration projects suggests there is an important role for spatial prioritisation to identify the most suitable sites.
- Many of the risks to which ecosystems are exposed, and the services they provide, are shared across terrestrial and marine ecosystems.
- Stakeholder engagement is essential for realisation of active or passive nature recovery opportunities due to the complex governance, legal framework and the uneven distribution of costs and benefits across stakeholders.

5. Spatial prioritization of marine opportunities

A spatial prioritisation of marine nature restoration opportunities can help identify those sites where the potential benefits and likelihood of success are greatest. As illustrated by the first iteration of Cornwall's LNRS, conservation planning tools and methods can provide a systematic and quantitative approach to spatial prioritisation. Use of these tools (**Box 4**) requires access to spatial data describing variation in key factors affecting the costs, benefits and likelihood of success. Any prioritisation of marine restoration opportunities also needs to form part of a broader framework of decision-making and stakeholder engagement.

5.1. Identifying natural assets for restoration

The identification of key natural assets for restoration is informed by a formal or informal assessment of their biodiversity, the ecosystem services they provide and the risks to their long-term sustainability. The assessment may take the form of a full Natural Capital Assessment or use available evidence and stakeholder engagement to identify assets of key cultural, socio-economic and ecological importance.

Where such assets correspond to individual species, species distribution or habitat suitability models (**Box 4**) can be used to identify key habitats or mosaics of habitats critical to the survival of the species such as spawning, nesting or feeding grounds.

5.2. Spatial prioritisation of restoration opportunities

Figure 5.1 outlines how the costs, benefits and likelihood of successful restoration can be determined by a range of spatially varying factors. These include biotic and abiotic conditions of the potential restoration site, but also characteristics of the wider seascape context.

Figure 5.1 most closely equates to 'active' MNR opportunities, such as the creation of new seagrass meadows or biogenic reefs. Passive MNR, involving enhanced protection of endangered habitats or the mitigation of key pressures, can also be prioritised using many of the same factors, such as potential biodiversity benefits and the magnitude of existing risks and pressures inhibiting natural recovery. However, many of the barriers to such measures are not readily captured by spatial mapping or prioritisation. Among these are the socio-economic interests and barriers that may be the most important factors determining the acceptance and realisation of passive MNR measures.

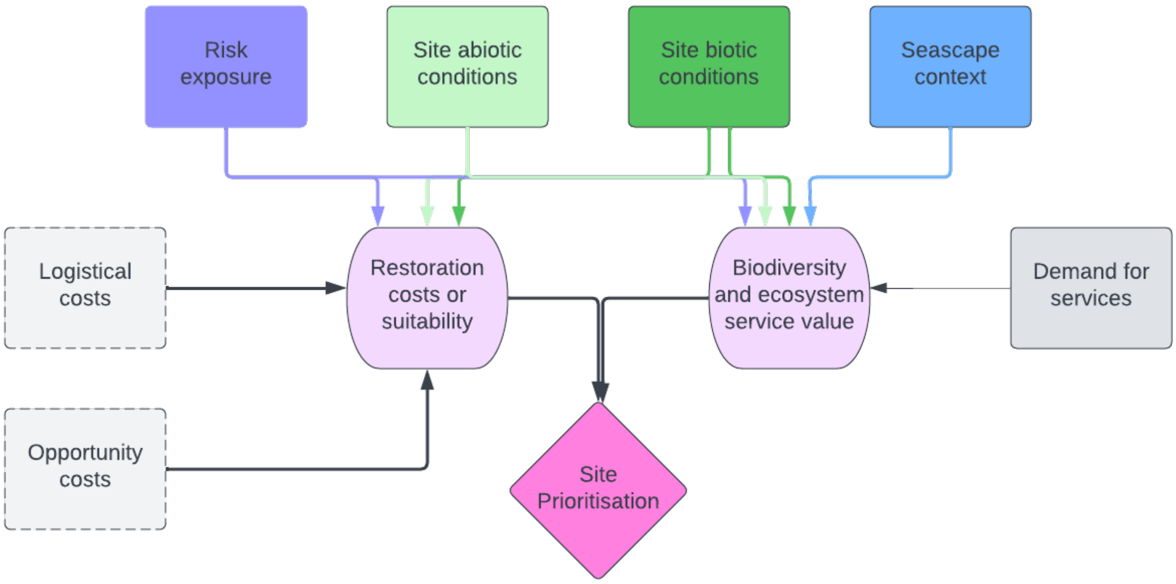

Figure 5.1: Major types of spatially-varying factors that affect the suitability, costs or potential benefits of marine habitat restoration and thereby could inform any spatial prioritisation of opportunities. Costs and values may be expressed in absolute monetary terms or by alternative metrics reflecting the *relative* variation and importance of different factors.

5.3. Site characteristics

There now exists a sizeable evidence base describing the site characteristics required for the successful restoration of key coastal ecosystems including biogenic reefs, seagrass and saltmarsh habitats (see Table 5.1). Regional and national mapping of potential restoration sites for several habitat types based on key abiotic site criteria have also been published. These maps may provide a starting point for opportunity mapping, but exclude many factors affecting the success and benefits of restoration projects. In general they take no account of the wider landscape context, exposure to risks and the potential value of the ecosystem services restoration can provide. Where available, mapping of potential restoration locations, such as estuaries, may provide more reliable indications of restoration sites.

Table 5.1: Marine and coastal habitats proposed in selected reports and literature as priorities for nature restoration – existing maps of potential restoration sites, example methods of restoration, key site criteria and risks affecting success.

Habitat	Maps of potential restoration sites	Examples of restoration methods	Key site criteria	Key risks and pressures	References
Saltmarsh	MMO Saltmarsh potential creation sites within currently protected floodplain areas.	• Reduce wave energy. • Encourage sedimentation. • Create intertidal areas behind existing defences. • Enhance estuary edges. • Planting / seeding.	• Sea level • Tidal regime • Wave exposure • Salinity • Sediment availability • Topography • Existing and historical habitats.	• Sea level rise • Coastal squeeze • Climate change • Water quality (N,P,O2, pH) • Historical land use.	Huson et al. (2021); Billah et al., (2022); D'Alessandro et al., (2020)
Seagrass meadows	EA Seagrass potential areas from wave and current energy, elevation and salinity criteria.	• Mitigation of pressures. • Reseeding – seed collection and resowing (various methods) in seabed. • Replanting – collection of adult shoots and replanting.	• Water depth • Water flow • Water clarity • Wave height • Substrate • Salinity	• Eutrophication - water O2, P & N, • Trampling • Anchoring & mooring • Digging • Habitat fragmentation • Storm frequency & intensity.	Gamble et al. (2021); Rezek et al., (2019); Tan et al., (2020)
Native oyster beds	EA native oyster bed potential restoration sites.	• Establish breeding populations to enhance recruitment. • Suspended brood stock to augment larval production. • Cage or concrete structures erected on sea floor. • Modification of seabed conditions (spat collectors or cultch laying) with methods and timing adapted to location site.	• Seabed conditions (substrate & mobility). • Water depth • Water flow/wave action. • Salinity • Phytoplankton & particulate matter. • Larval recruitment from existing populations.	• Anchoring & mooring • Fishing pressures • Shore gathering • Pollution risks • Disease or pests • Predation intensity • Temperature extremes • Habitat fragmentation.	Preston et al., (2020); Pogoda et al., (2020); zu Ermgassen et al., (2020)

5.4. Key risks and stressors to restoration success

Risk matrices produced by Natural Capital Assessments (Mace et al., 2015; Rees et al., 2022) or Sensitivity assessments (Tyler-Walters et al., 2023), although not spatially explicit, can nevertheless help identify key risks to the long-term sustainability and functioning of natural assets.

Estimating the spatial distribution of these risks permits their inclusion in a spatial prioritisation of restoration opportunities. In many cases, a direct measurement of key risks might not be possible and reliance must be placed on indirect indicators of, for example water quality, fishing or shipping intensity. Vessel monitoring systems (VMS) have been widely used for over a decade to provide information on the spatial and temporal distribution of fishing effort (Lee et al., 2010). More recently, Automatic Identification Systems (AIS) data has expanded our capacity to estimate and map shipping pressures to include recreational and smaller vessels (Meijles et al., 2021; Merchant et al., 2012; Metcalfe et al., 2018)

5.5. Wider seascape context

The spatial configuration of the wider seascape can significantly affect the potential costs and benefits of habitat restoration and needs to be accounted for in any spatial prioritization of restoration opportunities. The speed of nature recovery and biodiversity benefits will often depend on the connectivity of a site to other habitats and populations.

Simply considering the connectivity of a site to patches of the same habitat, however, is often insufficient (Gilby et al., 2018). Habitat mosaics of high structural complexity are a key seascape feature supporting high levels of biodiversity, including the nursery function of nearshore habitats such as seagrass (Olson et al., 2019).

Any estimate of connectivity must also extend to capturing the effects of winds, tides and currents on the dispersal of many species. Even relatively close populations of species reliant on the passive dispersal of larvae, can be isolated from one another due to unfavourable hydrologic conditions (Elsäßer et al., 2013). Although hydrologic and dispersal models (**Box 4**) can be used to measure connectivity and dispersal distances (Elsäßer et al., 2013; Jahnke et al., 2018) their use adds to the complexity of conservation planning approaches.

5.6. Ecosystem service mapping

Marine restoration projects have often been undervalued because of a failure to recognize and value the benefits of the ecosystem services they provide. Spatial prioritisation of restoration opportunities, unless comparing across different kinds of natural asset, does not require a valuation of all the services provided by a restored habitat. Rather, it benefits from capturing how the relative value of these services varies between potential restoration sites.

The value of services can vary either due to differences in the provision of the service, due to differences in habitat structure or quality, or to differences in the demand for the service. For example, the value of the mitigation of coastal erosion by seagrass meadows will depend on the height of the meadows and the oceanographical conditions (wave height), but also the value of land and infrastructure that may be protected by the service. Not all such variation can be realistically captured, but even a relatively crude approximation of where a service might be most valued, such as a coastal erosion risk map, can help inform spatial prioritisation.

5.7. Alternative approaches to opportunity prioritisation mapping

Conservation planning approaches to nature restoration sites will typically use site properties, estimates of ecosystem service benefits and elements of the wider landscape context to provide a spatial prioritisation of potential sites (see **Box 4**). The next step is generally considered to be wider stakeholder discussion and engagement to further consider the feasibility and desirability of highly prioritised sites. It is only at this second stage where many logistical and stakeholder factors affecting the feasibility of restoration are fully considered.

An alternative approach reverses this order. Initial site selection of restoration options takes place on the basis, for example, of existing and engaged stakeholder communities. More localised spatial prioritisations can then be undertaken in response to an existing community or stakeholder demand. This approach may also be more manageable in terms of stakeholder engagement and resource demands.

The risks of such an approach, however, are firstly that the existence of such engaged stakeholder communities may equate to certain socioeconomic or geographical areas, and secondly such an approach will not necessarily reflect the strategic priorities for the whole of Cornwall and the Isles of Scilly. Maps of Cornish coastal and marine networks and forums (Curry, 2022 - figure 6, p. 34) highlight how they are concentrated in larger population centres and estuaries along the south coast. Furthermore, performing prioritisations for multiple geographical subunits does not equate to a strategic prioritisation for the whole of Cornwall.

In effect, these two approaches are not exclusive, but an initial, Cornwall-wide, strategic prioritisation is likely to be of benefit even if complemented by more regional studies, as and when appropriate.

BOX 4: Spatial prioritisation and planning tools for marine restoration opportunities

General mapping and spatial analysis tools (GIS, R…) – for spatial data management, analysis and visualisation.

Habitat suitability & species distribution models - predict the suitability of a location for a given species or habitat type, based on knowledge of its biology and/or how its observed distribution relates to abiotic characteristics such as climate, substrate or water depth. Models range from a simple criteria list or tolerance ranges to sophisticated statistical approaches. Their value in restoration mapping depends upon how well they capture tolerance to any key threats/stressors and the availability of spatial data that corresponds to species requirements.

Connectivity models –range from simple proximity or geometric metrics to coupled hydrodynamic and particle dispersal models to provide measures of potential connectivity benefits of marine restoration.

Ecosystem service models (ESM) –attribute a relative ecosystem service values across a land or seascape. Methods can vary from simple 'benefit transfer' models that apply reference values largely irrespective of spatial location, to methods that seek to account for spatial variation in service supply and/or demand by accounting for key determinants of the demand and value of ecosystem services. Even relatively simple spatial indicators of service demand, such as coastal erosion and flood zones, these models can be important in helping to compare the relative benefits of different restoration sites.

Spatial prioritisation tools – have been widely used to help identify and prioritize locations for conservation planning and management. The complexity of these tools can vary from a simple ranking on the basis of a criteria list to more sophisticated optimization software tools such as Zonation (Moilanen et al., 2005, 2022) and Marxan (Ball *et al.* 2009). The more complex tools typically provide an optimised solution that balances various benefits and costs, such as identifying the optimal protected area configuration that conserves the greatest biodiversity for a given area. These tools can account for some of the effects of spatial configuration on biodiversity but often require weighting (positively or negatively) of the various data inputs to reflect their relative importance in the optimisation algorithm.

5.8. Summary points

- A range of spatial planning tools and resources can be used to deliver a spatial prioritisation of marine restoration opportunities.
- Nevertheless, the marine and coastal environment presents particular challenges in the use of these tools, particularly to capture the dynamic effects of the wider seascape.
- These challenges are magnified by uncertainty about the extent and quality of existing spatial data.

6. Recommendations

6.1. MNR mapping should not be immediately undertaken for the whole of Cornwall's & IoS inshore waters.

The approach used in Cornwall's terrestrial LNRS mapping of habitat restoration opportunities is also applicable to the mapping of MNR opportunities as part of an extension of the LNRS to cover marine and coastal areas. However, there exists too much uncertainty concerning the adequacy of data resources, available expertise and levels of stakeholder engagement to justify the commitment of the necessary resources at this time.

6.2. Instead steering and guidance of current and planned activities is recommended to address uncertainties associated with MNR mapping and develop regional expertise.

Key projects and activities (see figure 6.1) that directly address these uncertainties, while also delivering additional benefits to our understanding and mapping of marine and coastal ecosystems, are:

- Natural England's marine Natural Capital Environmental Assessment (mNCEA).
- ERCCIS Marine Data Hub.
- Isles of Scilly terrestrial NRN mapping.
- NERC funded research around the Isles of Scilly.
- Current habitat restoration projects and activity across Cornwall.
- Next iteration of Cornwall's terrestrial LNRS.

Recommendations on how each of these activities can contribute to the evidence base, skills and levels of stakeholder engagement required for successful delivery of mNRN mapping are as follows.

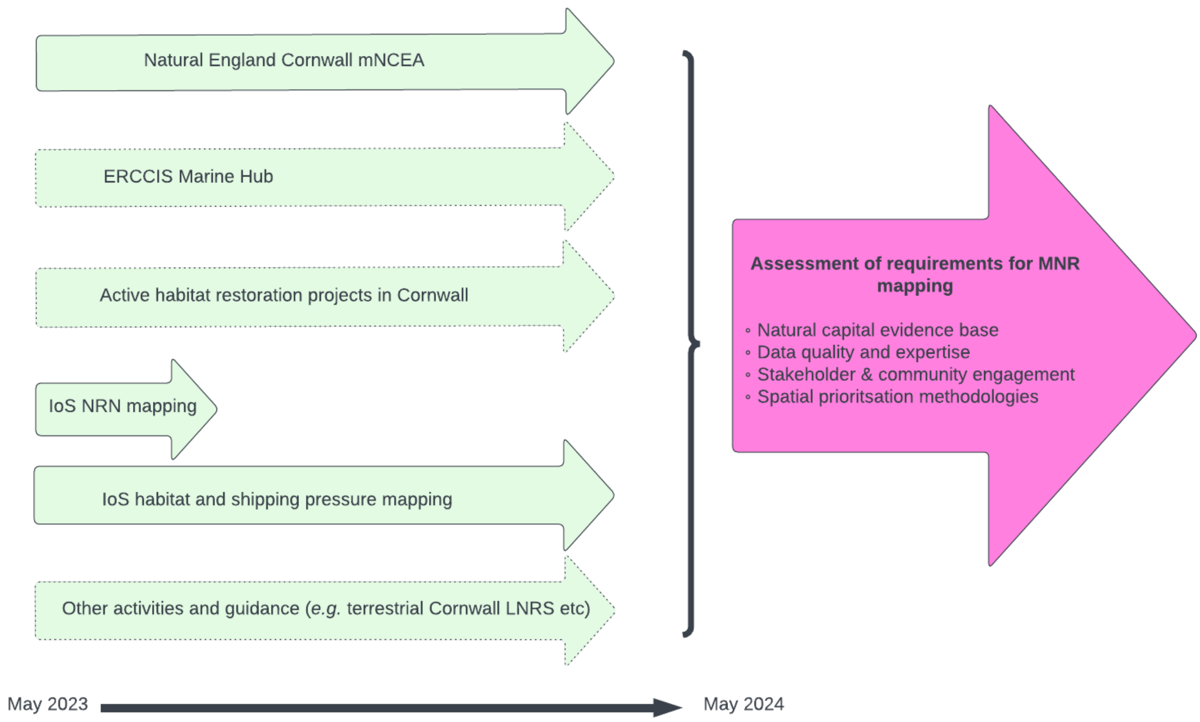

Figure 6.1: Planned and existing activities that could inform and support marine NRN mapping for Cornwall and the Isles of Scilly.

6.2.1. Ensure Natural England's mNCEA informs work on Cornwall mNRN.

The natural capital assessment to be carried out in 2023-4 offers significant benefits to delivering MNR mapping for Cornwall. Outputs of the assessment and lessons learnt from this project are likely to directly inform MNR mapping, particularly in terms of the identification, measurement and mapping of natural assets, ecosystem services, benefits and risks. Among the stated aims of the project is to begin developing guidance on the extension of LNRS into marine areas using mNCEA as an evidence base to identify spatial priorities.

6.2.2. Expand and support the remit of the ERCCIS Marine Data Hub.

As stated by the *Marine Nature Recovery - First steps* report (Christie et al., 2021) "*the baseline evidence (ecological or activity-focused) to support strategic planning around marine nature recovery action is incomplete and widely dispersed*". The collation of datasets by the ERCCIS Marine Hub to a single site is a useful step to address this challenge, but of itself adds limited value. The real benefit of a regional data hub requires an assessment of the available data, the provision of information on appropriate use and the generation of derived data products of immediate value for MNR planning. In doing so, a regional hub of expertise in the uses of marine data can be developed.

6.2.3. Extend delivery of the Isles of Scilly LNRS to consider interactions with coastal ecosystems below MLW.

Work on the IoS LNRS can help clarify the feasibility and benefits of an integrated approach to terrestrial and marine environments as well as the sufficiency of the existing coastal data resources. Mapping of the accompanying nature recovery network is to be driven primarily by biodiversity benefits, although some indicators of the value of ecosystem services such as coastal erosion and flood risks may be included.

6.2.4. Ensure capture of results and guidance from current NERC research focussed on the Isles of Scilly.

On-going research led by the University of Exeter and with collaboration of Cornwall & IoS IFCA is seeking to identify suitable indicator species for long-term monitoring purposes, establishing a protocol for using Automatic Identification Systems to establish measures of shipping activity and pressures and assessing the use of video and acoustic surveys to inform mapping of marine habitats and noise.

6.2.5. Ensure lessons and expertise not lost from marine and coastal nature recovery projects across Cornwall and the IoS.

Several projects and organisations, currently delivering MNR across Cornwall, provide a source of expertise, mapping and existing stakeholder engagement that should support work on a Cornwall-wide mNRN. These projects include 'active' and 'passive' restoration projects for seagrass[5], sand dunes[6], lobster[7] and native oyster beds[8], and often form part of national or international networks. It is important that the experience and knowledge acquired by these projects, often dispersed across several participating organisations, is not lost to future MNR work.

6.2.6. Cornwall LNRS will help inform methods of extending to marine and coastal zones.

In response to evolving guidance and stakeholder feedback, the development of Cornwall's LNRS will build on the methods used in the pilot study, while ensuring they are aligned with the requirements of Government and the stakeholder community.

[5] https://www.cornwallwildlifetrust.org.uk/restoring-cornwalls-seagrass

[6] https://dynamicdunescapes.co.uk/project/cornwall/

[7] https://www.nationallobsterhatchery.co.uk/research/

[8] https://www.crowdfunder.co.uk/p/savingestertheoyster

6.3. Improve key aspects of the evidence base to inform mNRN mapping of nature recovery opportunities.

The regional activities already identified will help improve the available evidence base (see Table 6.1). Additional improvements may be made by reviews of the academic and burgeoning ‘grey’ literature as well as other sources of advice, including central government guidance. If deemed insufficient, then additional work may need to be commissioned to help deliver key elements of the evidence that would help deliver MNR mapping.

Table 6.1: Indicative contributions of existing and planned activities to improving the evidence base, expertise and stakeholder engagement required for the mapping and prioritisation of marine nature recovery opportunities.

Current or planned activity	Evidence Base					Skills and expertise	Stakeholder engagement
	Species compilation	Habitat mapping	Pressures mapping	Ecosystem service maps	Assess habitat restoration maps		
Natural England mNCEA							
ERCCIS Marine Hub							
Isles of Scilly terrestrial LNRS							
Isles of Scilly marine research							
Current habitat restoration projects							
Cornwall terrestrial NRN & LNRS							

6.3.1. Compilation of species of conservation and economic importance

Species would be identified from protected area management plans and their criteria for selection, Cornwall and Isles of Scilly Red Data Book, fisheries data and information provided by expert and specialist groups. Assessment could be extended to identify the availability of species distribution models and other information to inform about habitat requirements and the key risks and pressures affecting populations. Information can help identify existing areas of biodiversity importance and restoration opportunities, and indicator species suitable for the long-term monitoring of habitat quality and biodiversity.

6.3.2. Marine and coastal habitat mapping

Marine habitat mapping is often inferred from indirect and abiotic measurements, risking inappropriate use and misinterpretation by non-specialist users. An effective synthesis of existing mapping data could be guided by the recommendations of recent reviews (e.g. Strong et al., 2019) to provide a suite of habitat maps, indicators of quality and supporting information that might include:

- Indications of where mapping is supported or not by direct observations of biota.
- Indicators of habitat condition or quality (*e.g.* condition assessments of SACs).
- Evidence of anthropogenic pressures (see also below) including the spatial boundaries of management measures (*e.g.* MPAs and fishery byelaws).
- Presence of habitat features not covered by any given classification scheme such as large fish shoals or wrecks likely to provide biodiverse habitats.

6.3.3. Spatial indicators of exposure to risks and pressures

Quantitative spatial indicators of exposure to key pressures and risks are essential for the reliable mapping of MNR opportunities. In many cases such indicators will need to integrate temporal variability through summed measures, frequency, maximum exposure levels or other appropriate statistics. Best practice should be followed where available or innovative measures developed. Priority risks and activities should include:

- Fishing intensity and other shipping usage (including mooring and anchoring) - assimilating AIS and VMS data with complementary sources of information.
- Recreational use of beaches and coastal paths - assessing ORVal[9] data derived from statistical models of recreational demand (Day & Smith, 2018).
- Water quality and exposure to pollution risks – assimilating multiple data sources concerning water quality, from the location of terrestrial activities or infrastructure (sewage outflows) and catchment and river quality data, to the use of remote sensing estimates of water clarity, chlorophyll-a or marine litter (Kikaki et al., 2022).

6.3.4. Methods to map spatial variation in the value of ecosystem services

As outlined in section 5.6 of this report, methods to map how the provision and benefits of ecosystem services vary across the land and seascape continue to evolve. Appropriate methods will be determined by the availability of suitable data and methodologies. However,

[9] https://www.exeter.ac.uk/research/leep/research/orval/

consideration also needs to be given to the transparency of the methods and how mapping reflects the way benefits are distributed across communities or stakeholder groups.

6.3.5. Assess existing maps of potential habitat restoration sites

Assess the quality and the criteria informing existing spatial datasets of habitat restoration opportunities. For example, spatial modelling of seagrass restoration (Environment Agency, 2020) considered bathymetry, wave and salinity but not the levels of sediment in the water. Existing datasets include:

- Environment Agency potential habitat restoration sites for seagrass and native oyster beds.
- Marine Management Organisation data layers as part of the 'Identifying sites for habitat creation (MMO1135)' project, including areas suitable for the creation of mudflats and saltmarshes.
- RSPB's Sustainable Shores Project (Miles & Richardson, 2018) mapped Mount's Bay and Tamar locations for potential coastal habitat creation.
- JNCC potential sites for blue mussel bed mapping.
- IoS seabird recovery team maps for priority land-breeding seabirds.

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