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Applying the natural capital approach to Sustainability Appraisal

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sweep

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Summary

The natural capital approach is based on recognising the contribution of nature to human welfare, and hence improving the manner in which the natural environment is traded-off against other things that are important to society. The natural capital system has three key components: the assets (species and habitats) and the ecosystem services (useful ecological products) that are provided by nature, and the goods and benefits that we receive from them, access to which requires human intervention through, for example, the availability of skills and infrastructure. There is significant policy momentum in the UK behind the adoption of the natural capital approach in natural resource management, but there remains no systematic or widespread application of the approach within impact assessment.

This report begins to outline the steps that could be taken to apply natural capital principles to Sustainability Appraisal (which was identified by stakeholders as the preferred mechanism for integrating the natural capital approach into local decision-making). As with any new methodology an iterative process is required, including significant engagement. This document represents an initial outline of the proposed methodology. It is expected to evolve, as lessons are learned from additional use of the framework in practice.

Incorporating the natural capital approach does not require a complete overhaul of Sustainability Appraisal. Instead, it offers an alternative means of framing sustainability issues that fits entirely within the existing process. The natural capital approach does not introduce environmental, social and economic factors beyond those that would be assessed for a standard Sustainability Appraisal; it simply suggests approaching the information and issues in a different way. Also, the approach does not require any additional data collection beyond that which would normally be undertaken; the expectation is that best available evidence will be used. The suggested method also seeks to fit to other obligations, processes and tools that may be relevant to planning and decision making at different scales.

The proposed framework is applicable initially during the scoping phase, as it sets up a protocol for gathering evidence and identifying sustainability issues, including using the wider five capitals model to break down overarching aims into their constituent parts from which specific objectives, indicators and targets can be derived that encompass the environment, infrastructure, individuals, and wider society. The method for collecting baseline information has four core elements: an asset register (in which information on the status of natural capital is compiled), an ecosystem services inventory (to list services, benefits and values); an asset-service matrix (to connect services to the assets from which they are derived); and a risk register (which summarises threats to continued system functioning).

Detailed habitat and ecosystem service classifications provide the framework for the collection/collation of baseline environmental information. This systematic approach also facilitates the construction of an evidence database, which supports data analysis, the subsequent evaluation of plan/programme impacts, and the monitoring of trends for subsequent updates and iterations. Holding evidence in a structured database also facilitates the creation of summary tables that present information clearly and coherently.

The process is designed to be comprehensive, but also flexible, recognising that Sustainability Appraisal is undertaken at different scales, in different contexts and with different levels of resource. Asset and service classifications are hierarchical, and so can be expanded or collapsed according to specific needs and scope. Summary tables are designed to be completed for the most part using three-point categorical rating scales, which recognises the likely difficulties in obtaining quantitative data for all elements of the evidence base. Even where complete quantitative data is available, summaries that can easily be given ‘traffic light’ coding are useful in highlighting key areas of concern and thus facilitate prioritisation.

The proposed scoping process provides a comprehensive and systematic baseline of the current status and trends in assets, services and benefits, and the degree to which they are at risk. This allows for the selection of detailed sustainability objectives and indicators that relate specifically to those assets and services, and for the full implications of plan options to be assessed, in turn supporting better outcomes than using high-level objectives and indicators such as the number and condition of protected sites.

The key steps in the method are outlined below, including the sections of the report in which they are described:

STEP 1 Set initial high-level sustainability objectives *[Section 3]*

With stakeholder input, and following identification and review of relevant programmes, policies and plans, define high-level objectives for each of the five capitals (natural, manufactured, human, social and financial)

Main output: A list of high-level objectives that define the scope of the Sustainability Appraisal

STEP 2 Collect baseline information [*Section 4*]

Step 2.1 Asset register

(a) Define assets of interest through a participatory stakeholder process, using the habitat classification hierarchy

(b) Select indicators for, and collect/collate data on, quantity, quality and spatial configuration of assets, including trends

Main output

Summary table of key asset data including 'traffic light' rating indicating where asset status and/or trend is of concern

Step 2.2 Ecosystem service inventory

(a) Define ecosystem services of interest through a participatory stakeholder process, using the ecosystem service hierarchy

(b) Select indicators for, and collect/collate data on, quantity and quality of ecosystem service, goods and benefits, including trends

(c) Determine ecosystem service delivery targets from local/national legislation, policy and management objectives

Main output

Summary table of key ecosystem service data including 'traffic light' rating indicating where ecosystem service status and/or trend is of concern

Step 2.3 Asset-service matrix

(a) Determine which assets are most important in the delivery of individual ecosystem services

Main output

Matrix with scores for the level of ecosystem service delivered by assets

STEP 3 Identify sustainability issues and problems using a risk register [*Section 5*]

(a) For each asset-service pair identified in the matrix, use the trend in asset status (determined from the asset register) and the target for ecosystem service delivery (defined by existing plans/policies) to assess the risk level.

(b) Amalgamate the individual scores into an overall risk category for each ecosystem service across all asset types.

Main output: Summary table using 'traffic light' coding to highlighting risks to continued delivery of services

STEP 4 Develop sustainability appraisal framework [*Section 6*]

(a) Use the outputs of the preceding steps to support a participatory process of defining detailed sustainability objectives that relate to specific natural capital assets and ecosystem services.

(b) Also use information gathered during the baseline assessment to identify indicators for assets and services that are appropriate in the local context and can be used to monitor progress against the sustainability objectives.

Main output: Table of sustainability objectives and their associated indicators

STEP 5 Evaluate effects of plan/programme alternatives on assets and services *[Section 7]*

(a) Using the same framework as for the previous steps, evaluate the likely level of impact of different plan/programme options on the different assets and ecosystem services to highlight key trade-offs.

(b) Use the outputs within a participatory process to identify the most appropriate options to be taken forward in the final plan/programme.

Main output: Summary table with 'traffic light' coding of impacts of plan/programme options on assets and services

Contents

1 Introduction

1.1 Background to the report

This report has been prepared as part of the South West Partnership for the Environment and Economic Prosperity (SWEEP)[1], a programme led by the Universities of Exeter and Plymouth and Plymouth Marine Laboratory together with partners in the public, private and third sectors, and funded by the Natural Environment Research Council. This work forms part of a wider project that is exploring ways to improve and extend the use of natural capital approaches in decision-making for the marine environment. The project was integrated within the North Devon Marine Pioneer, one of four Pioneers established by Defra through the 25 Year Environment Plan (HM Government, 2018), and led by the Marine Management Organisation. Outputs from the wider project include an analysis of the 'state of the art' in applying the natural capital approach in the marine context (Hooper et al., 2019a) as well as pilot natural capital asset and risk registers for North Devon and the Isles of Scilly (Ashley et al., 2018; 2020; Rees et al., 2019).

This report represents progress in developing a methodology for using the natural capital approach in Sustainability Appraisal, which is, to the authors' knowledge, the first time this has been attempted in either marine or terrestrial contexts. The development of a natural capital approach to Sustainability Appraisal, as with any new methodology, requires an iterative process including significant engagement. Sustainability Appraisal was identified at a stakeholder workshop in North Devon as the preferred mechanism for integrating the natural capital approach into local decision-making (Hooper, 2017). Specifically, this report presents an overarching conceptual framework and begins to outline the steps that could be taken in practice to apply natural capital principles to the Sustainability Appraisal process. A shorter method summary (Hooper and Austen, 2020) and supporting material has been prepared separately. While the approach was being developed, it became apparent that considering only the marine context was a limiting factor in the assessment, so the remit was expanded to also consider the terrestrial perspective, working in conjunction with Natural England and the Landscape Pioneer.

Case studies have been used to support development of the approach. The first relates to the South West Marine Plan, a case study that was undertaken at the request of the Marine Management Organisation (see Appendix 1). The Marine Plan was well advanced and so this work took account of the Sustainability Appraisal scoping already undertaken (MMO, 2016a,b,c; 2018) and drafts of other marine plan documents. The second case study concerned the North Devon Marine Natural Capital Plan, developed by the North Devon Biosphere Reserve as part of the Marine Pioneer and with funding from the European Marine Fisheries Fund (North Devon UNESCO Biosphere Reserve, 2020). This was the first such local marine plan attempted anywhere in the UK, and so provided a unique opportunity and an unconstrained application of the proposed process. The sustainability assessment prepared for the plan consultation is available as a separate report (reproduced in Appendix 2). The methodology was further refined through consideration the North Devon and Torridge Local Plan (Torridge District Council and North Devon Council, 2018) as well as wider developments nationally and in the Marine and Landscape Pioneer programmes. It is expected that the approach will continue to evolve with additional testing.

1.2 Sustainability Appraisal

The planning framework in England, both terrestrial and marine, seeks to promote sustainable development and to minimise and mitigate environmental impacts (Ministry of Housing, Communities and Local Government, 2018; HM Government, 2011a). There is a statutory obligation for responsible authorities at local, regional and national level within England to evaluate the environmental effects of plans and programmes, including those within England's territorial waters, under Statutory Instrument 2004 No. 1633: The Environmental Assessment of Plans and Programmes Regulations 2004. Such impact assessment is also mandated in the context of the European Union Directive 2001/42/EC, which details the requirements for Strategic Environmental Assessment (SEA) of plans and programmes.

[1] https://sweep.ac.uk/

In parallel with environmental criteria, development strategies also need to consider economic and social objectives and impacts. Sustainability Appraisal is a key mechanism for holistic assessment of environmental, economic and social implications of plans and programmes, and is designed to fulfil simultaneously the requirements of UK legislation and the SEA Directive (MHCLG, 2019a; HM Government, 2011a; ODPM, 2004). Its application is again enshrined in legislation. The Planning and Compulsory Purchase Act 2004 requires that regional planning bodies and local planning authorities carry out Sustainability Appraisal during the development of regional spatial strategies and local development plans. Sustainability Appraisal is also explicitly required for marine plan proposals under the Marine and Coastal Access Act 2009.

Although the circumstances in which Sustainability Appraisal is necessary are clearly mandated, the exact form such an appraisal should take is not. The overarching process of Sustainability Appraisal is well established, with clearly defined steps that follow the broad scheme outlined in Figure 1 (ODPM, 2004; MHCLG, 2019b; MMO, 2016a). The steps are modified depending on the scale of the plan (Neighbourhood Plans have a slightly different process from Local Plans, for example) and ongoing engagement and consultation is expected throughout. Additional broad guidance has been produced by many agencies including government departments and statutory authorities (e.g. ODPM, 2004; MHCLG, 2019b; MMO, 2016a; Historic England, 2016; MOD, 2018; RTPI, 2018).

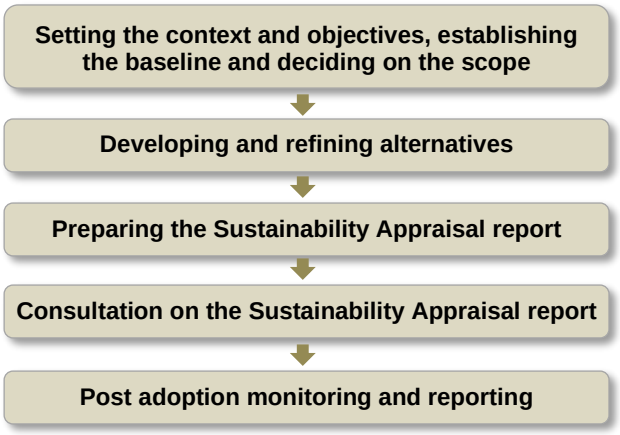


Figure 1. The broad steps in the Sustainability Appraisal process (adapted from MHCLG, 2019b).

The exact nature of the environmental, social and economic information that should be collected, and how it should be presented, is not prescribed, and it would be impractical to attempt to do so given the varied contexts in which Sustainability Appraisal could be applied. Annex I of the SEA Directive (replicated in Schedule 2 of the Environmental Assessment of Plans and Programmes Regulations 2004) requires that assessment is made of "*the likely significant effects on the environment*" and the interrelationships between its individual components. The Annex further provides high level examples of these different environmental components, which encompass ecological, social and economic factors (further details are provided in Section 2). In the marine context, the Marine Policy Statement (HM Government, 2011a) requires consideration of a similar broad list of environmental issues as well as key activities (such as marine protected areas, fisheries, and energy). Within these broad frameworks, however, there are opportunities to explore different ways to collect, assess and report the necessary information on the environmental, social and economic implications of plans and programmes.

1.3 The Natural Capital Approach

One option for a different approach is to use a natural capital framework to underpin the Sustainability Appraisal process. The natural capital approach is described by Hooper et al. (2019a, p2) in a report commissioned by Defra to explore its application to the marine environment:

"The natural capital approach is a somewhat broad term that encompasses assessment of the quantity, quality, function and value of environmental assets and the goods and services that flow from them, with the aim of ensuring the sustainable use of natural resources. Fundamentally, the approach is based on recognising the contribution of nature to human welfare, and hence improving the manner in which the natural environment is traded-off against other things that are important to society. The concept of value is central to the natural capital approach, as it seeks to better integrate environmental and economic information and thus to redress the historic trend in which natural capital and ecosystem services were undervalued and overexploited. Equally important is documenting ecological status as the characteristics of assets are usually only partially reflected in monetary values."

The natural capital system has three key components: the assets (species and habitats) and the ecosystem services (useful ecological products) that are provided by nature, and the goods and benefits that we receive from them, access to which requires human intervention through, for example, the availability of skills and infrastructure (Hooper et al., 2019a; Figure 2). Valuation is a central theme of the natural capital approach, and monetary value is an important metric for the measurement of goods and benefits. However, the status of assets, functions, and processes is determined through condition assessment using ecological metrics. Ecosystem services are also usually defined in ecological terms, although value-based metrics may be appropriate. (Hooper et al., 2019a; Figure 3).

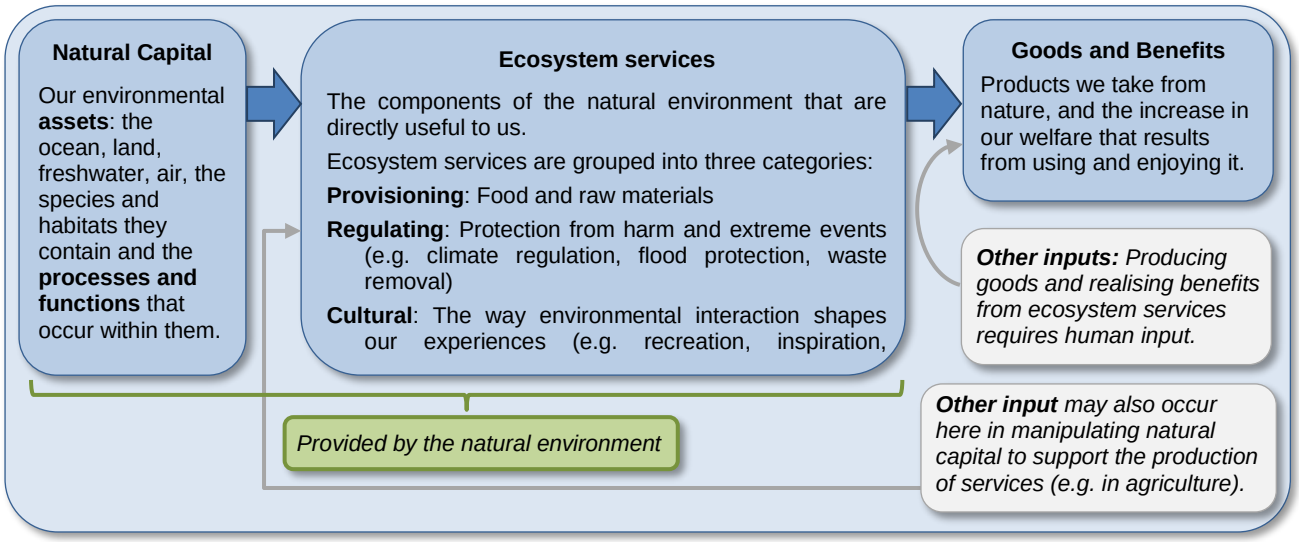


Figure 2. They key elements of the natural capital system (adapted from Hooper et al., 2019b)

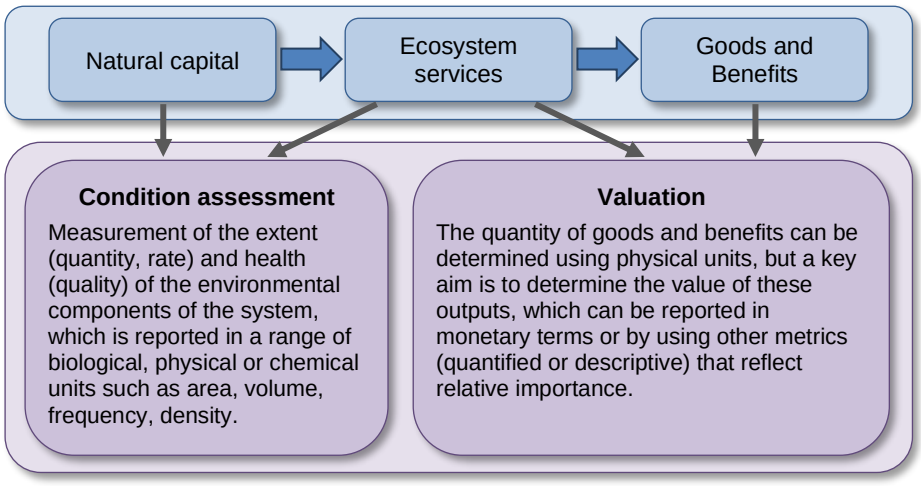


Figure 3. Measurement of the different components of the natural capital system (Hooper et al., 2019b)

The total value of the environment is comprised of many elements, including the non-use values which are derived just from knowing a species or habitat exists (the existence value) and that resources will still be available for future generations (bequest value). The benefits derived from actually using ecosystems can be further divided according to whether the benefit is obtained from direct or indirect use, or from some as yet unknown future use (the option value) (Figure 4). Monetary values are most easily derived where there are markets (e.g. fish landings or crop harvests), but methods exist to provide a monetary metric for other values. In practice, monetary valuation is difficult for many ecosystem services, and decision-makers often need to use other metrics for value, including through describing it in qualitative terms. Values can also fluctuate for reasons that are not linked to the state of the underlying asset (as a result of wider market trends for example).Therefore, decision-makers need to maintain a focus on the health of assets in order to ensure a sustainable flow of services and benefits.

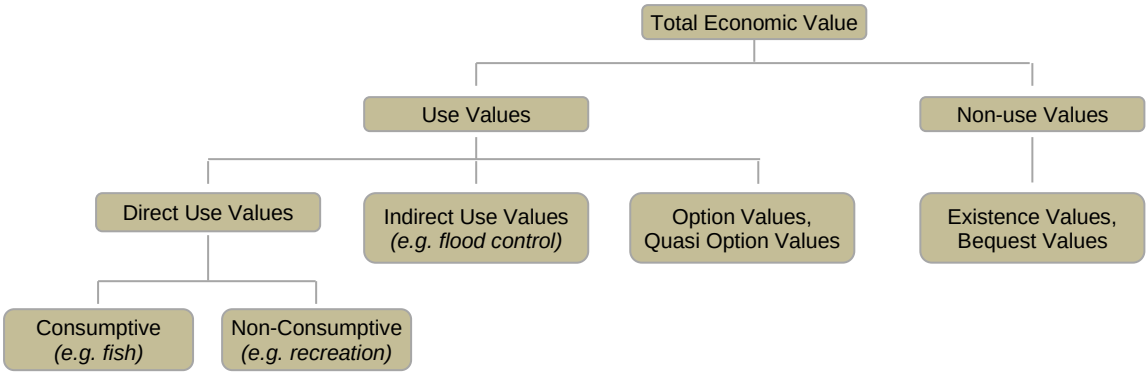


Figure 4. The different components of economic value (from Barbier, 1994; Turpie, 2003.)

Considerable literature exists that provides more detail on the natural capital approach, ecosystem services and valuation. In addition to extensive academic literature, this includes the outcomes of national and international programmes such as:

- The Millennium Ecosystem Assessment (2003)
- The Economics of Ecosystems and Biodiversity (TEEB, 2010);
- UK National Ecosystem Assessment (2011, 2014);
- EU Working Group on Mapping and Assessment of Ecosystems and their Services (MAES; Maes et al., 2013, 2018; Erhard et al., 2016);
- Natural Capital Committee (2013, 2014, 2015, 2017, 2019a,b);
- Common International Classification of Ecosystem Services (CICES; Haines-Young and Potschin 2013, 2018)
- Enabling a Natural Capital Approach (ENCA; Defra, 2020).

The recent Defra report (Hooper et al., 2019a) provides a detailed review of the natural capital approach, with a focus on UK policy and the marine context. There is a further wide literature on economic valuation including introductory guides produced by, or on behalf of, the UK Government (e.g. Defra, 2007; eftec & Environmental Futures Ltd., 2006).

1.4 The benefits of integrating the two approaches

There is significant policy momentum in the UK (and particularly England) behind the adoption of the natural capital approach in natural resource management. The UK National Ecosystem Assessment (2011, 2014), which was part-funded by the UK Government and devolved administrations, represented the first national-scale assessment anywhere in the world of the benefits provided by nature to society and the economy. This coincided with an Environment White Paper (HM Government, 2011b) that established natural capital thinking as a key component of UK environmental policy through commitments to develop natural capital accounts and to establish a Natural Capital Committee to advise government. This has been taken further in the 25 Year Environment Plan (HM Government, 2018), which explicitly

states that "*over the coming years the UK intends to use a 'natural capital' approach as a tool to help us make key choices and long-term decisions*."

Natural capital ideas and language are also becoming more widespread beyond the direct remit of Defra. The Green Book (HM Treasury, 2018), for example, provides comprehensive, approved guidance, methods and tools for appraisal process related "*to all proposals that concern public spending, taxation, changes to regulations, and changes to the use of existing public assets and resources.*" The most recent edition explains that the natural capital framework "*by providing a more comprehensive framework within which to develop and appraise policy, it suggests additional options to meet policy goals and enables all options to be assessed more accurately for potential improvements and/or damage to the environment.*" The Green Book further provides guidance on approaches to monetary and non-monetary valuation of natural capital. Within planning, the National Planning Policy Framework (MHCLG, 2019a) emphasises that planning policies and decisions should recognise "*the wider benefits from natural capital and ecosystem services*" and "*plan for the enhancement of natural capital*".

This policy position reflects well-established calls to reframe arguments for the conservation of nature (and hence natural resource management) in ways that better link the environment, society and the economy. It has long been argued that "*sustainable development is based on constant or augmented natural capital stock*" and that conserving or improving the natural capital stock directly contributes to the "*social objectives of equity within and between generations, economic efficiency and resilience*" (Pearce, 1988). Fundamentally, proponents of a natural capital approach believe that what we know about the natural environment is not being effectively synthesized and communicated to decision makers and the public, and so they are poorly equipped to make environmental trade-offs (Daily, 1997). The natural capital approach is intended to provide an alternative perspective and set of tools that can improve understanding of the value of the environment, our dependence on it, and the wider implications of allowing it to decline.

The academic literature further outlines the specific potential for applying a natural capital approach to impact assessment. This is considered primarily in the context of ecosystem services, which have been the focus of a larger body of research than the wider natural capital approach. The approach is considered appropriate for both SEA and also Environmental Impact Assessment (EIA) (e.g. Geneletti, 2016; Karjalainen et al., 2013; Rozas-Vásquez et al., 2017). Ecosystem service approaches are considered particularly appropriate for impact assessment, because the interaction between the environment, society and the economy is inherent in both processes (Geneletti et al., 2015) and there is already implicit consideration of ecosystem services within current practice (Honrado et al., 2013).

The language of natural capital is also becoming more prevalent beyond the academic literature. Brief reference to ecosystem services is made within the SEA for offshore energy in the UK (DECC, 2016) and, at the local authority level, aspirations to embed ecosystem services principles are clear within the North Devon and Torridge Local Plan (Torridge District Council and North Devon Council, 2018). In marine planning, extensive reference is made to natural capital assets and ecosystem services within the 'Iteration 3' environment consultation documents for the draft marine plans (MMO, 2019a), including around the need to minimise and mitigate adverse effects on marine or coastal natural capital assets and to enhance these assets where possible. Realising such aspirations requires proper classification, characterisation and assessment of all elements of the natural capital system at all stages of the development, implementation and evaluation of plans and policies, including in Sustainability Appraisal.

The natural capital approach also has the potential to bring some practical benefits in terms of streamlining the way in which information in impact assessment is summarised and reported. Asset and risk registers are proposed, respectively, as inventories of the present extent and condition of natural capital assets, and the current and future risks to them (Natural Capital Committee, 2017). This information is a fundamental starting point for impact assessment, and compiling it in the format of asset and risk registers provides a systematic means of summarising the large volumes of text typically included in impact assessment reports. The recent 'report card' format in which outcomes of the

Sustainability Appraisal scoping for marine plans were documented (MMO, 2016b) illustrates the benefits of improved summary formats.

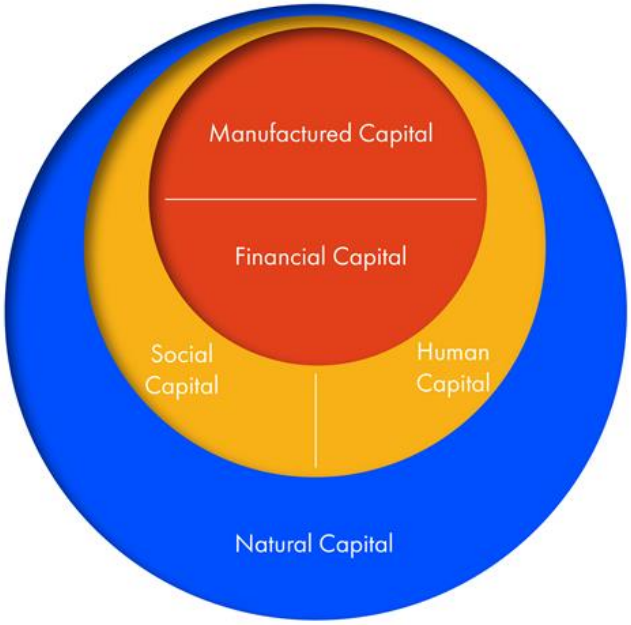
Practical guidance (albeit high level) on how to incorporate ecosystem services into impact assessment is also beginning to emerge, including through the UK National Ecosystem Assessment (Scott et al., 2014), from the Scottish Government (2016) and, beyond the UK, by the World Resource Institute (2013). The EIA industry is also beginning to adopt the language of natural capital (CIEEM, 2016) although has not yet provided methodological detail for practitioners. There is also an example of an application of ecosystem services within a 'real world' Sustainability Appraisal. The Sustainability Appraisal for the Marine Plan for Northern Ireland (AECOM & ABPmer, 2018) contains a high-level qualitative assessment (based on expert judgment) of changes in ecosystem services associated with the implementation of the Marine Plan compared to the baseline of no plan. This is provided in addition to the more usual 'topic-based' approach (discussed further in Section 2). However, there remains no systematic or widespread application of ecosystem services within impact assessment at the programme, plan or project level, and there appear to have been no attempts as yet to utilise the wider natural capital approach.

2 Conceptual framework for the proposed approach

2.1 Framework diagrams and descriptions

Sustainability Appraisal requires a comprehensive assessment of many different aspects of the ecosystem and its interactions with society and the economy. Annex I of the SEA Directive (and Schedule 2 of the Environmental Assessment of Plans and Programmes Regulations 2004) lists "*biodiversity, population, human health, fauna, flora, soil, water, air, climatic factors, material assets, cultural heritage including architectural and archaeological heritage, landscape*" as examples of the environmental factors which must be considered in assessment of the effects of plans and programmes. Categorisation of the environmental components of Sustainability Appraisal often tends to take a 'topic-based' approach of adhering closely to these subjects as listed (e.g. AECOM and ABPmer, 2018; Lepus Consulting. 2019). While this provides a functioning process through which to undertake the required assessment, it perhaps does not present the information obtained in a way that best facilitates whole system understanding or highlights key trade-offs. The natural capital approach provides an alternative way to frame the gathering and presentation of the information required under planning regulations.

The natural capital approach is intended to increase emphasis within decision-making on the natural environment, what it provides for people, and the value of this. However, decision-making bodies such as Local Authorities have wide-ranging responsibilities (including for social services, crime and education for example) some of which may have only minimal, or even indiscernible, direct relationships to the natural environment. Therefore, if the natural capital approach is to be integrated into Sustainability Appraisal in an efficient and effective manner, an overarching framework is required that captures all the elements likely to be pertinent to this wider decision-making context. The Five Capitals model (Forum for the Future, undated; (Figure 5) is already widely used in sustainable development contexts, including in local planning (such as by Powys County Council (2017) in their Local Development Plan) and thus provides a suitable framework for Sustainability Appraisal in which to nest an more comprehensive approach to natural capital assessment. The model further reinforces the importance of the natural environment, on which, ultimately, the production of all other capitals relies. The interconnected environmental, social and economic system can be represented using natural capital terminology in an overarching conceptual diagram (Figure 6).



Manufactured capital: goods or assets that contribute to the production process or the provision of services, rather than being part of the output itself. It includes for example tools, machinery, buildings and infrastructure.

Financial capital: those assets of an organisation that exist in a form of currency that can be owned or traded, including shares, bonds and banknotes.

Social capital: networks together with shared norms, values and understandings that facilitate cooperation within or among groups (such as families, unions, schools, voluntary organisations)

Human capital: the health, knowledge, skills and capabilities of individuals.

Natural capital: encompasses natural resources as well as the processes needed to sustain life and produce goods and services

Figure 5. The Five Capitals Model (Forum for the Future, undated) with associated definitions of each type of capital (Forum for the Future, undated; Hattam et al., 2017)

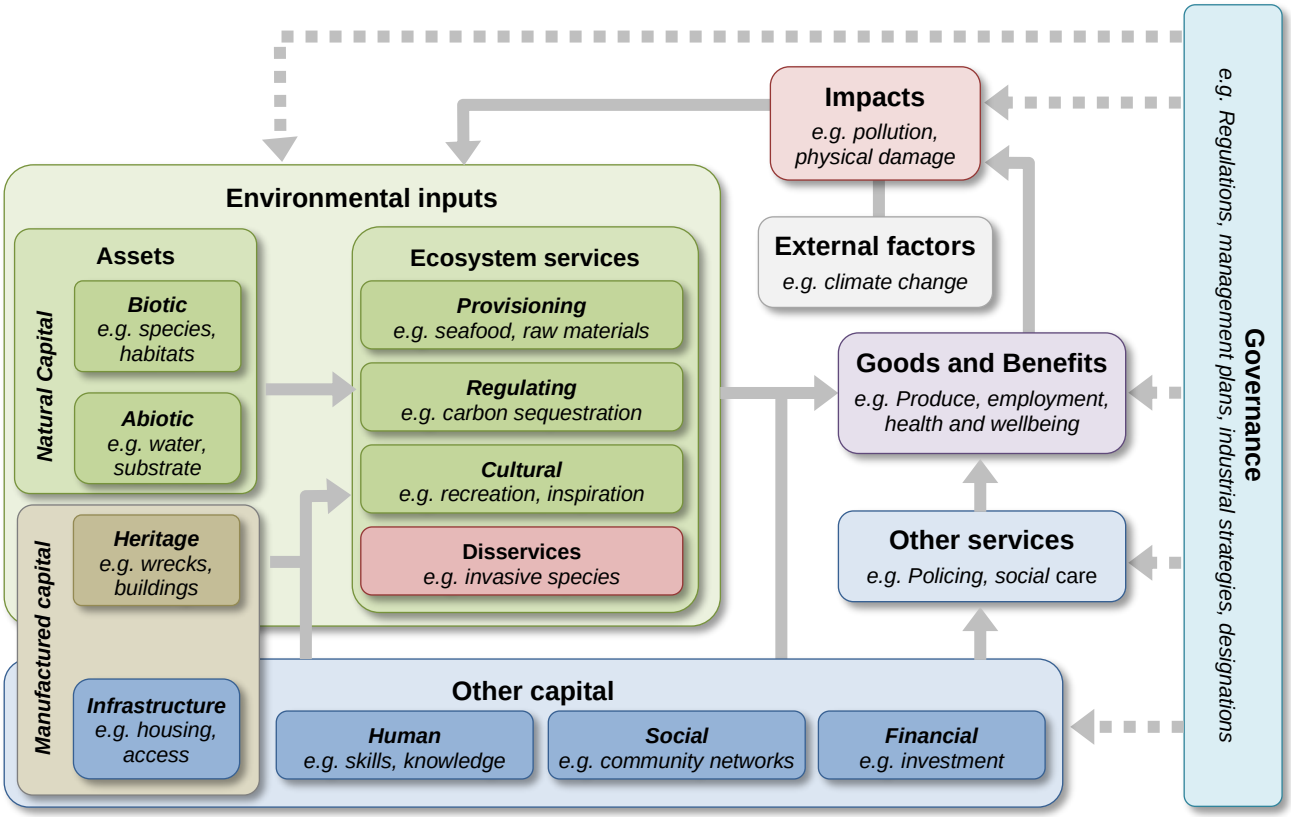


Figure 6. The overarching conceptual framework for the approach, showing how the elements considered in a Sustainability Appraisal interact with natural capital

The ecosystem provides **natural capital assets**: species, habitats, and abiotic components such as water and substrates. As pointed out by Firth (2019), the fundamental role of people in shaping the environment, and hence the connection between natural capital and heritage, is typically neglected in existing natural capital frameworks. To address this, the framework adopts a broad definition of **environmental inputs**, within which the heritage assets of **manufactured capital** (such as buildings and shipwrecks) are included. The explicit inclusion of heritage as an environmental input is in keeping with the SEA topics and with Sustainability Appraisal in practice, where listed buildings and other aspects of heritage are often grouped within overarching environmental quality objectives (e.g. Torridge District Council and North Devon Council, 2018). Heritage assets are also often managed in same way as natural capital assets, through designations and protected status.

These assets generate **ecosystem services** including harvestable stocks of seafood and raw materials (provisioning services), carbon storage and mitigation of flood risks (regulating services), and opportunities for leisure and recreation (cultural services). The term 'ecosystem services' is maintained for convention, even though some services should be termed 'environmental' as they relate to abiotic or heritage factors, rather than being produced by living organisms. Not all ecosystem services are positive, however. Natural ecological phenomena such as the proliferation of invasive species and algal blooms can have negative consequences for society or economic activity. These are termed **disservices**.

Other capital inputs including manufactured infrastructure, the skills of individuals, social networks, and financial investment, can be applied during the production of ecosystem services. This typically occurs within agriculture and aquaculture, for example the application of fertiliser or the deployment of settlement surfaces for shellfish. Other capital inputs are essential in the conversion of ecosystem services into useful **goods and benefits** that have a market value or contribute to our health and wellbeing. Fish stocks, for example, cannot be exploited without fishing vessels, equipment, and the expertise and knowledge of fishermen. The framework also includes **other services** (such as addressing crime, and providing social care), which do not have a direct relationship to environmental inputs but are important components of, for example, local plans which need to consider extensive social and economic issues.

The process of obtaining goods and benefits from the environment can have negative **impacts** upon it, both on the natural capital asset being exploited (such as through overfishing, or recreational disturbance caused by wildlife watching vessels) and the wider ecosystem (through, for example, abrasion, entanglement or collision). Maritime activities may also have positive benefits for natural capital and ecosystem services, such as shellfish aquaculture increasing water quality or the artificial reef effects of offshore wind farms providing nursery areas for commercial fish.

Many elements of the system are subject to **governance**, whether this is through the designation of protected areas, regulations to minimise and mitigate the impacts of certain activities, or management plans and industrial strategies that document objectives and priorities for key issues such as flood risk mitigation and economic development. The environment underpinning, and affected by, any particular plan, programme or project is not a closed system, particularly in the marine context with the interconnections provided by the water column. **External factors** beyond the geographical boundaries of a particular plan or programme and/or the jurisdiction of those responsible for its implementation also effect change on natural capital. Climate change is a key external factor, with other examples including pollution from airborne particulate matter, upstream discharges, and global ocean currents.

2.2 Fulfilling statutory criteria

It is essential that any new framework for Sustainability Appraisal complies with the requirements of the relevant legislation. A detailed assessment of the baseline information contained withing a standard Sustainability Appraisal was used to examine the suitability of the proposed framework, and is discussed in more detail in the marine planning case study (Appendix 1). As shown in Table 1, there are multiple ways to map the environmental factors listed in the SEA Annex I onto the proposed natural capital

elements, and thus the framework will allow comprehensive consideration of all of these factors, and their interactions, as required by planning legislation.

Table 1 does not include two topics from the SEA Directive Annex 1. 'Material assets' are not an element of natural capital, but fit within the wider framework as manufactured capital (e.g. roads, buildings, other infrastructure). Similarly, 'Population' tends to be interpreted as relating to demographic factors such as population size and density, employment structure, and deprivation, which again are not natural capital components. However, goods and benefits derived from the environment (which support jobs and therefore interact with demographics) are described for each element of the natural capital system. This illustrates a key benefit of the natural capital approach over the standard 'topic-based' framing of sustainability issues: the natural capital framework makes explicit how these factors (from assets to employment) are connected. Other elements of the conceptual framework feature in the Sustainability Appraisal process in other ways: for example, governance is considered by the identification of other relevant policies, plans and programmes that occurs during the first step of a Sustainability Appraisal, and impacts are evaluated within the stage of developing and refining alternatives.

Table 1. The key elements of the natural capital system, with indicative (but not exhaustive) examples of the multiple ways these map onto the environmental topics as listed in Annex 1 of the SEA Directive

SEA Directive Annex 1 Topic	**Environmental Inputs**		**Goods/Benefits**
	Assets	***Ecosystem Service***	
***Biodiversity, Fauna, Flora**	Species populations and habitats	Pollination and seed dispersal; cultivated and wild food stocks; non-food products	Quantity/value of crop and fish harvests and wildlife watching trips; wellbeing related to existence of wildlife
Soil	Soil types, species populations and habitats	Weathering, decomposition and fixing processes and their effect on soil health	Quantity/value of crop harvests
Water	Water bodies	Water supply, hydro, tidal and wave energy potential, transport options	Water for drinking and irrigation, electricity, shipping, recreation and leisure
Air	Wind conditions, species populations and habitats	Dilution by the atmosphere, bioremediation and filtration, wind energy potential	Clean air, electricity
Climatic factors	Species populations and habitats, water bodies, geological features	Regulation of temperature, humidity and chemical composition of the atmosphere and oceans, flood and erosion control	Stable climate, mitigation of impacts from climate change
Cultural heritage	Wrecks, listed buildings, monuments and their settings; Iconic species; Ancient woodlands	Characteristics of living systems that are resonant in terms of culture or heritage and/or have symbolic, sacred or religious meaning	Recreation, leisure, inspiration, wellbeing
Landscape	Habitats, as well as water bodies and geological features	Characteristics of living systems that enable observational interactions and aesthetic experiences	Recreation, leisure, inspiration, wellbeing
***Human health**	Species populations and habitats, water bodies	Disease and pest control; noise reduction; visual screening; flood control, observational and immersive interactions, aesthetic experiences	Improved health/wellbeing from food, clean air and water, flood protection, interactions with nature

* NOTE: Biodiversity, flora and fauna supports all assets and ecosystem services except those provided by non-living components of the ecosystem, and human health/wellbeing is a key benefit of most ecosystem services so these categories also interact with the other SEA topics.

2.3 Scope of the proposed methodology

Sustainability Appraisal is well-established and follows an accepted process (as described in e.g. ODPM, 2004). Incorporating the natural capital approach does not require that process to be completely overhauled. Instead, it offers an alternative means of framing sustainability issues that fits entirely within the stages and steps of the process as already defined. The natural capital approach does not introduce environmental, social and economic factors beyond those that would be assessed for a standard Sustainability Appraisal; it simply suggests approaching the information and issues in a different way. Also, the approach does not require any additional data collection beyond that which would normally be undertaken; the expectation is that best available evidence will be used.

The proposed framework is applicable initially during the scoping phase, as it sets up a protocol for gathering evidence and identifying sustainability issues. This is done through the four core elements: an asset register (in which information on the status of natural capital is compiled), an ecosystem services inventory (to list services, benefits and values); an asset-service matrix (to connect services to the assets from which they are derived); and a risk register (which summarises threats to continued system functioning). These are described in detail in Section 4.

The natural capital approach also applies to the second stage in Sustainability Appraisal, that of developing and refining alternatives. Again, using the proposed approach does not change the overarching requirements for this phase, but recommends assessing the implications of plan/programme options against the framework established for the scoping phase. Steps such as consultation, developing alternative options, and proposing monitoring strategies do not require alternative methods, but can be applied to the information as organised under the natural capital framework. The steps in the Sustainability Appraisal process for which a natural capital methodology is proposed, and hence the scope of this guidance, are outlined in Figure 7.

The proposed process is comprehensive, with a detailed and systematic approach to collecting baseline information and identifying sustainability issues. It is important to ensure that the scoping phase provides a sufficient understanding of what natural capital assets are present, what ecosystem services are supplied, and the goods and benefits that result. Documenting the extent and status of individual assets allows for the selection of detailed sustainability objectives and indicators that relate specifically to those assets, and for the full implications of plan options to be assessed. This in turn supports better outcomes than using high-level objectives and indicators such as the number and condition of protected sites.

The proposed natural capital framework is designed to be comprehensive while also recognising that Sustainability Appraisal is undertaken at different scales, in different contexts and with different levels of resource. Therefore, it is flexible and can accommodate differences in the requirements for (and availability of) data. The framework has been developed with the broader planning and licensing system in mind, and so has a wider application beyond Sustainability Appraisal. For example, the framework can be used at more strategic levels such as in setting overarching Local Plan objectives, not just those for the Sustainability Appraisal. Furthermore, the proposed framework can also be applied to Environmental Impact Assessment, and so supports better integration of assessment at site and strategic scales.

In order facilitate use of the framework in a range of contexts, the approach seeks to fit to other obligations, processes and tools that may be relevant to planning and decision making at different scales. This includes in particular the Biodiversity 2.0 metric for assessing net gain (Crosher et al., 2019), but also to the work undertaken by Natural England in developing natural capital indicators and atlases (Lusardi et al., 2019; Wigley et al., 2020) and Defra's guidance on Enabling a Natural Capital Approach (ENCA; Defra 2020). ENCA relates particularly to accounts and valuation, which are not a primary focus of Sustainability Appraisal. However, consideration of ENCA in designing the Sustainability Appraisal framework should allow for greater coherence if agencies (such as Local Authorities) also seek to develop natural capital accounts. The common conceptual elements between Sustainability Appraisal and ENCA are shown in Figure 8.

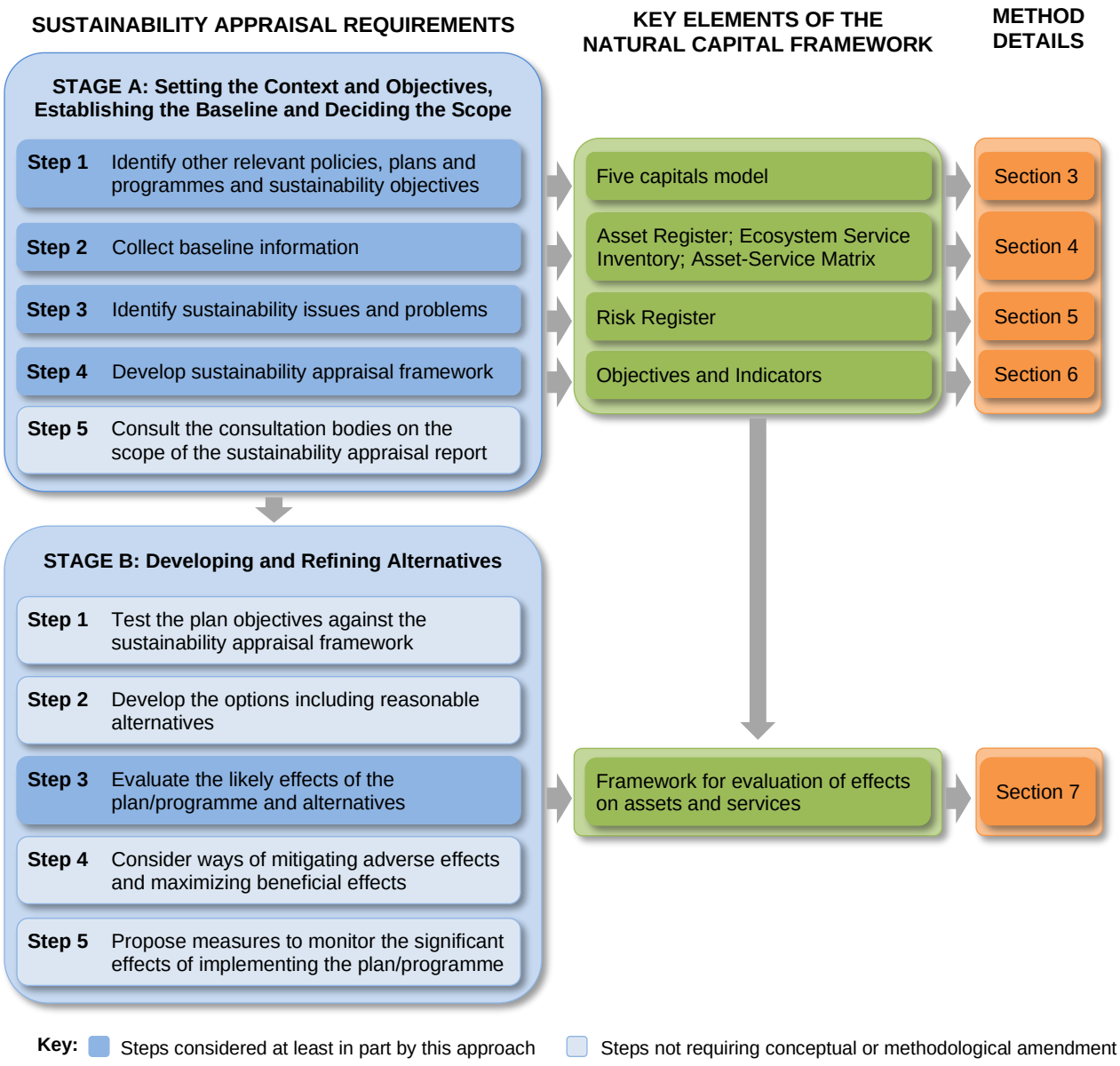


Figure 7. The steps in Sustainability Appraisal (based on MHCLG, 2019b) for which a natural capital methodology is proposed, the key elements of the framework relating to each, and the relevant sections in this report.

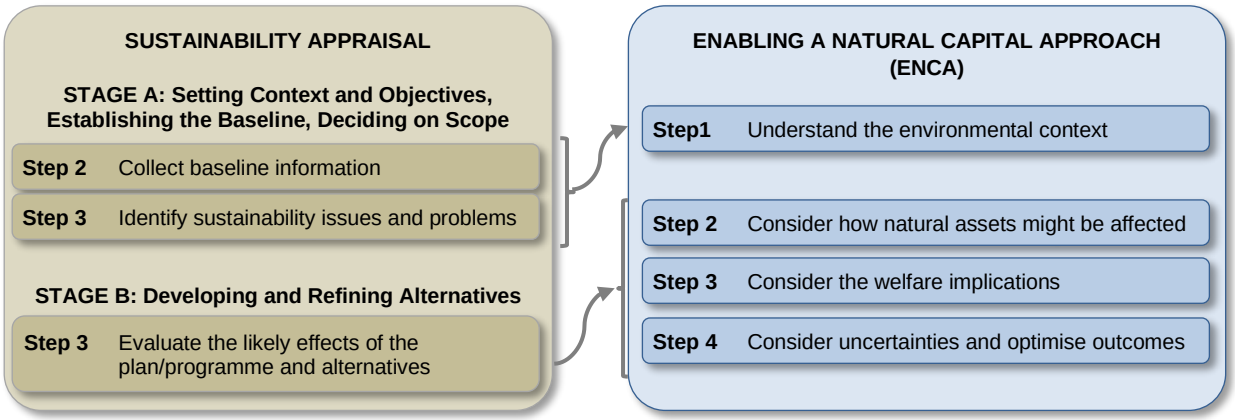


Figure 8. The common conceptual elements between Sustainability Appraisal and Defra's Enabling a Natural Capital Approach (ENCA; based on MHCLG, 2019b and Defra, 2020).

2.4 Building a natural capital database

In addition to any narrative reporting, a comprehensive database should be constructed that allows for information to be systematically recorded (supporting subsequent analysis) and from which summary sheets can be drawn in order to present information clearly and coherently. While such databases may not be a common component of reporting they are not unheard of. A substantial database was used to compile evidence during scoping for the Sustainability Appraisal for UK Marine Plans (MMO, 2016c). As will be described in detail in the sections that follow, the proposed database will contain information on the quantity, quality, trends, designations and other management of assets together with details of ecosystem services provided, the goods/benefits they supply and who benefits; a matrix to connect assets and services; and a summary of risks to the continued delivery of benefits. This will serve to demonstrate the breadth and extent of support the local environment provides to people within and beyond the plan/programme area.

The content of summary tables is outlined within this guidance. They are designed to be completed for the most part using three-point categorical rating scales (high, medium, low; increasing, stable, declining; etc). This recognises the likely difficulties in obtaining quantitative data for all elements of the evidence base, particularly for marine areas (and hence the need to use expert judgement). Also, even where complete quantitative data is available, summaries that can easily be given 'traffic light' coding are useful in highlighting key areas of concern and thus facilitate prioritisation. The process of determining the rating, the underlying information used, and assumptions made should be included as part of the wider evidence base. The evidence base should further include confidence assessments, to highlight possible inadequacies in the available data, and list sources of data and other references used. Such information should not be limited to published documents, and details of any sources such as personal communications, stakeholder workshops or expert judgement should also be given. Approaches for confidence assessments are not included (they are not specific to natural capital); reference should be made to general best practice. Geographical Information Systems (GIS) should be used where possible, as mapped outputs aid visualisation and interpretation, and support spatial planning. Again, GIS techniques are not specific to natural capital and so are not described here.

Detailed habitat and ecosystem service classifications (described in the sections that follow) provide the framework for the collection/collation of baseline environmental information. Their purpose is to ensure that evidence gathering and presentation is systematic and comprehensive and so supports development of a Sustainability Appraisal framework that is fit for purpose. It is recognised that there is a trade-off between the optimum level of detail required to provide the most complete natural capital assessment and the availability of resources to collect the necessary information. However, an initial participatory process with stakeholders as part of the scoping phase will quickly reduce the full framework to a subset that is appropriate for the plan/programme. Habitat and ecosystem service classifications in particular are hierarchical, and so can be expanded or collapsed according to the needs and scope of a specific context.

Description and discussion of the structure and content for the database and summary tables is given in the following sections. The main elements of the database are summarised in Figure 9, and the different components are introduced and explained in a logical progression, as the process for developing the asset register, ecosystem services inventory, asset-service matrix and risk register is outlined. A preliminary worked example that includes certain elements is included in the sustainability assessment for the North Devon Marine Natural Capital Plan (Appendix 2). Identification of a full suite of resources that can support data gathering to complete the database in particular contexts is beyond the scope of this guidance, but some indicative examples of such resources are given.

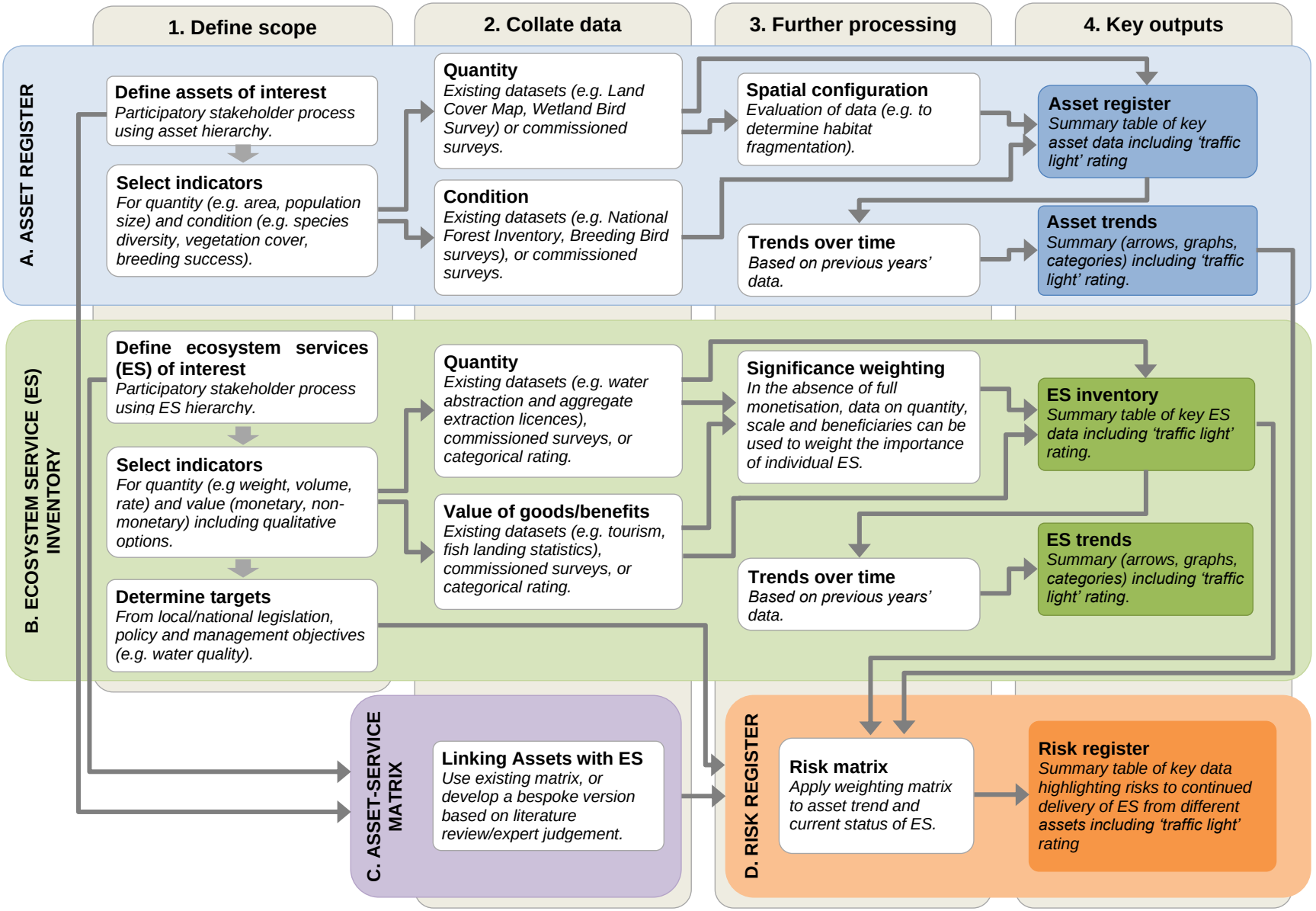


Figure 9. The main steps and elements of the natural capital assessment process and their outputs, which form the key elements of the sustainability appraisal database.

3 Set High Level Sustainability Objectives (Step 1)

3.1 The Five Capitals Model

Employing a natural capital approach has no effect on methods for identifying other relevant policies, plans and programmes, and so those components are not considered here. A natural capital framework is, however, pertinent to the identification of sustainability objectives.

Sustainability objectives will be specific to individual contexts, but in all cases these should seek to secure environmental improvements, an ethos encouraged by the 25 Year Environment Plan (HM Government, 2018) and the National Planning Policy Framework (MHCLG, 2019a). Sustainability objectives tend to be defined initially at a high level, for example 'Promote sustainable tourism' (Torridge District Council and North Devon Council, 2016a), 'Protect and conserve natural resources' (Lepus Consulting, 2019), or 'Ensure resources are available and efficiently used to sustain development and reduce waste and consumption' (Wood Environment & Infrastructure Solutions UK Limited, 2019).

Such high-level objectives are appropriate initially as a means of steering the general direction of the Sustainability Appraisal, but these need to be supported by detailed sustainability indicators defined within the final sustainability appraisal framework (Step 4), and developed following an iterative process undertaken as baseline information and sustainability issues are identified (Steps 2 and 3).

The Five Capitals Model (Figure 5) and overarching natural capital system concept (Figure 6) should be used to frame consultations around the key issues to be addressed by the sustainability objectives, and thus ensure that there are appropriate objectives that support the whole system. The five capitals model has already been applied to Sustainability Appraisal, for example in the creation of the Powys Local Development Plan (Powys County Council, 2017), and more widely during scoping in other planning contexts (e.g. Calne Town Council et al., 2012). Examples of how specific planning topics have previously been classified according to the type of capital represented are given in Table 2.

Table 2. Examples of topics relevant to each of the five capitals, in a local planning context (adapted from Powys County Council, 2017; with definitions from Forum for the Future, undated and Hattam et al., 2017).

Capital	Natural	Manufactured	Human	Social	Financial
Definition	Encompasses natural resources as well as the processes needed to sustain life and produce goods and services	Goods or assets that contribute to the production process or the provision of services, rather than being part of the output itself. It includes for example tools, machinery, buildings and infrastructure.	The health, knowledge, skills and capabilities of individuals	Networks together with shared norms, values and understandings that facilitate cooperation within or among groups (such as families, unions, schools, voluntary organisations)	Those assets of an organisation that exist in a form of currency that can be owned or traded, including shares, bonds and banknotes.
Examples	• Energy • Climate Change • Waste • Water • Green Infrastructure	• Housing • Access • Regeneration	• Health • Education • Skills • Employment	• Community support • Governance • Equality • Culture, Sense of Place • Business	• Maximising financial effectiveness

In practice, however, it may prove difficult to allocate high level plan/programme themes and objectives to a single type of capital, as they are likely to encompass a multitude of issues. The five capitals model is more useful in breaking down overarching aims into their constituent parts from which specific objectives, indicators and targets can be derived that encompass the environment, infrastructure, individuals and wider society.

For example, an aim to manage and adapt to climate change can be considered in terms of:

- the ability of the environment to sequester carbon and to protect infrastructure from flooding and erosion (*natural capital*)
- the availability and suitability of renewable energy infrastructure, public transport and flood protection infrastructure (*manufactured capital*)
- the required skills, employment opportunities and need to encourage behaviour change around e.g. transport use (*human capital*)
- the opportunity for community-led energy projects (*social capital*)
- mechanisms to encourage related inward investment (*financial capital*)

Examples of specific sustainability objectives for the different types of capital are given in Table 3.

Table 3. Examples of high-level sustainability objectives for each of the five capitals (Torridge District Council and North Devon Council, 2016a; Powys Council, 2017; Halcrow Group Ltd, 2009; Calne Town Council et al., 2012).

Main capital type	Examples of high-level sustainability objectives
Natural	• Protect and enhance biodiversity and important wildlife habitats • Protect and enhance the countryside, natural landscape and townscape. • Maintain and enhance heritage assets and their settings. • Maintain and enhance air quality. • Protect high-grade soils
Manufactured	• Provide suitable housing that meets the needs of the population and maximise affordable housing • Improve energy efficiency and use of sustainable construction materials • Make public transport, walking and cycling easier and more attractive • Ensure that new buildings are of a high quality both in main town centre areas and within the remainder of the town,
Human	• Provide access to learning, training, skills and knowledge for everyone • Diversify the range of local employment opportunities • Improve health of population and reduce health inequalities • Strengthen research, technology and innovation
Social	• Reduce crime and the fear of crime • Promote development which supports community wellbeing and cohesion, especially in those areas facing multiple deprivations • Use information technology to promote and facilitate opportunities within the community planning process including buildings and services which can be utilised by the community, using business networks to provide opportunities for new enterprise • Contribute to a diverse and growing population with a balanced demographic structure • Fully engage with and positively involve the local community and other interested parties at all stages of the planning process
Financial	• Foster sustainable economic growth • Contribute to a private sector that is a high-level economic contributor • Provide export opportunities • Become a location of choice for startup businesses

Although the full five capitals model has been presented here, only environmental inputs (Natural Capital, and Manufactured Capital where this relates to built heritage) will be discussed further in the remainder of this document. Wider issues related to, or attempts to classify, other capitals and other (non-environmental) services are beyond the scope of this guidance.

4 Collect Baseline information (Step 2)

4.1 Asset Register (Step 2.1)

The first constituent of the natural capital evidence base is an asset register, defined simply as "*an inventory of the natural assets in an area and their condition*" (Natural Capital Committee, 2017). Much of the development of the natural capital approach has been in relation to changes in land use, which can be mapped and are often amenable to remote-sensing approaches. This has led to a focus on habitats

as key assets and the units which supply ecosystem services. There are limitations to this 'land cover' approach particularly for marine areas (Hooper et al., 2019a), but an alternative with the same level of understanding and acceptance has not yet been developed. Populations of mobile species are also important natural capital assets, and heritage assets should be considered. While heritage assets are not 'natural' capital, they are important environmental inputs to the socio-ecological system (and generate ecosystem services in tandem with ecological assets) and so should be included in the asset register.

4.1.1 Habitat classification hierarchy

Classification systems are designed to provide a consistent categorisation where there are multiple individual elements to be considered, and thus enable systematic and comparable assessment. It is therefore recommended that baseline information on habitats is collected using a recognised classification hierarchy. For terrestrial and freshwater natural capital assets, the UK Habitat Classification[2] (UKHab; UK Habitat Classification Working Group, 2018) is considered most appropriate as a framework for data collection and presentation. It is recommended to those intending to apply the Biodiversity Metric 2.0[3] (Crosher et al., 2019). Given the relevance of this metric to determining biodiversity net gain, which is expected to be mandated in the forthcoming Environment Bill (Defra, 2019), it seems probable that the UKHab will become familiar to, and widely used by, both planning authorities and developers. Furthermore, the scoring within the Biodiversity Metric 2.0 contains a weighting for strategic significance, recognising how strategic objectives should be explicitly linked to actions at a site scale. Using the same framework at the plan/programme scale supports identification of strategically significant assets to be considered in net gain assessment and planning/licensing decisions.

UKHab also links closely with the broad habitats from the UK National Ecosystem Assessment (2011), which are also those of the Countryside Survey (Maskell et al, 2008), the Land Cover Map (CEH, 2017) and Natural England's Natural Capital atlases (Wigley et al., 2020). Thus, the use of UKHab should facilitate access to extent and condition data associated with these national monitoring programmes and tools, further details of which are available from the relevant websites[4,5,6]. The UK National Ecosystem Assessment (2011) classification is also the basis of the ENCA framework (Defra, 2020), and so the straightforward translation between this and UKHab also facilitates linkages to accounts developed using the ENCA methodology.

An alternative classification system on which to base a natural capital assessment is the European Nature Information System (EUNIS[7]), which has been used for Scotland's Natural Capital Asset Index (Watkinson, 2017). EUNIS is a "*comprehensive pan-European system to facilitate the harmonised description and collection of data across Europe through the use of criteria for habitat identification"* (European Environment Agency, 2019). The EUNIS classification is commonly used for categorising coastal and marine areas, and is the basis of the UK[8] and EU[9] SeaMaps (Populus et al., 2017). The Biodiversity Metric 2.0 recommends the EUNIS classification for net gain assessment in intertidal areas (Alvarez et al., 2020), and it was also used in the Mapping and Assessment of Ecosystems and their Services (MAES) programme (Maes et al., 2013).

A drawback to using EUNIS in practice at more strategic scales is that the higher levels of the classification do not indicate the presence of important habitats. The Biodiversity Metric 2.0 has therefore created an additional category such that intertidal bedrock habitats (including peat/clay/chalk) will be identified (Alvarez et al., 2020). For this reason, the UKHab classification may be more appropriate in sustainability appraisal for coastal areas. UKHab links closely to priority habitats and therefore features such as seagrass and mussel beds, as well as chalk, peat and clay exposures, are highlighted. Also,

[2] https://ecountability.co.uk/ukhabworkinggroup-ukhab/
[3] http://publications.naturalengland.org.uk/publication/5850908674228224
[4] https://countrysidesurvey.org.uk/
[5] https://www.ceh.ac.uk/services/land-cover-map-2015
[6] http://publications.naturalengland.org.uk/publication/6672365834731520
[7] https://eunis.eea.europa.eu/habitats-code-browser.jsp
[8] https://jncc.gov.uk/our-work/marine-habitat-data-product-ukseamap/
[9] https://www.emodnet-seabedhabitats.eu/

UKHab facilitates use of Countryside Survey data, which provides information on temporal change in intertidal habitats.

UKHab, the Biodiversity Metric 2.0 and data sources such the Countryside Survey do not apply below the low water mark. Marine habitats are included within the UK National Ecosystem Assessment (2011) but this classification for coastal and marine habitats is not comprehensive (pelagic habitats are lacking) or consistent, as it mixes supralittoral (splash zone) and littoral (intertidal) habitats in one category (Hooper et al., 2019a). Therefore, EUNIS is a more appropriate classification for marine habitats, which again should facilitate the use of open-access marine habitat maps.

In developing an asset register for Sustainability Appraisal, it is recommended that the UKHab classification is used for terrestrial, freshwater and intertidal habitats and that EUNIS is used for fully marine areas. Both systems use expandable hierarchies, allowing the level of resolution required to be adapted to the context of the plan or programme being considered by the Sustainability Appraisal. It is expected that setting the scope for the Sustainability Appraisal will require consideration of habitats to Level 4 in both UKHab and EUNIS, even if detailed, systematic data and maps are not available for all habitats at this level of resolution. The high levels of the proposed classification for natural capital assets is given in Table 4, and the full classification in Appendix 3. Deep sea habitats (EUNIS category A6) and pelagic zones below the euphotic are not included as they are considered outside scope of this guidance. In principle, the approach should apply to all marine systems, but deep sea areas have particular challenges, and the proposed method should be evaluated in that specific context.

Published conversion tables exist to support understanding of correlations between different habitat classifications (e.g. UK Habitat Classification Working Group, 2018; JNCC, 2018). An example of cross tabulation between UKHab and EUNIS for intertidal habitats is also included in Appendix 3. The marine component of EUNIS is also begin updated, but the related documentation (EEA, 2019) contains correlation with the 2012 version (which is used in this guidance).

Table 4. Broad and component habitat types for assessment of natural capital assets in Sustainability Appraisal, (based on UK Habitat Classification Working Group, 2018; and EUNIS[6])

Zone	Broad Habitat	Component Habitat
Land	Grassland	Acid grasslands Calcareous grasslands Neutral grasslands Modified grassland
	Woodland and forest	Broadleaved, mixed and yew woodlands Coniferous woodlands
	Heathland and shrub	Dwarf shrub heath Hedgerows Dense scrub
	Wetland	Bog Fen, marsh and swamp
	Cropland	Arable and horticultural
	Urban	Built up areas and gardens
	Sparsely vegetated land	Inland rock Supralittoral rock Supralittoral sediment
Freshwater	Rivers and lakes	Standing open waters and canals Rivers and streams
Marine	Marine inlets and transitional waters	Littoral rock Littoral sediment
	Sublittoral habitats	Sublittoral rock Sublittoral sediment Pelagic water column

Abiotic assets

Natural capital assets also include abiotic elements which supply ecosystem services regardless of the presence of any living organisms, including:

- bodies of freshwater (used for drinking, irrigation, or navigation)
- mineral reserves (that supply e.g. gems or building aggregates)
- energy sources (peat stocks, as well as water/air as a source of e.g. tidal and wind flows)
- landscape features (such as caves, cliffs)

It is not expected that abiotic assets should be categorised separately from biotic assets (they can be combined together within the proposed habitat classifications) but the abiotic component of an asset needs to be recognised in determining the supply of ecosystem services (see Section 4.2 below).

4.1.2 Species and heritage assets

The UK National Ecosystem Assessment identifies the role of biodiversity in the provision of ecosystem services, and lists ten main species groups (Norris et al., 2011):

- micro-organisms
- fungi
- lower plants
- higher plants
- invertebrates
- fish
- amphibians
- reptiles
- birds
- mammals

However, the level of species diversity renders impractical the development of a manageable, generic framework for species similar to that for habitats. In determining key species assets therefore, it is proposed that a context-specific list is defined for each Sustainability Appraisal, which considers in particular protected species (including those defined in the Annexes of the Habitats and Birds Directives, or are otherwise features of terrestrial and marine protected areas), as well as those species that support ecosystem services such as food and recreation and/or have high non-use values (for example species of fish, birds and mammals). The habitats framework (Table 4) can also be used to direct thinking on the species present in these different areas. An example of a bespoke species list developed for Sustainability Appraisal is given in the case study for the Marine Natural Capital Plan (Appendix 2), which included wetland birds, seabirds, commercial fish and shellfish, protected marine and coastal plants and invertebrates, grey seals and harbour porpoise.

In the expanded natural capital system proposed, heritage assets become part of the environmental inputs to the system, to be considered in parallel with natural capital assets. The National Planning Policy Framework (MHCLG, 2019a) defines seven categories of designated heritage assets namely:

- World Heritage Site
- Scheduled Monument
- Listed Building
- Protected Wreck Site
- Registered Park/Garden
- Registered Battlefield
- Conservation Area

These provide a starting point for assessment, but the historic environment also includes non-designated heritage assets, encompassing locally significant buildings, monuments, sites, places areas or landscapes identified by Local Planning Authorities (MCHLG, 2019). The inclusion of non-designated assets is further reinforced in the Marine Policy Statement (HM Government, 2011a) for heritage assets in the marine environment. Thus, as with species assets, generic frameworks to support assessment of the full suite of heritage assets are not practicable and context-specific lists should be defined.

4.1.3 Database summary table

The natural capital evidence database is designed to be a summary of available information that facilitates reporting at the overarching scale of the sustainability appraisal. The key information required for an asset register is the extent (quantity), condition (quality) and spatial configuration of each asset (Table 5), and the use of maps and Geographical Information System (GIS) layers is encouraged (Natural Capital Committee, 2017).

Table 5. The format of the asset register summary table, with a description of the information required and suggested options/examples of cell content

Column header	Description	Options/*examples** for cell contents
Quantity	A quantified assessment of the area, volume or number of individuals (as appropriate).	*e.g.6.7km^2, 3,184 individuals*
Quantity trend	Where time series data is available or can be estimated, the broad trend in the quantity of the asset should be noted, which can be represented visually, e.g. as directional arrows.	Improving; Stable; Declining
Quality rating	Quality rating should be given on a categorical scale, which can be represented visually, e.g.as a traffic light system.	Poor; Moderate; Good
Quality trend	Where time series data is available or can be estimated, the broad trend in the status of the asset should be noted, which can be represented visually, e.g. as directional arrows.	Improving; Stable; Declining
Spatial configuration *(habitats only)*	The degree to which the asset is spatially coherent (i.e. occurs in patches of sufficient size to support effective ecological functioning, and has connections to other areas) and appropriately sited to provide ecosystem services.	Poor; Moderate; Good
Spatial configuration trend *(habitats only)*	Where time series data is available or can be estimated, the broad trend in the spatial status of the asset should be noted, which can be represented visually, e.g. as directional arrows.	Improving; Stable; Declining

* the associated categories/scales to be used in recording (given in normal type) or, where category lists are extensive or not applicable, examples of possible content (*in italics*)

Quantity is perhaps the most straightforward metric for which to gather data, particularly with the availability of remote sensing options and resources including the Land Cover Map[4] and, for intertidal and marine habitats, the UK[7] and EU[8] SeaMaps. Useful population data also exist for certain species (such as the Wetland Birds Survey[10]) and individual Local Authorities hold data on heritage assets in the form of Historic Environment Records[11]. Indicators for asset quality (and other metrics related to the natural capital approach) are included in Defra's consultation on measuring progress of the 25 Year Environment Plan (Defra, 2018), although the suite of indicators currently proposed has been criticised as being insufficient (Natural Capital Committee, 2019; 2020). A comprehensive assessment of indicators was undertaken by Natural England (Lusardi et al., 2018), which has been applied in the development of their national natural capital atlas (Wigley et al., 2020). Other suggestions for, and reviews of, indicators include those of Maes et al. (2018), Tillin et al. (2019) and Burdon (2020).

In determining the quality of assets, an existing formal quality assessment may be available, for example for protected sites that undergo statutory condition monitoring. Otherwise, literature providing guidance on conducting condition assessment is available. For example, Natural England's work in developing a biodiversity metric for net gain (Crosher et al, 2019) provides criteria against which terrestrial habitats (including coastal habitats found in the splash zone) should be judged for poor, medium or good status, and is designed particularly for the planning context. For the marine environment, Rees et al. (2019) propose a method for determining the Likely Relative Condition of marine habitats, based on knowledge of pressures occurring in an area and the sensitivity of habitats to those pressures. Quality information for species can include factors such as breeding success, which may be recorded as part of condition assessment for designated species. Some quality information may be available for heritage (for example, in the entry records for listed infrastructure), and this parameter can also be used to capture information about the setting of the asset.

The third component of natural capital status is spatial configuration, which applies only to habitats. Spatial configuration should be considered in terms of the extent to which the overall area of the habitat is fragmented, as this can significantly affect the ecological functions and hence any services or benefits provided (Mace *et al.*, 2015; Bateman *et al.*, 2011). Assessment of the spatial configuration should also

[10] https://bto.org/our-science/projects/wetland-bird-survey
[11] https://www.heritagegateway.org.uk

consider whether the asset is appropriately located for the provision of ecosystem services. The role of saltmarsh in providing coastal protection is likely to be site dependent (Shepard et al., 2011) and other habitats such as woodlands need to be in the right place to, for example, intercept pollution and hence improve environmental quality. There is not a straightforward and universally accepted mechanism for assessing spatial configuration, although the connectivity of habitats is considered within the Biodiversity Metric 2.0 (Crosher et al., 2019) and experimental indicators are being developed (JNCC, 2019). Therefore, for the purposes of the asset register, it is expected that a categorial rating will be used.

Information on temporal trends for asset quantity, quality and spatial configuration is also important for highlighting those assets most at risk and understanding the likely impacts of any plan or programme. An indicator that combines all three elements could be developed, although keeping the different facets separate aids understanding of whether sustainability issues relate to the loss or the degradation, or both, of natural capital and heritage assets. Maintaining the asset register in database form supports understanding of trends. Many plans and programmes (particularly local plans, marine plans, and some strategic environmental assessments such as that for offshore energy) are refreshed or repeated after an interval of several years. The systematic storage of data from previous assessments facilitates its comparison with updated information. Temporal change in asset quantity will be challenging to assess in marine habitats unless local monitoring is undertaken. Resources such as UKSeaMap use primarily modelled data and are not appropriate for determining trends in habitat cover.

The summary table should be supported by a wider narrative containing additional information about each asset, to aid understanding of the likely response of the asset to any change resulting from the plan/programme. Noting any conservation designations and other relevant management systems in place for particular assets will also support understanding of the interactions between the proposed plan/programme and existing policies. Further information related to the status of the habitat (such as reasons for declining quantity, poor quality or fragmentation; proximity to thresholds/tipping points; and comparisons with wider national trends) should be included, together with reference to any other factors that constrain, inform or otherwise affect aspects of resource use and management.

4.2 Ecosystem Services Inventory (Step 2.2)

4.2.1 Classification Hierarchy for Ecosystem Services

The next stage is to identify the ecosystem services important within the context of the plan/programme. As is the case for assets, a standard classification should be used to identify and categorise the services that will feature in the inventory. There has been some debate as to whether universal classification for ecosystem services is desirable or even possible (as reviewed in e.g. Hooper et al., 2019a). However, certain classifications have emerged that have been widely used in different circumstances, and thus demonstrated their applicability in practice as a framework to support natural capital assessment. The Common International Classification of Ecosystem Services (CICES; Haines-Young and Potschin, 2013; 2018) has been applied extensively outside the academic sector, particularly in Europe (La Notte *et al.,* 2017), including as the basis for Scotland's Natural Capital Asset Index (Watkinson, 2017). Alternative classifications are in development particularly to support ecosystem accounting, such as the National Ecosystem Services Classification System (NESCS) in the United States (United States Environmental Protection Agency, 2015). However, these have rarely been applied in practice.

CICES[12] was first published in 2013, and updated to its current version (5.1) in 2018. It provides a hierarchy of ecosystem services within the three broad sections of Provisioning, Regulation and Maintenance, and Cultural (further details of which are provided in Appendix 4). CICES includes the contribution of abiotic features, i.e. those aspects of the environment that provide services independent of species or habitats, such as marine aggregates as raw materials, and caves and rock faces used for recreation. It is thus compatible with the wider definition of environmental inputs as used in the overarching conceptual framework proposed in this guidance. In its definitions and examples, CICES

[12] https://cices.eu/

further seeks to reinforce that ecosystem services represent the ecological end point of the chain, and do not of themselves provide goods and benefits to people without further human interaction. Therefore, cultural services are described as “opportunities” for recreation and provisioning services are described in terms of, for example, standing crops and the harvestable proportion of stocks rather than as the quantity of food or raw materials that ultimately result.

CICES is designed to be a comprehensive and precise categorisation, with unambiguous, mutually exclusive categories. In practice, however it may be challenging to disentangle particular individual services (especially, for example, different cultural services obtained from indirect interactions) and so it may be necessary to assess these in aggregate. While CICES is a hierarchical classification, the higher levels of the classification (division, group) are perhaps not arranged in the most straightforward way from an end-user perspective. Therefore, the ecosystem services framework proposed for Sustainability Appraisal combines the individual CICES classes (the most detailed level of that hierarchy) with a higher level classification used by Natural England in the development of accounts for National Nature Reserves (Sunderland et al., 2018). In doing so, this provides more accessible categories for ecosystem service groups. The higher levels of this framework are shown in Table 6, with the CICES classes (Level 4 of the hierarchy) included in Appendix 4. The hierarchy also includes a provisioning category of ‘Carrier’ services to recognise the role of waterways in the transport of goods (following Hooper et al., 2014).

Table 6. The higher levels of the ecosystem service hierarchy proposed for supporting Sustainability Appraisal, (developed from Sunderland et al., 2018; Haines-Young and Potschin, 2018; Hooper et al., 2014).

Level 1	Level 2	Level 3
Provisioning	Food	Cultivated food crops
		Livestock
		Cultivated seafood
		Foraged plants
		Game and wild fish
		Food products from non-living sources
	Materials	Non-food products from plants, animals & algae
		Non-food products from non-living sources
		Genetic resources
	Water	Water supply
	Energy	Energy from non-living sources
		Energy from plants
		Energy from animals
	Carrier	Commercial and other transport
Regulation and maintenance	Environmental quality	Water quality
		Air quality
		Soil health
	Maintaining wild populations	Pollination & seed dispersal
		Maintenance of nursery populations and habitats
	Hazard and nuisance reduction	Erosion control
		Flood protection
		Storm protection
		Pest and disease control
		Fire protection
		Noise reduction
		Visual screening
	Climate regulation	Climate regulation
Cultural	Physical, experiential and intellectual interactions	Recreation, tourism and other experiential opportunities
		Scientific and educational opportunities
	Cultural significance of nature	Aesthetic
		Heritage, spiritual and representational significance
	Non-use values	Existence, bequest and option values

The categories listed Table 6 can be used as the main scoping framework, but further reference to the full CICES list (Appendix 4) should also be made, as this will serve to highlight services that are important but may not be immediately obvious (as is often the case for regulating services in particular). As with the identification of key assets, a participatory process with stakeholders should quickly identify services that are not applicable or are not provided in a significant quantity, and hence allow the list to be refined for the context of a specific Sustainability Appraisal.

4.2.2 Database summary table

Ecosystem services should be recorded separately in the database in the format suggested in Table 7. Again, a wider narrative is also required, in particular to capture additional information such as who are the beneficiaries of particular services, which can link to other aspects of the plan/programme related to human and social capital. The first requirement for the summary table is to document information about the quantity and trend of the ecosystem service itself. It is important to remember the distinction between ecosystem services (the ecological endpoint) and goods/benefits (access to which requires human intervention). For example, the presence of harvestable woodland and stocks of edible fish are services, while timber and landed seafood are the goods that result from exploiting these services. The quantity of a particular ecosystem service delivered is therefore likely to be in physical units representing, for example, an area, volume or rate. The work at a national level to develop natural capital indicators (Defra, 2018; Lusardi et al., 2018; Wigley et al., 2020) includes those for ecosystem services, and further recent work has been undertaken with a particular focus on cultural services and heritage (Burdon, 2020).

Where appropriate, targets related to the ecosystem services should also be recorded. These are likely to include existing policy targets (such as those specifying minimum standards for bathing water quality), which should have been determined as part of the first Sustainability Appraisal scoping step to identify other relevant policies, plans and programmes. Details of the specific target should be recorded, but this should also be converted for the purposes of the summary table to a rating reflecting whether the service is at, below or substantially below the target (as proposed by Mace et al., 2015). This will highlight potential sustainability issues and also links directly to inputs for the risk register (Section 5).

Table 7. The format of ecosystem service inventory summary table, with a description of the information required and suggested options/examples of cell content

Column header	**Description**	**Options/*examples** for cell contents**
Quantity	A quantified assessment where possible of the quantity of the service (which may be an area, volume or rate).	*e.g.93 tonnes/year*
Trend	Where time series data is available or can be estimated, the broad trend in the supply of the service should be noted, which can be represented visually, e.g. as a traffic light system or directional arrows.	Improving; Stable; Declining
Target	A categorical rating scale to demonstrate whether the service is being delivered at an acceptable level.	At/above target; Below target; Substantially (>50%) below target
Value of goods/benefits	Monetary value can be provided where available.	*e.g.£480,906*
Significance	Where monetary value for benefits is not available, an indicative rating of the significance of the service should be given on a categorical scale, which can be represented visually, e.g.as a traffic light system.	Low; Moderate; High
Risk rating	A categorical rating scale that indicates the degree to which continued delivery of the service is at risk (*to be completed following compilation of the risk register*)	Low; Moderate; High

* the associated categories/scales to be used in recording (given in normal type) or, where category lists are extensive or not applicable, examples of possible content (*in italics*)

The value of the goods/benefits arising from the service should also be recorded. Market data on the quantity and monetary value of goods and benefits such as fish and timber and for tourism and recreational activities are potentially already published or relatively easy to obtain (e.g. the Marine Management Organisation provides data on the quantity and value of fish landings from particular areas and/or into particular ports). Obtaining monetary values for non-market benefits arising from ecosystem services can be costly and time consuming. However, a growing number of studies have sought to determine these values. Reviews of these exist (such as, for marine, Torres and Hanley, 2017, and Hooper et al., 2019), and other sources of valuation data are provided within ENCA[13] (Defra, 2020). Online databases include the Environmental Valuation Reference Inventory[14], and the Environmental Value Look-up Tool prepared for Defra (eftec, 2015). The latter was developed in the specific context of increasing the use of environmental valuation in Government appraisals, and it is organised around the UK National Ecosystem Assessment broad habitat categories. Where published values have not been obtained in the same context as that underlying the Sustainability Appraisal, it may be possible to apply a value transfer (or benefits transfer) approach to apply the value in the new situation (eftec, 2009).

Monetary valuation of changes in natural capital has been promoted as a means to support decision making processes because it can provide a common metric for comparison (Natural Capital Committee, 2013). This remains true, but it is similarly asserted that "*monetary valuation is problematic or incomplete for a broad suite of ecosystem services*" (Chan et al., 2012, p14). In the context of the natural capital approach in Sustainability Appraisal, there is no expectation that all goods and benefits will be monetised. Instead, a categorical rating of the importance of the service, based on the scale of supply and types of beneficiary can be used to indicate the significance of particular services.

The risk rating category for the summary table shown here for convenience, but it will be completed after the risk register has been compiled (see Section 5).

4.3 Asset-Service Matrix (Step 2.3)

It is also important in the scoping phase of a Sustainability Appraisal to make the connection between the ecosystem services and the assets from which they are generated. This is necessary to ensure that the proposed plan/programme does not affect the assets in a way that jeopardises the continued delivery of services and benefits. Furthermore, the process will highlight those assets that require prioritisation due to the type and level of ecosystem services they provide but which may lack protected status. Local Plans often include sustainability objectives that are not explicitly linked to the environment, but are supported by ecosystem services (e.g. tourism, health and wellbeing, climate change adaptation). Therefore, understanding how these are delivered is fundamental in supporting objectives and options that are coherent across the plan.

The proposed approach is to generate an asset-service matrix that highlights the degree to which the assets present in the plan/programme area provide ecosystem services. This will form a further sheet in the database, supporting the asset register and ecosystem service inventory. The key component of the matrix is the level of service provision, with a categorical scale used to indicate the degree to which a particular asset generates a particular ecosystem service. Table 8 provides an example of an asset-service matrix taken from Scotland's Natural Capital Asset Index (Watkinson, 2017). This uses a five point scale (in addition to a 'no relevant potential' category). However, a three point scale (low, moderate, high) may be more practicable with constrained resources. The process of developing the asset-service matrix may highlight the presence of ecosystem services that were not initially apparent (particularly in the case of regulating services), which may require the ecosystem services inventory to be modified.

These linkages between assets and services may be clear (such as how the presence of certain bird or mammal species supports recreational wildlife watching activities), and the knowledge of local stakeholders will be important at this stage. However, it is expected that there will be a limit to the extent

[13] https://www.gov.uk/government/publications/enca-featured-tools-for-assessing-natural-capital-and-environmental-valuation
[14] http://www.evri.ca/

of stakeholder knowledge (particularly for regulation and maintenance services such as mediation of hazards and climate regulation) and so additional reference to literature will be required. Published matrices such as that used in Scotland's Natural Capital Asset Index (Watkinson, 2017), the original work on which it is based (Burkhard et al., 2014), and detailed marine examples (Potts et al. 2014, Burdon et al., 2017) are a useful starting point for a specific Sustainability Appraisal. However, they provide a generic assessment of ecosystem service potential (i.e. what the asset has the capacity to deliver), which may not be what is actually delivered in the context of the plan/programme. Where assets are degraded, for example, they may not be providing the expected level of ecosystem services.

A further limitation of published matrices is that they do not use a consistent underlying framework; they may use EUNIS habitats at different levels, or ecosystem services classifications that predate CICES v5.1. Thus, there is likely to be the need to translate the published information to better fit the Sustainability Appraisal framework. The full adapted versions of published matrices are included in the spreadsheet that supports this document.

Table 8. An excerpt from the table of ecosystem service potential contained within the model used for Scotland's Natural Capital Asset Index (Watkinson, 2017)

Key: Ecosystem service potential	**PROVISIONING**					**REGULATION AND MAINTENANCE**							**CULTURAL**		
0 No relevant potential 1 Low relevant potential 2 Relevant potential 3 Medium relevant potential 4 High relevant potential 5 Maximum relevant potential	Cultivated crops	Reared animals and their outputs	Water for drinking purposes	Materials from animals, plants and algae (for direct use or processing)	Plant-based energy sources	Mediation of waste, toxins and other nuisances (by biota)	Mediation of mass flows and erosion	Mediation of liquid flows (hydrological cycle/flood protection)	Pollination and seed dispersal	Maintenance of nursery populations and habitats	Soil formation and composition	Global, regional and micro-climate regulation	Physical and experiential interactions	Heritage, scientific and educational interactions	Aesthetic and entertainment interactions
B. COASTAL HABITATS															
B1 Coastal dunes and sandy shores	1	1	0	0	0	1	5	5	3	2	2	1	5	4	5
B2 Coastal shingle	1	1	0	0	0	1	5	5	3	2	2	1	5	4	5
B3 Rock cliffs, ledges and shores, including the supralittoral	0	1	0	0	0	0	3	1	0	1	0	0	3	3	3
C INLAND SURFACE WATERS	0	0	5	1	1	5	3	5	1	4	3	2	5	4	5
E. GRASSLANDS AND LANDS DOMINATED BY FORBS, MOSSES OR LICHENS															
E1 Dry grasslands	0	3	0	1	0	2	4	2	3	1	4	4	3	4	3
E5 Woodland fringes and clearings and tall forb stands	0	2	0	1	2	2	4	3	4	2	3	3	3	4	3
E7 Sparsely wooded grasslands	1	5	0	1	2	4	4	2	4	2	3	2	2	3	2
G. WOODLAND, FOREST AND OTHER WOODED LAND															
G1 Broadleaved deciduous woodland	0	2	0	5	5	4	5	4	4	4	5	5	5	5	5
G3 Coniferous woodland	0	1	0	5	5	4	5	4	4	4	5	5	5	5	5
G6 Exotic woodland and scrub	0	1	0	2	3	3	3	2	2	1	2	3	3	4	3
H. INLAND UNVEGETATED OR SPARSELY VEGETATED HABITATS															
H2 Screes	0	0	0	0	0	0	2	1	0	0	1	0	3	3	3
H3 Inland cliffs, rock pavements and outcrops	0	0	0	0	0	0	2	1	0	0	1	0	3	3	3
I. CULTIVATED AGRICULTURAL, HORTICULTURAL AND DOMESTIC HABITATS															
I1 Arable land and market gardens	5	1	0	3	3	3	1	1	4	1	1	2	1	2	1
I2 Cultivated areas of gardens and parks	2	1	0	2	1	3	1	1	4	2	2	2	3	2	3

As for all information reported in the database, it is important to record the sources used in constructing the matrix, which are likely to include stakeholder consultations and expert judgement as well as published peer-reviewed and grey literature. The quantity and quality of sources used will affect the level of confidence in the stated connections between assets and services. Ideally, this confidence should be reported in the matrix, and once again a three point scale (low, moderate, high) will suffice. An example of a matrix including a confidence assessment is given (Table 9), in which the confidence level depends primarily on the type of publication and its geographic origin. Confidence scales that provide a rating based on the quantity of evidence and the level of agreement between sources would also be appropriate, such as those used in Rapid Evidence Assessment (e.g. Collins et al., 2015).

Table 9. An excerpt from an assets-services matrix that includes a confidence rating (from Potts et al., 2014)

Key: *Relative ecosystem service contribution:* Significant contribution Moderate contribution Low contribution Not assessed *Confidence:* 3 UK-related, peer-reviewed literature 2 Grey or overseas literature 1 Expert opinion	Larval / Gamete supply	Natural hazard regulation	Regulation of water & sediment quality	Carbon sequestration
Intertidal mud	3	3	3	3
Coastal saltmarshes and saline reedbeds	3	3	3	3
Estuarine rocky habitats	1	1		
Blue Mussel beds	1	1	3	1
Honeycomb worm *Sabellaria alveolata* reef	1	2	1	1
Mud habitats in deep water	3	3	1	
Native Oyster *Ostrea edulis* beds	1	1	1	1
Kelp and seaweed communities on sublittoral sediment	1	1	1	1
Seagrass beds	1	1	2	2

5 Identify Sustainability Issues (Step 3)

5.1 Develop a Risk Register

The central component of the method proposed for identifying sustainability issues and problems is to compile a risk register, which is used to connect the continued delivery of ecosystem services with the status of natural capital assets. It thus identifies those assets at greatest risk from current human activity, allowing their management to be prioritised (Natural Capital Committee, 2013). As with all elements of the natural capital approach, examples of risk registers are few, but include Rees et al. (2019), and Lovett et al. (2018), as well as the preliminary high level assessment at the national scale prepared by Mace et al. (2015), on which the other examples are based.

The methodology proposed by Mace et al. (2015) has four preliminary steps:

(i) define natural asset classes;
(ii) determine trends in asset status;
(iii) determine asset-benefit relationships; and
(iv) establish targets and acceptability limits.

These steps will have already been completed, with the natural capital asset classes relevant to the plan/programme defined at the start of the process (Sections 4.1.1 and 4.1.2), and the trends in asset status also already recorded in the asset register (Section 4.1.3). Mace et al. (2015) propose using asset-benefit relationships in the risk register, but the recommendation here is that asset-service relationships are used. This is because service delivery is connected more directly to asset status; and the value of benefits can be affected by wider issues that are not related to the health of the environment (wider market trends, for example). These asset-service relationships have also already been defined in the asset-service matrix (Section 4.3), and targets for ecosystem service delivery form part of the ecosystem service inventory (Section 4.2.2). The risk to the continued delivery of the service is then determined, for each asset-service pair according to the criteria in Table 10, and recorded in the database as high, medium or low.

Table 10. The criteria for rating risks to the continued delivery of benefits as low, medium and high (adapted from Mace et al., 2015)

		Status of service		
		Above, or at, target	Below target	Substantially below target (>50%)
Trend in asset status	Positive or not discernible	Low	Medium	Medium
	Negative	Medium	Medium	High
	Strongly negative	High	High	High

Mace et al. (2015) proposed that the risk register be compiled for all three dimensions of the asset status: the quantity, quality, and spatial configuration, as changes to each of these has the potential to affect the generation of ecosystem services and the delivery of benefits. In practice, there will be limitations on the availability of evidence and so this may not be possible for all assets or services. An example of a summary table from a risk register is given in Table 11. An overall risk rating for each service should be added to the summary table for the ecosystem service inventory (Section 4.2.2), which will be derived from amalgamating the ratings across the different asset types. Amalgamation can be achieved by, for example, taking a precautionary approach (with the highest risk category from an individual asset being used to represent the service as a whole) or by using the most common risk rating. As before, the summary tables should be supported by a narrative that includes discussion of how evidence gaps may have led to the omission of certain assets or services from the risk register and any known risks associated with these.

Table 11. An excerpt from an example risk register output, showing risks associated with the three components of asset status: quantity (*Qun*), quality (*Qul*) and spatial configuration (*Sp*) (from Mace et al., 2015)

	Enclosed farmland			**Woodlands**			**Freshwaters**			**Coastal margins**		
	Qun.	*Qul.*	*Sp.*	*Qun.*	*Qul.*	*Sp.*	*Qun.*	*Qul.*	*Sp.*	*Qun.*	*Qul.*	*Sp.*
Food												
Fibre												
Energy												
Clean water												
Clean air												
Recreation												
Aesthetics												
Hazard Protection												
Wildlife												
Equitable climate												

Risk level: Low Medium High No significant relationship/no available information

Lighter shading indicates increasing uncertainty

5.2 Linking to wider plan/programme objectives and actions

For the purposes of Sustainability Appraisal, the risk register needs to link to the wider plan/programme objectives rather than simply providing a generic assessment of where asset status is of concern, so that (i) appropriate sustainability objectives can be defined; and (ii) to highlight (and hence amend) wider plan objectives that may contradict those related to natural capital aspirations. Making this connection includes the need to understand the pressures to which assets are vulnerable, and the ongoing or proposed activities within the context of the plan/programme to which the Sustainability Appraisal relates. Tools such as the Marine Biological Association's Marine Evidence and Sensitivity Assessment (MarESA[15]) provide an online resource for determining the sensitivity of marine habitats to pressures, allowing the compilation of a matrix that details the different impacts affecting the individual assets and ecosystem services. This can be summarised in a similar format to that suggested in Table 12.

Table 12. The sources of impacts on selected marine assets and ecosystem services, based on information from the South West Marine Plan scoping process (MMO, 2016a)

	Coastal defence erosion, development	Commercial fisheries	Industry, other activities	Marine litter, pollution, noise	Recreation, tourism	Renewables, other energy	Climate change
Natural Capital Assets							
Intertidal							
Subtidal							
Coastal Lagoons							
Mudflat							
Saltmarsh							
Sand dwelling species							
Shellfish							
Protected sites							
Mobile species							
Basking sharks							
Cetaceans							
Fish							
Marine mammals							
Marine megafauna							
Plankton							
Seabirds							
Seals							
Turtles							
Waterbirds							
Protected species							
Cultural services							
Leisure and recreation							
Visual amenity							

6 Develop the Sustainability Appraisal Framework (Step 4)

The Sustainability Appraisal framework requires the identification of sustainability objectives and indicators by which progress towards these objectives can be measured. The ultimate purpose of compiling an asset register, ecosystem service inventory and risk register is to summarise the current state of the environment within the plan/programme area and hence allow sustainability issues to be identified. The key outputs from these preliminary stages of the Sustainability Appraisal are:

- The current status of habitats, species and heritage assets in terms of quantity, quality and (for habitats) spatial connectivity
- Trends in this status over time
- The level of, and trend in, delivery of ecosystem services, and the value of the benefits arising
- The key areas of risk to the continued delivery of ecosystem services

[15] https://www.marlin.ac.uk/evidence

These are mostly presented as categorical summaries with 'traffic light' coding so that areas of potential concern can be easily identified, and are enhanced by summaries of the evidence and a wider narrative. These outputs therefore provide useful materials to support the process of defining detailed sustainability objectives that relate to specific natural capital assets and ecosystem services.

Examples of detailed sustainability objectives are shown in Table 13, which cover natural and other capitals to illustrate interconnection between the issues (such as engaging recreational users to support behaviour change, and the link between sustainable resource use and secure incomes). Under the expectations of the new Environment Bill, sustainability objectives could also be developed that explicitly identify assets that are considered strategically significant and should be prioritised for net gain. The process of gathering baseline information will have identified indicators for assets and services that are appropriate in the local context and can be used to monitor progress against the sustainability objectives. Programmes of ongoing data collection to support this monitoring will also have been identified. The identification of indicators is the final component of the sustainability framework. An example of indicators for the natural capital objectives of the North Devon Marine Natural Capital Plan is given in Table 14.

Table 13. The sustainability objectives from the sustainability appraisal for the North Devon Marine Natural Capital Plan (from Hooper et al., 2020)

Natural Capital (including related heritage)
• Disturbance of waterbirds, sea birds and marine mammals is reduced • All mussel beds in the Taw Torridge estuary rated at least Class B by 2030 • All designated bathing waters reach guideline standards by 2025 • All estuarine and coastal water bodies reach appropriate standards under the Water Framework Directive • Commercial stocks of fish and shellfish (wild capture) increase • Stocks of salmon and sea trout are maintained above their conservation limits • Health of fish habitats is maintained and where possible improved • Disturbance of intertidal mudflats in the Taw Torridge estuary from recreational bait collection (bait digging, crab tiling) is reduced • The quantity of plastic waste and litter on beaches and in the water column is reduced • Carbon storage capacity of the Taw Torridge estuary is increased • Disturbance (scour) of subtidal sediments is reduced • Levels of protection for environmental assets are maintained and where possible improved • Environmental quality in protected areas reaches at least minimum acceptable status • Likely relative condition of subtidal habitats is maintained and where possible improved • The cultural heritage value of ongoing inshore fisheries is maintained
Human Capital
• Employment opportunities increase in mariculture, shellfish hand-harvesting, and value-added activities for wild capture fisheries, where these do not exceed levels of sustainable exploitation • Local people are motivated to take part in environmental initiatives • Members of the public are motivated to improve their behaviour around waste disposal • Recreational users are motivated to improve their behaviour in order to minimise environmental disturbance • Fishers and harvesters are more engaged in sustainable fisheries management
Social Capital
• Networks for sustainable management of coastal and marine areas are strengthened • Recreational users are more engaged with sustainable management • Conflict amongst marine users is reduced • The use of citizen science data in decision making is increased
Manufactured Capital
• New infrastructure for renewable energy and mariculture conforms to sustainability criteria • New mooring infrastructure is installed to reduce habitat damage due to anchoring and scour from traditional moorings
Financial Capital
• Incomes for fishers/harvesters using low-impact techniques are maintained, and where appropriate increased, through sustainable management of resources and value-added activities • The economic contribution of recreation and tourism linked to marine and coastal natural capital is maintained • New financial mechanisms and products are established to support maritime activities and environmental protection

Table 14. The sustainability objectives and indicators from the natural capital elements of the sustainability appraisal for the North Devon Marine Natural Capital Plan (from Hooper et al., 2020)

Objectives	Indicators
Disturbance of waterbirds, sea birds and marine mammals is reduced	Number of disturbance incidents (from disturbance surveys)
All mussel beds in the Taw Torridge estuary rated at least Class B by 2030	Annual rating of shellfish water quality
All designated bathing waters reach guideline standards by 2025	Annual rating of bathing water quality
All estuarine and coastal water bodies reach appropriate standards under the Water Framework Directive	Annual water body status rating
Commercial stocks of fish and shellfish (wild capture) are within safe biological limits, and where possible are increased	(i) Stock sizes for, particularly, herring, bass, whelk, squid, skates and rays; (ii) Extent of Taw Torridge mussel beds; (iii) Size structure of Taw Torridge mussel beds
Stocks of salmon and sea trout are maintained above their conservation limits	(i) Catch per unit effort (from stock surveys) (ii) Stock status category
Health of fish habitats is maintained and where possible improved	Extent and condition of spawning and nursery habitats
Disturbance of intertidal mudflats in the Taw Torridge estuary from recreational bait collection (bait digging, crab tiling) is reduced	Size of disturbed area (from aerial photography)
The quantity of plastic waste and litter on beaches is reduced	Quantity of litter removed from beaches
Carbon storage capacity of the Taw Torridge estuary is increased	Extent/condition of saltmarsh (from aerial photography/LiDAR)
Disturbance (scour) of subtidal sediments is reduced	(i) Frequency of anchoring within restricted zones (from aerial photography) (ii) Area of scoured seabed around moorings (from surveys)
Levels of protection for environmental assets are maintained and where possible improved	(i) Percentage area within designated and voluntary marine protected areas; (ii) Percentage area protected by management measures;
Environmental quality in protected areas reaches at least minimum acceptable status	Condition assessment in protected area monitoring reports
Likely relative condition of subtidal habitats is maintained and where possible improved	Intensity of fishing and other activities (e.g. aggregate extraction) that impact on the seabed
The cultural heritage value of ongoing inshore fisheries is maintained	Number of licenced inshore fishing vessels

7 Evaluation of effects and alternatives (Step 5)

7.1 Developing a framework for comparing plan/programme options

The sustainability objectives provide the basic framework against which to evaluate overarching plan/programme policies and delivery options. Typical Sustainability Appraisal outputs include tables in which the relative magnitude of positive/negative impact upon each objective by each policy or option is indicated (e.g. Torridge District Council and North Devon Council, 2016b,c). Using a natural approach to sustainability appraisal as described in the steps described above will ensure that the sustainability objectives are explicit and relate to specific assets and ecosystem services. Having appropriately focused objectives (rather than those referring to environmental issues in vague or general terms), will facilitate more robust evaluation of likely impacts, and so support decision making that improves environmental outcomes.

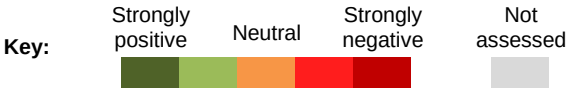
Other approaches to Sustainability Appraisal go further, and compare the impacts of different plan/programme options on the individual receptors identified within the scoping process. Although this more detailed approach is likely to be more resource intensive, it was used in the Sustainability Appraisal for the South West Marine Plan, which considered 254 individual options across its 29 themes (see Appendix 1). Presenting summary information in a visual way (Figure 10) is likely to be beneficial in highlighting important trade-offs and thus supporting a participatory process for evaluating the different options and selecting which to take forward in the final plan/programme.

		Policy Option A		Policy Option B		Policy Option C	
SA Topic	**SA Sub Topic**	Significance	SA Database Topic Identifier	Significance	SA Database Topic Identifier	Significance	SA Database Topic Identifier
Cultural heritage	Heritage Assets within marine plan areas	Not Significant		Uncertain (Dependent on Implementation)	Cultural_178	Uncertain (Lack of Evidence)	
	Heritage Assets adjacent to marine plan areas	Not Significant		Uncertain (Dependent on Implementation)	Cultural_178	Uncertain (Lack of Evidence)	
Seascape and landscape	Effects on seascape and landscape	Significant Negative	Landscape_170	Uncertain (Dependent on Implementation)	Landscape_170	Uncertain (Dependent on Implementation)	Landscape_170
Water	Pollution and water quality	Significant Negative	Water_286, Water_14	Significant Positive	Water_286, Water_14	Uncertain (Dependent on Implementation)	Water_286, Water_14
	Marine litter	Significant Negative	Water_14, Water_288	Significant Positive	Water_14, Water_288	Uncertain (Dependent on Implementation)	Water_14, Water_288
Communities, health and well being	Health and wider determinants of health Effects on communities	Not Significant		Uncertain (Dependent on Implementation)	Communities_55, Communities_46, Economy_482	Uncertain (Dependent on Implementation)	Communities_55, Communities_46, Economy_482
Economy	Ports and shipping	Not Significant		Uncertain (Lack of Evidence)	Economy_578, Economy_620	Uncertain (Dependent on Implementation)	Economy_578, Economy_620
	Leisure / recreation	Not Significant		Significant Positive	Economy_481, Economy_482	Uncertain (Dependent on Implementation)	Economy_481, Economy_482
	Tourism	Not Significant		Significant Positive	Economy_481, Economy_482	Uncertain (Dependent on Implementation)	Economy_481, Economy_482
Biodiversity, Habitats, Flora and Fauna	Protected sites and species	Significant Negative	Biodiv_465	Significant Positive	Biodiv_465	Uncertain (Dependent on Implementation)	Biodiv_465
	Marine mega fauna	Significant Negative	Biodiv_465	Significant Positive	Biodiv_465	Uncertain (Dependent on Implementation)	Biodiv_465
	Ornithology	Significant Negative	Biodiv_465	Significant Positive	Biodiv_465	Uncertain (Dependent on Implementation)	Biodiv_465

Figure 10. An extract from the marine plan areas Sustainability Appraisal scoping report database (MMO, unpublished data)

Where resource allows, a detailed approach similar to that taken for the South West Marine Plan is recommended. The framework described above should be carried through into this phase of developing and refining alternatives; i.e. the implications of different plan/programme options should be considered against the constituent natural capital elements used in the scoping phase (e.g. assets, ecosystem services, benefits). In reporting, it is again suggested that summary tables are provided, using a 'traffic light' (or similar) system to report how the plan/programme options affect the different natural capital assets, services and benefits, as in the example below from North Devon Marine Natural Capital Plan (Table 15).

Table 15. An example output showing how the implications of plan/programme options on assets, ecosystem services and benefits, and human, social, and financial capital could be presented (based on and plan vs no plan scenario, and taken from Hooper et al., 2020)



	Short term (1-5yrs)	Longer term (>5yrs)
Natural capital assets		
Geology		
Supralittoral rock		
Supralittoral sediment		
Littoral rock		
Littoral sediment		
Saltmarsh		
Mussel beds		
Sublittoral rock		
Sublittoral sediment		
Commercial finfish		
Crab and lobster		
Wetland birds		
Seabirds		
Marine mammals		
Heritage assets		
Designated and non-designated sites		
Ecosystem services and benefits		
Cultivated seafood		
Foraged plants		
Game and wild fish		
Non-food products from plants, animals & algae:		
Bait		
products from cultivated macroalgae		
Genetic resources (*mussel spat*)		
Energy from non-living sources (*tidal energy*)		
Commercial and other transport		
Water quality		
Maintenance of nursery populations and habitats		
Erosion control		
Flood protection		
Climate regulation		
Recreation, tourism and other experiential opportunities		
Scientific and educational opportunities		
Aesthetic		
Heritage, spiritual and representational significance		
Existence, bequest and option values		
Social and human capital		
Community networks		
Knowledge, skills and capabilities		
Financial capital		
Inward investment		

In addition to traffic light coding, full reporting should also accommodate notation such as that used within the South Marine Plan Sustainability Appraisal to indicate the direction and magnitude of impacts arising from the different options, the type and reversibility of effects, and the level of confidence in the predictions (Table 16). Any such notation, and other outputs for reporting purposes, must take account of the requirement in the SEA Directive to include secondary, cumulative, synergistic, short, medium and long-term, permanent and temporary, positive and negative effects.

Table 16. The notation used to report changes from baseline conditions resulting from marine plan options for the South Marine Plan area (Ramboll Environ et al., 2018)

Notation	Description
Degree to which baseline conditions may change (significance of change) compared with the future baseline situation	
++	**Major Positive Effect (significant positive)** The plan is likely to lead to significant improvements in baseline conditions.
+	**Minor Positive Effect** The plan is likely to lead to some improvements in baseline conditions.
0	**Neutral Effect** The plan is unlikely to alter baseline conditions significantly.
-	**Minor Negative Effect** The plan is likely to lead to a deterioration in baseline conditions.
--	**Major Negative Effect (significant negative)** The plan is likely to lead to a significant deterioration in baseline conditions.
+/-	**Positive and Negative Effect** The plan is likely to lead to both a deterioration and an improvement in baseline conditions, perhaps in different areas or ways.
?	**Uncertain Effect** It is not known whether the plan would lead to an improvement or deterioration in the baseline conditions.
Degree to which baseline conditions may change (significance of change) compared with the future baseline situation	
Direct / Indirect	
D	Direct effect
I	Indirect effect
Reversibility of effects	
R	It is considered that the effects upon the receptor group could be reversed if activities were to change in the future. The receptor may hence be able to recover or indeed improvements could be diminished.
IR	It is considered that the effects upon the receptor group could not be reversed and would be permanent. This may apply to situations where, for example, features are destroyed for ever or systems/trends are irrevocably changed.
Certainty of prediction / Likelihood	
H	There is a high level of confidence in the assessment prediction. No identified data gaps.
M	There is a medium level of confidence in the assessment prediction. This means that the appraiser is largely certain of the direction of impact and some of the elements of prediction but there remains some doubt or certainty about some other elements.
L	There is low level of confidence in the assessment prediction. This may be as a result of significant baseline data gaps, there being very little control over how an activity may come forward or there is limited evidence to support the prediction.

It is not proposed that a set of natural capital accounts is included within the Sustainability Appraisal, but where monetary values are available option appraisal could take the form of a preliminary cost benefit analysis. However, as it is expected that the availability of monetary values will be limited, care should be taken with this approach. It would be appropriate to attempt to assess value change in this manner where consistent values are available across the different plan/programme options, and so any such assessment is more likely to be in the context of market values such as for fisheries, tourism or energy. Where monetary values are not available, other metrics can be used including quantitative data to document change in quantity supplied, or qualitative information that documents relative importance.

It is known that members of the public do not respond well to natural capital terminology (e.g. FM3, 2010) and so a modified typology may be required for outputs of the Sustainability Appraisal that are intended more specifically for a non-technical audience, such as the report cards produced as part of the Marine Plan Sustainability Appraisal process (MMO, 2016b).

8 Conclusions

The different elements of the process described above provide the framework for applying a natural capital approach to Sustainability Appraisal. Compilation of the asset register, ecosystem service inventory and risk register (and the wider evidence base) will show the current status and trends in assets, ecosystem services and benefits, the degree to which they are at risk and the activities most likely to impact upon them. This provides a comprehensive and systematic baseline against which to assess the implications of a plan/programme. This process also identifies the key sustainability issues and so allows the definition of sustainability objectives explicitly for natural capital assets and ecosystem services (as opposed to the general and high level objectives that are often used in current sustainability appraisals).

The proposed process helps to fulfil the Natural Capital Committee's call for a methodology for baseline natural capital assessments at a local level (Natural Capital Committee, 2019). The framework developed has the potential to support consents and licensing decisions based on Environmental Impact Assessment, as well as Sustainability Appraisal and other elements of the planning process, including, potentially, the application of net gain principles. Finally, a systematic baseline methodology and joined-up assessment process could further link to natural capital accounting and economic evaluation to support investment decisions.

As with any new approach, an iterative process, including significant engagement, is required to develop a robust and applicable method. This document represents an initial outline of the proposed methodology. It is expected to evolve, as lessons are learned from additional use of the framework in practice.

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APPENDIX 1: Evaluating Compatibility with Statutory Requirements

A1.1 Background

Between September 2018 and March 2019, the possibility of applying a natural capital approach to the 'live' Sustainability Appraisal for the South West Marine Plan was explored. This is being developed by the Marine Management Organisation (MMO) as part of their statutory obligations under the Marine and Coastal Access Act 2009. The MMO is responsible for Marine Plans for all English waters, and are developing these on a regional basis, with inshore and offshore plans for each region (Figure A1). The East and South Marine Plans have both been adopted, and the Marine Plans for the other regions are currently being prepared.

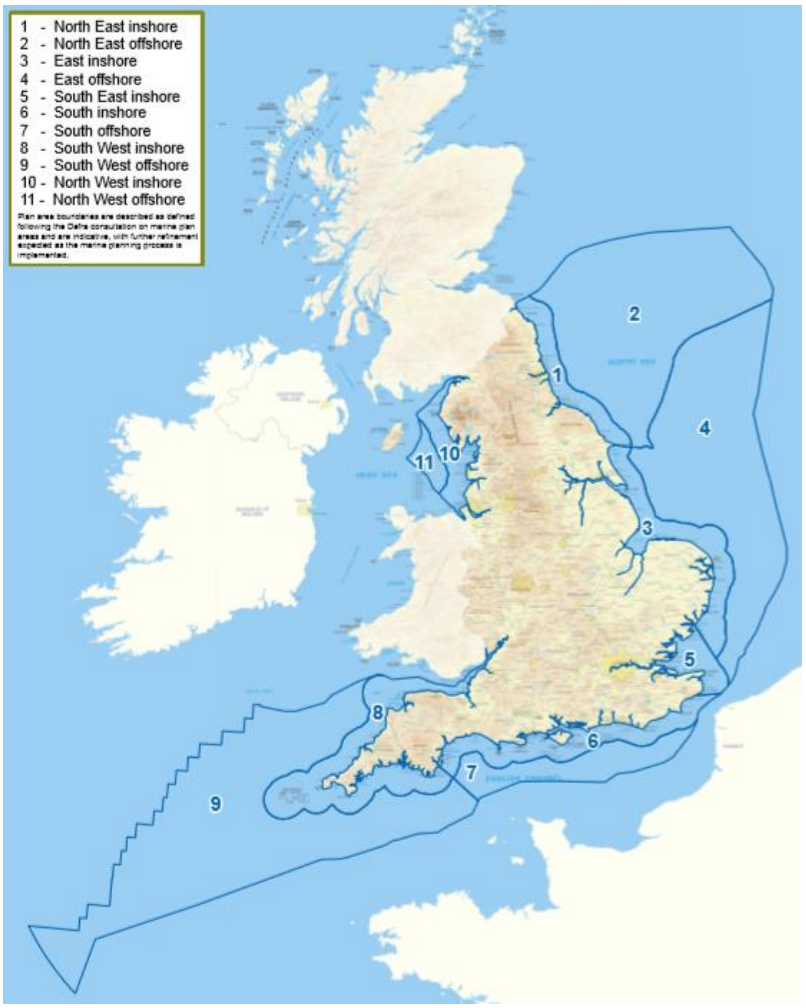

Figure A1. The English Marine Plan Areas (MMO, 2014)

The Sustainability Appraisal process for the South West Marine Plan was already underway before the opportunity for using a natural capital approach was considered. Therefore, the application of a new approach in this context incorporates the work already undertaken and ongoing. It builds from the point of the completed Sustainability Appraisal scoping assessment (MMO, 2016a,b,c; 2018) and takes account of the drafts of other marine plan documents, which at the time were in Iteration 3 (MMO, 2019a). The opportunities within this case study were also constrained by the 'live' nature of the marine planning process, which (being a statutory obligation) has defined, rigidly timetabled stages and requires interaction with parties operating under specific contracts with the MMO. However, it did provide the opportunity to determine whether a natural capital approach was compatible with the statutory requirements for Sustainability Appraisal and to explore a preliminary framework for the collation of baseline information.

A1.2 Key elements of the Sustainability Appraisal scoping process

The mandatory requirements for Sustainability Appraisal include consideration of "*biodiversity, population, human health, fauna, flora, soil, water, air, climatic factors, material assets, cultural heritage including architectural and archaeological heritage, landscape*", as listed in Annex I of the SEA Directive (and Schedule 2 of the Environmental Assessment of Plans and Programmes Regulations 2004). The Marine Policy Statement provides a similar list of environmental considerations, as well as a more detailed list of the key activities that should be considered when appraising economic and social implications (Table A1). In practice in the marine context, Sustainability Appraisal and SEA use these lists, often almost verbatim, to define a series of topics around which the assessment will be framed (Table A2).

Table A1. The environmental, economic and social considerations of which account must be taken marine planning, as required in the Marine Policy Statement (HM Government, 2011a)

Environmental considerations	Economic and social considerations
Marine ecology and biodiversity	Marine Protected Areas
Air quality	Defence and security
Noise	Energy production and infrastructure development
Ecological and chemical water quality and resources	Ports and shipping
Seascape	Marine aggregates
Historic Environment	Marine dredging and disposal
Climate Change Adaptation and mitigation	Telecommunications cabling
Coastal Change and Flooding	Fisheries
	Aquaculture
	Surface water management and wastewater treatment and disposal
	Tourism and recreation

Table A2. A comparison of the environmental elements listed within Annex I of the SEA Directive with two examples of topics chosen to frame an Offshore Energy SEA (DECC, 2016) and the Sustainability Appraisal for a marine plan for Northern Ireland (AECOM and ABPmer, 2018)

SEA Annex I	Offshore Energy SEA (DECC, 2016)	Northern Ireland marine plan sustainability appraisal (AECOM and ABPmer, 2018)
Biodiversity Fauna Flora	Biodiversity, habitats, flora and fauna; Conservation of sites and species	Biodiversity, flora and fauna
Population Human health	Population and human health	Socio-demographics
Soil Water	Geology, substrates, coastal geomorphology Water environment	Water and soils
Air	Air quality	Air quality
Climatic factors	Climate and meteorology	Climatic factors
Material assets	Other users and material assets	Material assets; Uses and activities
Cultural heritage	Cultural heritage	Cultural heritage
Landscape	Landscape/seascape	Landscape and seascape

The scoping process for the South West Marine Plan Sustainability Appraisal (MMO, 2016a,b,c; 2018) was similarly framed around a standard series of topics and subtopics (Table A3). Extensive work was undertaken to create a substantial database (MMO, 2016c) which allocated unique topic identifiers to multiple policies, targets, baselines, issues and data gaps relevant to the different subtopics, and linked through to the sources of supporting evidence. An excerpt from this database is shown in Figure A2. Subsequently, this database was used during the process of screening and identifying significant effects of the different options through which the marine plan could seek to achieve the UK's Higher Level Marine Objectives (MMO, 2018). A series of groupings (themes) was identified, each of which had several possible options (Table A4). A further database (MMO, unpublished data) was created, which used a traffic light system to summarise the likely impact of each option within each grouping for each of the relevant individual topics and sub-topics, linking back to the relevant topic identifier and underlying evidence (Figure A3). The scoping process also included extensive narrative reporting (MMO, 2016a; 2018) and summaries in the form of report cards (MMO, 2016b).

Table A3. The topics and sub-topics used to frame the South West Marine Plan areas Sustainability Appraisal scoping process (MMO 2016a, 2016b, 2018)

Topic Area	Sub-Topic
Air	Air pollutants
Biodiversity	Benthic and Inter-Tidal Ecology Fish and Shellfish (including cephalopods) Invasive Species Marine Mega Fauna (including marine mammals and turtles) Ornithology Plankton Protected Sites and Species
Climate	Climate change resilience and adaptation (including coastal flooding) Greenhouse gas emissions
Communities	Effects on communities (including employment and skills) Effects on protected equality groups Health and wider determinants of health
Cultural	Heritage Assets adjacent to Marine Plan Areas Heritage Assets within Marine Plan Areas
Economy	Aggregate Extraction Defence Dredging and disposal Energy Generation and infrastructure development - Carbon capture and storage Energy Generation and infrastructure development - Conventional Energy Energy Generation and infrastructure development - Fossil Fuels Energy Generation and infrastructure development - Nuclear Energy Generation and infrastructure development – Renewables Fisheries and aquaculture Leisure / recreation Marine manufacturing Ports and shipping Seabed Assets (including cables, outfalls and pipelines) Tourism
Geology	Coastal features and processes Seabed substrates and bathymetry
Landscape	Landscape designations and landscape and seascape character.
Water	Marine litter Pollution and water quality (including eutrophication) Tides and currents Water temperature and salinity

Topic Idenfier	SA Topic Area	Sub-Topic	Description of Policy/Target, Baseline, Issue or Data Gap	Policy/Target/ Baseline/Issue/Gap
Air_1	Air	Air pollutants	The Marine Policy Statement for the UK recognises that activities and developments in the marine and coastal area can have adverse effects on air quality	Policy / Target
Air_2	Air	Air pollutants	The MARPOL Convention aims to prevent marine pollution from ships and in part from oil rigs and production platforms. Six annexes covering pollution by oil, noxious liquids carried in bulk, harmful substances in packaged form, sewage, garbage and air pollution. MARPOL (Marine Pollution Convention, 1973 / 1978) is the main international convention governing the prevention of pollution of the marine environment from ships and in part oil rigs and production platforms. It covers pollution by chemicals, oil, harmful substances in packaged form, rubbish, sewage and air pollution. It was amended in 2008 to further reduce harmful emissions from ships of sulphur oxides (SOx) and nitrogen oxides (NOx). There are also regulatory controls on atmospheric emissions for oil and gas platforms e.g. EU Emissions Trading System and Pollution Prevention and Control Regulations	Policy / Target
Air_3	Air	Air pollutants	Relevant annexes of the Ospar Convention include I: Prevention and elimination of pollution from land-based sources (point or diffuse sources) / II: Prevention and elimination of pollution by dumping or incineration (vessels, aircrafts or offshore installations) and III: Prevention and elimination of pollution from offshore sources.	Policy / Target
Air_4	Air	Air pollutants	Article 222 (UNCLOS), defines enforcement with respect to pollution from or through the atmosphere	Policy / Target
Air_5	Air	Air pollutants	Directive 1996/62/EC aims to ensure prevention and reduction of airborne pollutants for the protection of human health and t	Policy / Target
Air_6	Air	Air pollutants	Strategic Framework for Air Quality Objectives for key air pollutants: controls and monitors the levels of airborne pollutants. Marine licensing should meet the general aim of a reduction in the amount of airborne pollutants that are produced.	Policy / Target

Figure A2. An extract from the marine plan areas Sustainability Appraisal scoping report database (MMO, 2016c)

Table A4. The different groupings that reflect the key issues within the South West Marine Plan area, and the number of options within each considered by the Sustainability Appraisal scoping process (MMO, 2018)

Grouping	Number of options
Access	9
Aquaculture	9
Cables	7
Climate change	14
Coastal change	11
Co-existence	13
Disturbance	10
Dredge Disposal	7
Dredge Harbours and Ports	4
Deep Sea Habitat	8
Ecosystem Approach	6
Employment: Diversification	4
Employment: Growth Skills	11
Energy	5
Fisheries	7

Grouping	Number of options
Habitat Loss	13
Heritage Assets	15
Infrastructure	9
Litter	6
MPAs and Geodiversity	14
Non Native Invasive Species	6
Ports and Harbours	7
Recreation	11
Renewables	6
Seascape	7
Shipping	6
Species	12
Tourism	7
Water Quality	10

SA Topic	SA Sub Topic	Policy Option A		Policy Option B		Policy Option C	
		Significance	SA Database Topic Identifier	Significance	SA Database Topic Identifier	Significance	SA Database Topic Identifier
Cultural heritage	Heritage Assets within marine plan areas	Uncertain (Lack of Evidence)	Cultural_184	Uncertain (Dependent on Implementation)	Cultural_167	Not Significant	
	Heritage Assets adjacent to marine plan areas	Significant Negative	Cultural_178, Economy_767	Uncertain (Dependent on Implementation)	Cultural_178, Economy_767	Not Significant	
Biodiversity, Habitats, Flora and Fauna	Protected sites and species	Significant Negative	Biodiv_474	Uncertain (Dependent on Implementation)	Biodiv_474	Not Significant	
	Benthic and inter-tidal ecology Fish and shellfish	Significant Negative	Biodiv_470, Biodiv_471, Biodiv_476, Biodiv_487	Uncertain (Dependent on Implementation)	Biodiv_470, Biodiv_471, Biodiv_476, Biodiv_487	Not Significant	Biodiv_470, Biodiv_471, Biodiv_476, Biodiv_487
	Marine mega fauna	Uncertain (Lack of Evidence)	Biodiv_467, Biodiv_468, Biodiv_469, Biodiv_650	Uncertain (Dependent on Implementation)	Biodiv_467, Biodiv_468, Biodiv_469, Biodiv_650	Not Significant	Biodiv_467, Biodiv_468, Biodiv_469, Biodiv_650

Figure A3. An extract from the marine plan areas Sustainability Appraisal scoping report database (MMO, unpublished data)

A1.3 Applying the natural capital framework

The existence of the scoping databases (with their systematic layout) was of fundamental importance in facilitating reclassification of the information into the natural capital framework. In the first step of this process, the information for each topic identifier that had been labelled as relevant to all Marine Plan areas or to the South West Marine Plan area was extracted. This information was used to allocate each topic identifier to at least one of the elements and subtypes from the natural capital framework, as listed in Figure 6 (of the main report). A spreadsheet was compiled with the complete natural capital classification for each row within the MMO (2016c) Sustainability Appraisal scoping report database (for the data applicable to the South West Marine Plan). This spreadsheet adds 16 columns to the original database (Table A4). Not all of these columns are necessarily completed for each topic identifier, although this format provides for the systematic recording of how the topic interacts with the multiple elements of the natural capital framework (e.g. which services link to specific assets, the impacts of particular activities on particular assets, or the legislation governing a specific asset or the benefits derived from it). Thus, the conceptual natural capital classification (Figure 6) was expanded with a 'detail' column unique to the South West Marine Plan case study, reflecting the additional relevant factors related to the issues considered (Table A5).

Table A4. The additional information added to the MMO (2016c) scoping database to provide the natural capital classification for each topic identifier

Column header	Description	Options
Natural capital element	The high-level natural capital category, from the conceptual framework.	Asset (bioic), Asset (abiotic), Service, Disservice, Other capital, Benefit, Impact, Governance
SPU type	The Service Providing Unit (SPU): i.e. the broad category of asset (biotic or abiotic) from which services are derived[1]	Benthos, Mobile species, Air, Water Column, Substrate
Habitat detail	The specific habitat type.	Unrestricted[2]
Species	The species of interest.	Unrestricted[2]
Service Class	The broad ecosystem service category, from standard ecosystem service classifications.	Provisioning, Provisioning (Carrier)[3], Regulating, Cultural
Service subclass	A more detailed hierarchy of the ecosystem service type.	Unrestricted[2,4]
Disservice type	The broad category of naturally occurring species or process that may cause harm to the economy or society.	Invasive species, Harmful/Toxic species
Benefit type	The broad sector to which benefits accrue	Economic, Security, Health, Wellbeing
Benefit detail	Additional characteristics of the benefit	Unrestricted[2]
Impact origin	Whether the impact occurs locally to the area of scope of governance, or is external to it	Local, External
Impact source/type	Further details of the source of the impact (such as specific activities or climate change)	Unrestricted[2]
Governance type	Major elements of the governance system that constrain, inform or otherwise affect aspects of resource use and management.	Designations, Consents and Licensing, Legislation, Management Plans, Processes
Governance detail	Details or the relevant governance issue such as specific designations, legislation or agencies involved	Unrestricted[2]
Other capital type	The broad capital category, from the five capitals concept[5]	Financial, Human, Manufactured, Social
Other capital detail	Additional information about the other types of capital.	Unrestricted[2]
Additional summary detail	Key additional details from the wider topic description, such as the nature of impacts (e.g. noise, entanglement) or the specifics of governance processes.	Unrestricted[6]

[1] See e.g. Luck et al. (2003) and Culhane et al. (2018) for further explanation of the SPU concept.
[2] See Table A5 for the categories derived for the South West Marine Plan context.
[3] This subcategory of non-extractive use refers to the role of the sea in providing space for e.g. transport (see Hooper et al., 2014).
[4] A classification system such as CICES (Haines-Young and Potschin, 2018) could be applied.
[5] See e.g. Forum for the Future (undated) for further explanation of the five capitals concept
[6] In some cases (such as the nature of impacts) these have the potential to be refined into systematic categories.

Table A5. Natural capital elements, sub-types and details derived from the South West Marine Plan scoping process

Element	Sub-type	Detail
Asset (biotic)	Benthos	Intertidal
		Subtidal
		Deep sea
		Beaches
		Coastal Lagoons
		Mudflat
		Saltmarsh
		Sand dunes
		Echinoderms
		Molluscs
		Sand dwelling species
		Shellfish
		Protected sites
	Mobile species	Basking sharks
		Cetaceans
		Fish
		Marine mammals
		Marine megafauna
		Plankton
		Seabirds
		Seals
		Turtles
		Waterbirds
		Protected species
Asset (abiotic)	Air	
	Water column	
	Substrate	
Service	Provisioning	Aggregates
		Energy
		Food
		Seaweed
	Provisioning (carrier)	Military activity
	Regulating	Climate regulation
	Cultural	Leisure and recreation
		Environmental interaction
		Visual amenity
Disservice	Invasive species	Pacific oysters
		American drill oyster
		Leathery sea squirt
		Other/unspecified
	Harmful/toxic species	Plankton/algae
Other capital	Manufactured capital	Heritage assets
		Ports, harbours
		Infrastructure
		Cables
	Human capital	Jobs
		Skills
Benefit	Economic	Income/revenue
		Employment
		Market goods
		Development
		Reduced expenditure
	Security	Energy security
		Food security
	Health	Physical health
		Mental health
	Wellbeing	
Impact	Local origin	Aggregate and mineral extraction
		Agriculture
		Aquaculture
		Cables, pipelines
		Coastal defence, erosion, development
		Commercial fisheries
		Defence, national security
		Dredging
		Hazardous substances
		Historic sources
		Industry, other activities
		Marine litter, pollution, noise
		Ports, harbours, shipping
		Recreation, tourism
		Renewables, other energy
	External origin	Marine litter
		Climate change
Governance	Designations	Marine Conservation Zone
		Heritage Coast
		Ramsar site
		Site of Special Scientific Interest
		Special Protection Area
		Blue Flag status
	Consents, licensing	Oil and gas
		Offshore wind farms
		Dredge disposal
		Historic environment
	Legislation	Bathing Water Directive
		Marine Strategy Framework Directive
		Marine Strategy Regulations 2010
		Water Framework Directive
	Management Plans	River Basin Management Plan
		Shoreline Management Plan
	Processes	

Figure A4 shows how the components of the original scoping framework map onto the proposed natural capital approach. This is not intended as a classification tool, but to illustrate how the information as organised within the scoping topics applies to multiple natural capital categories. An example of how the scoping report database (MMO, unpublished data) would look when the information is presented in the natural capital framework is given in Figure A5.

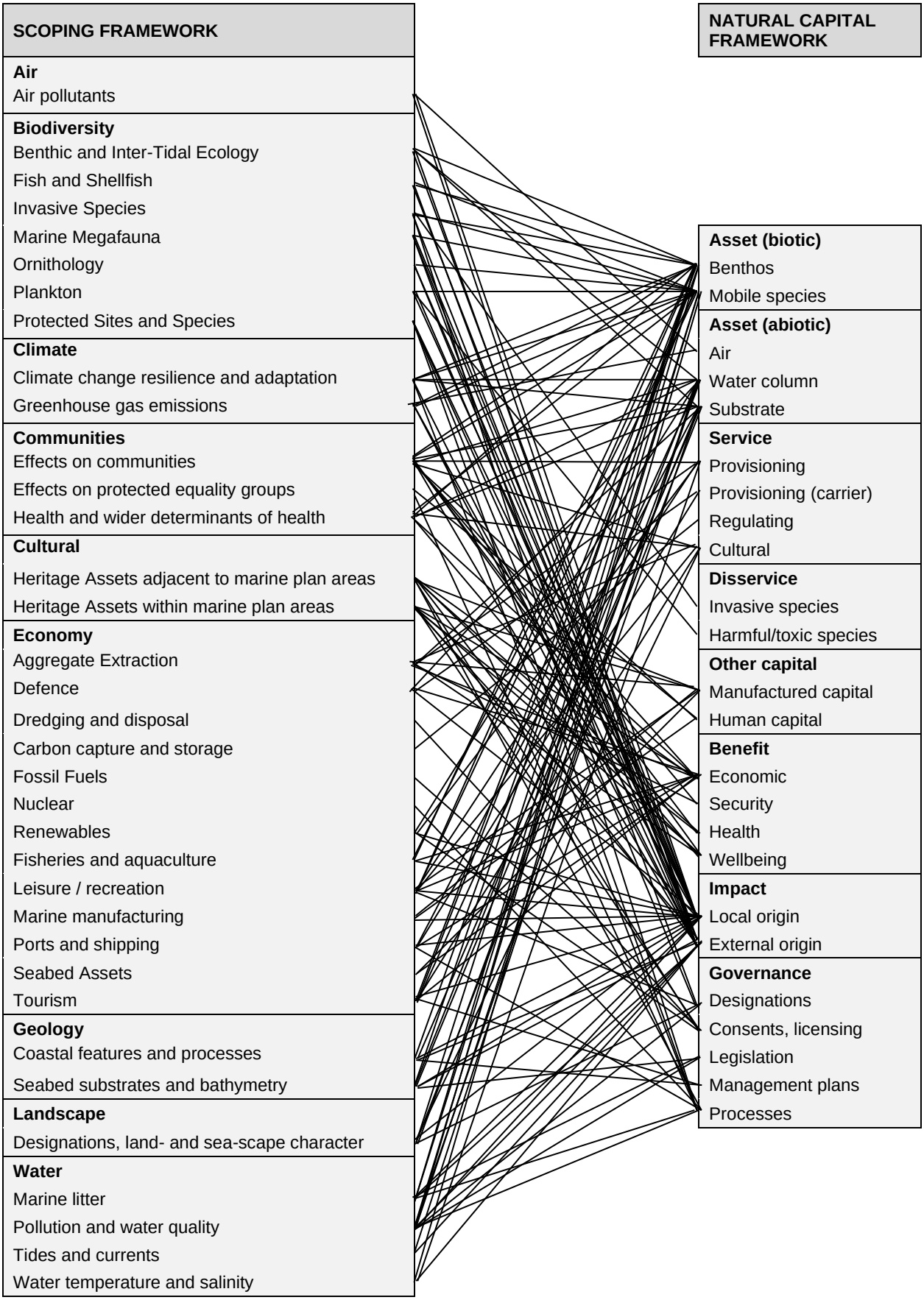

Figure A4. Mapping topics and sub-topics from the South West Marine Plan scoping process onto the natural capital framework

Natural Capital Element	Natural Capital Detail	Policy Option A		Policy Option B		Policy Option C	
		Significance	SA Database Topic identifier	Significance	SA Database Topic identifier	Significance	SA Database Topic identifier
Asset (biotic)	Benthic habitat	Uncertain (Lack of Evidence)	Biodiv_574	Not Significant	Biodiv_574	Not Significant	Biodiv_574
	Basking sharks, marine mammals, seals	Significant Negative	Biodiv_502, Biodiv_503, Biodiv_649, Biodiv_536, Biodiv_537, Biodiv_538, Biodiv_546, Biodiv_547, Biodiv_554, Biodiv_555, Biodiv_556	Uncertain (Dependent on Implementation)	Biodiv_502, Biodiv_503, Biodiv_649, Biodiv_536, Biodiv_537, Biodiv_538, Biodiv_546, Biodiv_547, Biodiv_554, Biodiv_555, Biodiv_556	Uncertain (Lack of Evidence)	Biodiv_502, Biodiv_503, Biodiv_649, Biodiv_536, Biodiv_537, Biodiv_538, Biodiv_546, Biodiv_547, Biodiv_554, Biodiv_555, Biodiv_556
	Waterbirds, seabirds	Significant Negative	Biodiv_465, Biodiv_274	Uncertain (Dependent on Implementation)	Biodiv_465, Biodiv_274	Uncertain (Lack of Evidence)	Biodiv_465, Biodiv_274
Asset (abiotic)	Air	Uncertain (Dependent on Implementation)	Air_19, Air_23	Significant Negative	Air_19, Air_23	Uncertain (Dependent on Implementation)	Air_19, Air_23
Service	Visual amenity	Uncertain (Dependent on Implementation)	Landscape_132 Landscape_133	Uncertain (Dependent on Implementation)	Landscape_132 Landscape_133	Not Significant	Landscape_132 Landscape_133
	Leisure and recreation	Uncertain (Lack of Evidence)	Water_271	Not Significant	Water_271	Uncertain (Lack of Evidence)	Water_271
		Uncertain (Dependent on Implementation)	Economy_631	Uncertain (Dependent on Implementation)	Economy_631	Not Significant	Economy_631

Figure A5. An extract from the South West Marine Plan scoping report database (MMO, unpublished data) presented using the natural capital framework

A1.4 Conclusion

Consideration of the information collated during the scoping phase of the Sustainability Appraisal for the South West Marine Plan has shown that it is relatively straightforward to map the original scoping topic areas onto a natural capital framework, and in doing so ensure that the legislative requirements are met. However, the process of undertaking the Sustainability Appraisal for the South West Marine Plan was already underway before the opportunity for using a natural capital approach as considered. As a result, there are some restrictions on what could be proposed. Applying a natural capital approach from the very beginning of a Sustainability Appraisal process would provide additional options. In particular, the scoping phase could be framed around the development of asset and risk registers. As with the proposed reframing of the main phase described above, this would not change the type of information that should be collected, as Sustainability Appraisal scoping has the same objective as the development of asset and risk registers; to understand what is there, what state it is in, and what the current threats to it are. The use of asset and risk registers provides the opportunity to formalise the process and present the outcomes systematically and in line with Government policy aspirations for natural capital based decision making. A comprehensive, systematic process for baseline assessment would also help to ensure that all aspects of natural capital and ecosystem services were considered. The South West Marine Plan example shows that there are some possible gaps in the scoping around regulating services.

Ultimately, a natural capital approach to Sustainability Appraisal was not adopted for the marine plans:
"MMO have explored the inclusion of natural capital through the SA process. MMO have discussed with academia, lead experts in government and the SA consultancy team as to what could be possible at this stage of the SA and in the future. As Marine natural capital is still in its infancy, it was ultimately deemed too early to incorporate a robust natural capital approach into the SA. At the time of the SA being undertaken, no clear definition of what the natural capital approach is for the marine area exists. It is therefore unfeasible to define and implement any methodology within the sustainability appraisal process. Once a definition and agreed approach is confirmed at a national level, it may be possible to include natural capital in a marine plan SA." (MMO, 2019b).

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North Devon Marine Natural Capital Plan
Sustainability Assessment

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CONSULTATION DRAFT
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1 Summary

The purpose of this assessment is to consider how the Marine Natural Capital Plan (MNCP) could impact upon the marine environment, coastal communities, and maritime economy in North Devon. The MNCP is the first iteration of what is expected to be an evolving process, and serves to build the necessary framework for long term sustainable management. Thus, few detailed benchmarks are included in the sustainability assessment, which instead evaluates the expected direction of travel of the MNCP. The sustainability appraisal uses a natural capital framework in order to continue to test the approach being developed under the SWEEP programme and the Marine Pioneer.

Several plans and policies interact with the MNCP, most of which have similar high-level objectives to: support sustainable development of the maritime economy; protect the marine environment; connect people to nature; and develop strong and just societies. These include the South West Marine Plan, the North Devon and Torridge Local Plan, fisheries byelaws from the Inshore Fisheries and Conservation Authorities, national conservation legislation relating to the protection of landscapes, habitats and species, and the 25 Year Environment Plan.

Thirty sustainability objectives are defined, which overlap significantly with the objectives of the MNCP itself as a result of the overarching aims of the MNCP being intrinsically linked to sustainable development. The sustainability objectives encompass natural, human, social, manufactured and financial capital, and include those for species populations, habitats, heritage; engagement of fishers, recreational users and the wider public; strengthening networks; minimising the impact of new infrastructure; and securing inward investment. Indicators for each objective are given within the sustainability assessment framework. Few policy targets exist at present (and mostly concern water quality and protected areas), but more targets are expected to be defined as the MNCP evolves.

The baseline assessment includes (i) an asset register, (ii) an ecosystem services inventory, and (iii) a risk register. It highlights the large extent of subtidal sedimentary habitats, the presence of estuarine mussel beds, saltmarsh and mudflats, and the important sand dunes. Wetland and sea bird populations are found in the Taw Torridge and on Lundy, demersal fish species as well as crab and European lobster are important for commercial fisheries, and protected species include seals, porpoise, spiny lobster and pink sea fans. Heritage assets range from scheduled ancient monuments and protected wreck sites to memorials to sailors and fishermen. The North Devon marine area also provides important ecosystem services (and associated benefits), particularly related to tourism, recreation and leisure, seascape and cultural heritage, and commercial fisheries. Marine and coastal habitats (especially saltmarsh) also contribute to regulating and maintenance services including carbon sequestration, water quality, coastal defence, and the provision of nursery habitats for fishery species. The continued supply of ecosystem services and benefits from the assets of the North Devon marine area is in some cases at risk however, due to the level of pressure on certain habitats. The ability of subtidal habitats to support food production, and saltmarsh condition are of most concern.

The sustainability assessment compares implementing the plan versus not doing so. In the short term (1-5 years), the principal positive impacts relate to human, social and financial capital, due to the expected strengthening of networks, improved governance, data-sharing, raising awareness, and new finance initiatives. Impacts on natural capital assets, ecosystem services and benefits are largely neutral. In the longer term, positive impacts are expected for sudtidal habitats where management measures reduce sea bed abrasion and for local stocks that have limited exposure to external pressures. Water quality is expected to improve as the MNCP supports actions to reduce diffuse pollution, and improved water quality is likely to increase the economic viability of mussel harvesting. There is potential for positive impact on cultivated seafood and macro-algae as well as tidal energy if the MNCP intention to support maritime industries is realised through the establishment of new businesses. A reduction in litter is likely to improve aesthetic quality, with improvements potentially occurring quickly with increasing support for ongoing initiatives. The quality of nursery habitats may increase if management reduces subtidal abrasion impacts, and through increasing saltmarsh area. More saltmarsh will also increase climate regulation, although benefits may be relatively limited, depending on the extent to which current land use promotes carbon uptake. Impacts on recreation are expected to be neutral, although there may be a decline in benefits from bait digging. It is not possible to make useful judgments about the likely effects on erosion control and flood protection. The limited benefits of the MNCP reflect the limitations of local management: ensuring positive outcomes for natural capital is also dependent on national and international governance.

2 Introduction

2.1 Background and Scope

The purpose of this assessment is to consider how the Marine Natural Capital Plan (MNCP) could impact upon the marine environment, coastal communities, and maritime economy in North Devon. The MNCP broadly follows the North Devon Marine Pioneer boundary (Figure 1) but extends seaward to 20nm and includes part of Bridgwater Bay. The MNCP reaches to the tidal limits of the Taw and Torridge rivers, and also includes the area up to 1km inland for the purposes of accounting for economic flows, thus joining to the boundary of the North Devon Landscape Pioneer. The governance and actions of the plan (and hence the scope of the sustainability assessment) are restricted to the marine component of the North Devon Biosphere.

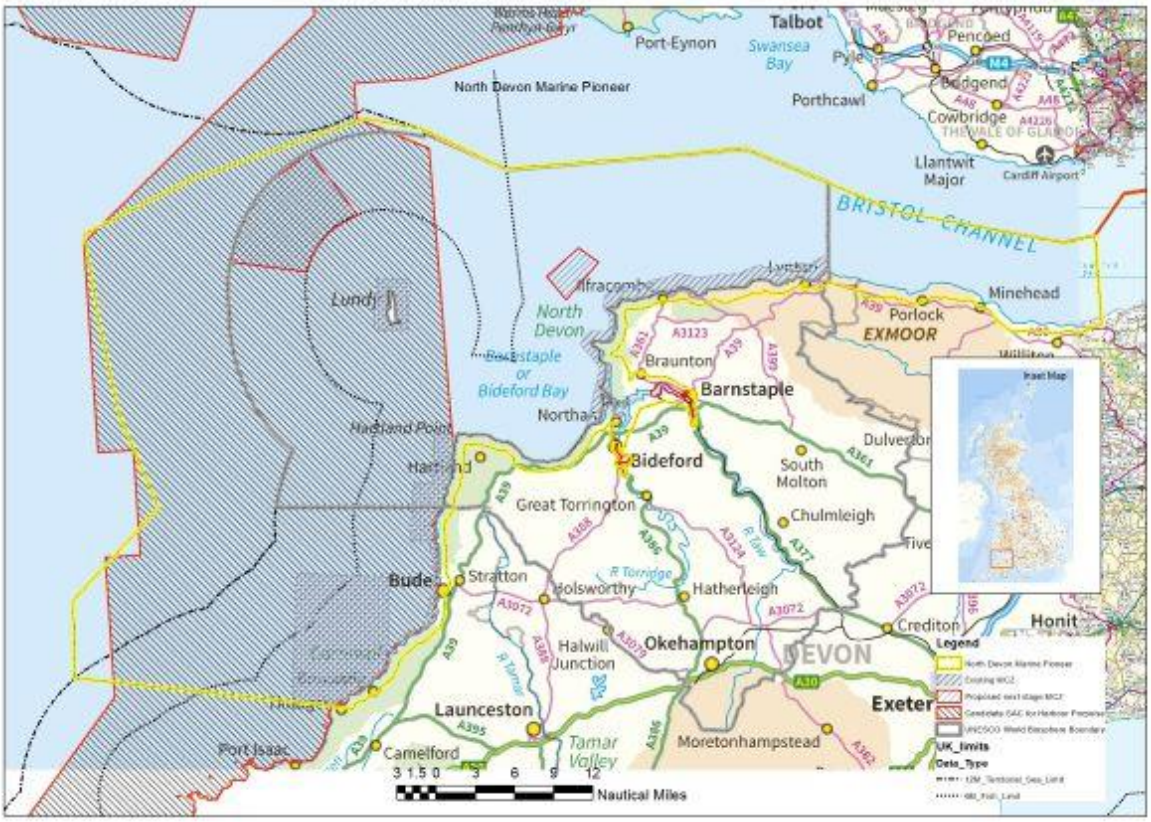


Figure 1. The area covered by the North Devon Marine Natural Capital Plan.

The MNCP is the first of its kind in the UK, and is the first iteration of what is expected to be an evolving process. This initial plan therefore primarily serves to build the necessary framework for long term sustainable management: to put in place a participatory governance structure, and to initiate or support the development of further management plans, financing options, research programmes and data sharing that address specific issues and sectors. Thus, few detailed benchmarks are included in the sustainability assessment, which instead evaluates the expected direction of travel of the MNCP. Future iterations, into which learning from, and specific actions developing as a result of, this first phase will be incorporated, are expected to include more specific targets for species, habitats and maritime sectors.

The sustainability appraisal is structured using a natural capital framework in order to continue to test, and enabling further refinement of, the approach being developed under the SWEEP programme and the Marine Pioneer (Hooper et al., 2019).

2.2 Relevant plans and policies

The principal plans and policies that interact with the MNCP include, at the regional level, the South West Marine Plan (SWMP; MMO, 2020a), which is currently in draft form as it progresses through public consultation. The SWMP has 13 specific objectives within three high level objectives from the Marine Policy Statement (HM Government, 2011): (1) achieving a sustainable marine economy; (2) ensuring a strong, healthy and just society; and (3) living within environmental limits. The SWMP also contains a number of specific policies that support delivery of the objectives. These policies are wide ranging, and concern different sectors and locations. The key text of those with particular relevance to the MNCP are summarised in Table 1.

Table 1. Extracts from the main policies within the South West Marine Plan (MMO, 2020a) of relevance to the North Devon Marine Natural Capital Plan.

Policy code	Policy text
SW-AQ-2	Proposals enabling the provision of infrastructure for sustainable aquaculture and related industries will be supported.
SW-REN-1	Proposals that enable the provision of renewable energy technologies and associated supply chains, will be supported.
SW-WIND-1	Proposals for offshore wind inside areas of identified potential will be supported.
SW-HER-1	Proposals that demonstrate they will conserve and enhance elements contributing to the significance of heritage assets will be supported.
SW-FISH-1	Proposals supporting a sustainable fishing industry, including the industry's diversification, should be supported.
SW-FISH-3	Proposals enhancing essential fish habitat, including spawning, nursery and feeding grounds, and migratory routes should be supported.
SW-EMP-1	Proposals that result in a net increase to marine related employment will be supported
SW-CC-1	Proposals which enhance habitats that provide flood defence or carbon sequestration will be supported.
SW-ML-1	Public authorities must make adequate provision for the prevention, re-use, recycling and disposal of waste to reduce and prevent marine litter. Public authorities should aspire to undertake measures to remove marine litter within their jurisdiction.
SW-WQ-1	Proposals that enhance and restore water quality will be supported.
SW-SOC-1	Those bringing forward proposals are encouraged to consider and enhance public knowledge, understanding, appreciation and enjoyment of the marine environment as part of (the design of) the proposal.
SW-MPA-1	Proposals that support the objectives of marine protected areas and the ecological coherence of the marine protected area network will be supported.
SW-BIO-1	Proposals that enhance the distribution of priority habitats and priority species will be supported.
SW-BIO-3	Proposals that deliver environmental net gain for coastal habitats where important in their own right and/or for ecosystem functioning and provision of ecosystem services will be supported.
SW-NG-1	Proposals should deliver environmental net gain for marine or coastal natural capital assets and services.

At a more local level, the North Devon and Torridge Local Plan (Torridge District Council and North Devon Council, 2018) has four strategic aims:

Aim 1: A Vibrant Northern Devon Economy – where excellent opportunities support diverse low carbon growth and moves towards an economy that supports our world class environment.

Aim 2: A World Class Environment – where important assets are valued and enhanced for future generations.

Aim 3: A Balanced Local Housing Market – where a choice of decent housing of all types is available and new development meets community needs.

Aim 4: Mixed Communities – where there is a strong community spirit and the opportunity for an excellent quality of life.

A number of the general Local Plan objectives (such as diversifying the local economy without adverse environmental and social impacts, learning and skills development, habitat protection, and improving public access to the environment to support wellbeing) apply to marine and coastal areas, but the plan also includes objectives that make explicit reference to marine and maritime issues:

- sustainable growth in the maritime, engineering, tourism and leisure economies;
- the undeveloped coastline, estuarine and important countryside assets of northern Devon are protected and enhanced;
- development improves water quality in rivers, lakes, estuary and coastal waters to help deliver the South West River Basin Management Plan objectives

The Local Plan also includes a Coast and Estuary Strategy (Policy ST09), elements of which concern maintaining and enhancing the cultural heritage and landscape setting of coastal communities; a diverse maritime economy; defence against coastal erosion and tidal flooding; and improving water quality, as well as stressing the importance of the coastal, estuarine and marine environments. The Devon and Severn Inshore Fisheries and Conservation Authority (IFCA) are responsible for legislation and enforcement specific to fisheries (both wild capture and mariculture), which includes byelaws related to permitting for mobile fishing, potting, netting and diving for scallop, crab and lobster, and the management of shellfish beds. The IFCA are also developing Fisheries Research and Management Plans. Voluntary agreements are also in place for ray and whelk fisheries (Ashley et al., 2018).

Also pertinent to the MNCP is national conservation legislation relating to the protection of landscapes, habitats and species associated within the designated Sites of Special Scientific Interest (SSSIs), Marine Conservations Zones (MCZs), Area of Outstanding Natural Beauty (AONBs), and Special Areas of Conservation (SACs) within the marine and coastal areas of the North Devon Biosphere Reserve. These highlight the important species, habitats and other features that require protection. The MNCP interacts with the North Devon AONB, four SACs (Braunton Burrows, Lundy, Bristol Channel Approaches and Tintagel-Marsland-Clovelly Coast), five MCZs (Lundy, Northwest of Lundy, Morte Platform, Bideford to Foreland Point, Hartland Point to Tintagel, and the South West Approaches) and more than 20 SSSIs in coastal areas, including the Taw-Torridge estuary, Exmoor coast, Saunton to Baggy Point, and Northam Burrows. Salmon and Sea trout are also subject to national management objectives (Cefas, Evironment Agency & Natural Resources Wales, 2018).

Defra's 25 Year Environment Plan (25YEP; HM Government, 2018) sets out the vision for national environmental policy. It seeks to secure clean, healthy productive and biologically diverse seas and oceans through implementing a sustainable fisheries policy, and achieving good environmental status while allowing marine industries to thrive and completing an ecologically coherent network of well-management marine protected areas. The 25YEP also contains commitments to reduce marine litter and reduce risks from flooding and coastal erosion as well as having wider objectives (not linked explicitly to the marine environment but of relevance to it), to recover nature and enhance the beauty of landscapes; connect people with their environment; and reduce pollution.

3 Sustainability Objectives

The overarching aims of the MNCP focus on ensuring environmental improvement, empowering communities, and securing coastal livelihoods, and thus are intrinsically linked to sustainable development. Therefore, there is significant overlap with the sustainability objectives and those of the MNCP itself. A similar approach was taken for the South West Marine Plan (MMO, 2019), for which the sustainability appraisal does not have separate objectives, but instead considers the wider objectives of the Marine Plan and associated policies. The five capitals model (Forum for the Future, undated; Table 2) was used in formulating the sustainability objectives, to ensure that they had relevance across different aspects of the environment, society and the economy. The full list of sustainability objectives is given in Table 3.

Table 2. Descriptions for each of the five capitals (Hooper et al., 2019).

Capital type	Description
Natural	Encompasses natural resources as well as the processes needed to sustain life and produce goods and services.
Social	Networks together with shared norms, values and understandings that facilitate cooperation within or among groups (such as families, unions, schools, voluntary organisations)
Human	The health, knowledge, skills and capabilities of individuals.
Manufactured	Goods or assets that contribute to the production process or the provision of services, rather than being part of the output itself. It includes, for example tools, machinery, buildings and infrastructure.
Financial	Those assets of an organisation that exist in a form of currency that can be owned or traded, including shares, bonds and banknotes.

Table 3. The sustainability objectives for the North Devon Marine Natural Capital Plan

Natural Capital (including related heritage)
• Disturbance of waterbirds, sea birds and marine mammals is reduced • All mussel beds in the Taw Torridge estuary rated at least Class B by 2030 • All designated bathing waters reach guideline standards by 2025 • All estuarine and coastal water bodies reach appropriate standards under the Water Framework Directive • Commercial stocks of fish and shellfish (wild capture) increase • Stocks of salmon and sea trout are maintained above their conservation limits • Health of fish habitats is maintained and where possible improved • Disturbance of intertidal mudflats in the Taw Torridge estuary from recreational bait collection (bait digging, crab tiling) is reduced • The quantity of plastic waste and litter on beaches and in the water column is reduced • Carbon storage capacity of the Taw Torridge estuary is increased • Disturbance (scour) of subtidal sediments is reduced • Levels of protection for environmental assets are maintained and where possible improved • Environmental quality in protected areas reaches at least minimum acceptable status • Likely relative condition of subtidal habitats is maintained and where possible improved • The cultural heritage value of ongoing inshore fisheries is maintained
Human Capital
• Employment opportunities increase in mariculture, shellfish hand-harvesting, and value-added activities for wild capture fisheries, where these do not exceed levels of sustainable exploitation • The availability of data on (and therefore knowledge of) environmental, social and economic issues related to marine areas is increased • Local people are motivated to take part in environmental initiatives • Members of the public are motivated to improve their behaviour around waste disposal • Recreational users are motivated to improve their behaviour in order to minimise environmental disturbance • Fishers and harvesters are more engaged in sustainable fisheries management
Social Capital
• Networks for sustainable management of coastal and marine areas are strengthened • Recreational users are more engaged with sustainable management • Conflict amongst marine users is reduced • The use of citizen science data in decision making is increased
Manufactured Capital
• New infrastructure for renewable energy and mariculture conforms to sustainability criteria • New mooring infrastructure is installed to reduce habitat damage due to anchoring and scour from traditional moorings
Financial Capital
• Incomes for fishers/harvesters using low-impact techniques are maintained, and where appropriate increased, through sustainable management of resources and value-added activities • The economic contribution of recreation and tourism linked to marine and coastal natural capital is maintained • New financial mechanisms and products are established to support maritime activities and environmental protection

4 Baseline

Extensive, detailed information on North Devon's marine area, including on species, habitats, and activities such as fisheries, recreation and tourism has already been collated and analysed by Ashley et al. (2018) and Rees et al. (2019), much of which is available through the geodatabase (https://pioneer-geonode.plymouth.ac.uk), and so will not be duplicated here. This assessment will instead provide a short narrative summary taken, with the exception of the information on heritage assets, primarily from Ashley et al. (2018) and Rees et al. (2018), with additional information from Hooper (2013). This is accompanied by a series of summary tables comprising: (i) an asset register (with both species and habitats), (ii) an ecosystem services inventory, and (iii) a risk register.

In terms of natural capital assets, the marine area is dominated by sedimentary habitats, particularly sand and coarse sediments. There are also rocky reef areas, and pockets of macro-algae. Intertidal habitats include mussel beds, saltmarsh and mudflats within the Taw Torridge estuary, as well as rocky shores and sandy beaches. The sand dunes at Braunton and Northam Burrows are important coastal margin habitats and support protected species including the petalwort and sandbowl snail. The estuary supports some regionally and nationally important populations of waterbirds, and curlew, lapwing and golden plover are designated features of protected areas. Protected seabirds including puffins, razorbill, Manx shearwater, guillemot and kittiwake are found in the area, primarily on the cliffs of Lundy. Subtidally, demersal fish species as well as crab and European lobster are important for commercial fisheries, and protected species include seals, porpoise, spiny lobster and pink sea fans.

The evaluation of heritage assets was beyond the scope of Ashley et al. (2018) and Rees et al. (2019), but they were described by Hooper (2013), whose work was informed particularly by Preece (2005, 2008). The estuary contains two scheduled ancient monuments (a buried Bronze Age stone row at Isley Marsh, and the Bideford Long Bridge), as well as three prehistoric sites at Westward Ho! The remains of several fish weirs can be found in the Taw, and assets related to shipbuilding remain on the banks of the Torridge. Historic military infrastructure can be found at Instow and, particularly, on Braunton and Northam Burrows. Further heritage assets are recorded on local lists maintained by local authorities (North Devon Council, undated; Torridge District Council, undated). These include memorials to sailors and fishermen, buildings associated with the former uses of Fremington Quay and with Victorian/Edwardian seaside tourism in Ilfracombe and Woolacombe, a former lifeboat station, and riverfront warehouses. Historic England (undated) lists two wrecks designated under the Protection of Wrecks Act 1973, both close to Lundy: the Iona II, an American paddlesteamer lost in 1864, and the remains of a 15th/16th Century ship wrecked at Gull Rock.

Tourism, recreation and leisure are extremely important in North Devon, with watersports participation making a significant economic contribution. The seascape and cultural heritage of the area are also important services that contribute to its popularity as a visitor destination. Ray, whelk, lobster and sole contributed over 80% of the value of annual landings into North Devon ports in 2018 (MMO, 2020b). There are also moderate levels of hand-harvesting of mussels from beds within the estuary, a commercial operator culturing oysters in Porlock, and occasional harvesting of purple laver and cockles from rocky shores. Bait collection (particularly for rag- and lugworm, and tiling for moulting shore crabs) occurs frequently on mudflats in the estuary. Spat for seeding mussel beds elsewhere has previously been collected, but is not occurring at the present time. The estuary is also used for commercial shipping into Appledore and Bideford and for military exercises, particularly amphibious craft training. A tidal energy test site can be found at Lynmouth, although is currently dormant. Marine and coastal habitats (especially saltmarsh) also contribute to regulating and maintenance services including carbon sequestration, water quality (through filtration, remediation and other processing of waste and toxins), coastal defence, and the provision of nursery habitats for fishery species. The continued supply of ecosystem services and benefits from the assets of the North Devon marine area is in some cases at risk however, due to the level of pressure on certain habitats. The ability of subtidal habitats to support food production and the condition of saltmarsh are of most concern.
The following tables summarise data on the key habitats, species and ecosystem services in the North Devon marine area. Their extent (quantity), trends in that extent, and condition are summarised,

and some monetary values for benefits from ecosystem services are provided. Quantified information is given where available for extent and value, while trends and condition are categorised. The information in Tables 4–7 is primarily from Rees et al. (2019) and Ashley et al. (2018), with further information from Hooper (2013), and additional fisheries landing values from MMO (2020). Rees et al. (2019) and Ashley et al. (2018) also include confidence assessments and caveats related to the data. For example, the data on which fisheries stock assessments are based is collected on a much larger spatial scale and the sampling methods used are not the most appropriate for some of the species documented. The method for development of the risk register and the justification for the risk scoring are also given in Rees et al. (2019).

4.1 Asset register summary

Table 4. The extent and condition of the major habitats in the North Devon marine area

Key: *Trend*: Positive, Stable, Negative; *Condition*: Good, Acceptable, Of concern; Insufficient data

Broad Habitat	Detail (with EUNIS code)	Extent (km^2)	Extent trend	Condition
Sparsely vegetated land				
Supralittoral sediment	Sand dune	6.72		
	Sand dune with shrubs	0.39		
	Shingle	0.17		
Marine inlets and transitional waters				
Littoral rock	Littoral rock and other hard substrata (A1)	11.31		
	High energy littoral rock (A1.1)	5.73		
	Moderate energy littoral rock (A1.2)	2.98		
	Low energy littoral rock (A1.3)	1.69		
	Features of littoral rock (A1.4)	0.38		
	Littoral chalk communities (B3.114, B3.115, A1.441, A1.2143)	0.002		
	Honeycomb worm, Sabellaria alveolata reef (A2.71, A2.711, A5.612)	0.004		
	Intertidal underboulder communities (A1.2142, A3.2112)	0.03		
	Estuarine rocky habitats	1.18		
	Supralittoral rock (lichen or splash zone) (B3.1)	0.85		
Littoral sediment	Littoral sediment (A2)	29.31		
	Littoral coarse sediment (A2.1)	0.76		
	Littoral sand and muddy sand (A2.2)	14.99		
	Littoral mixed sediments (A2.4)	0.45		
	Littoral biogenic reefs (A2.7)	0.01		
	Features of littoral sediment (A2.8)	0.03		
	Coastal saltmarshes and saline reedbeds (A2.5)	2.80		
	Blue mussel beds	0.28		
	Littoral mud (A2.3)	9.98		
Sublittoral habitats				
Sublittoral rock	Infralittoral rock and other hard substrata (A3)	17.27		
	Atlantic and Mediterranean high energy infralittoral rock (A3.1)	11.19		
	Atlantic and Mediterranean moderate energy infralittoral rock (A3.2)	2.12		
	Atlantic and Mediterranean low energy infralittoral rock (A3.3)	0.07		
	Features of infralittoral rock (A3.7)	0.0003		
	Circalittoral rock and other hard substrata (A4)	876		
	Atlantic and Mediterranean high energy circalittoral rock (A4.1)	477		
	Atlantic and Mediterranean moderate energy circalittoral rock (A4.2)	394		
	Fragile sponge & anthozoan communities on subtidal rocky habitats			
Sublittoral sediment	Sublittoral coarse sediment (A5.1)	2,845		
	Sublittoral sand (A5.2)	1,690		
	Sublittoral mud (A5.3)	10.85		
	Sublittoral mixed sediments (A5.4)	48.56		
Sublittoral vegetated habitats	Tide-swept algal communities (L.hyperborea) (A3.126, A3.213)	0.68		
	Kelp and seaweed communities on sublittoral sediment (A5.52)			
Transitional and shelf waters	Shelf waters	5,500		
	Estuarine waters	2.45		

Table 5. The extent and condition of key species (designated as protected features or particularly important for ecosystem services) in the North Devon marine area

Key:

	Positive	Stable	Negative	
Trend				
Condition	Good	Acceptable	Of concern	Insufficient data

Scientific name	Common name	Quantity	Quantity unit	Quantity trend	Condition
Uria aalge	Guillemot	6,198	Census count		
Rissa tridactyla	Kittiwake	238	Apparently occupied nests		
Puffinus puffinus	Manx shearwater	3,451	Pairs		
Fratercula arctica	Puffin	375	Census count		
Alca torda	Razorbill	1,735	Census count		
Numenius arquata	Curlew	623	Annual peak count		
Pluvialis apricaria	Golden Plover	3,184	Annual peak count		
Vanellus vanellus	Lapwing	2,765	Annual peak count		
Branta canadensis	Canada Goose	597	Annual peak count		
Anas penelope	Wigeon	391	Annual peak count		
Anas crecca	Teal	290	Annual peak count		
Anas platyrhynchos	Mallard	236	Annual peak count		
	Waterbird assemblage				
Gadus morhua	Cod	0	n per km²		
Pleuronectes platessa	Plaice	2,698	n per km²		
Solea solea	Sole	4,437	n per km²		
Clupea harengus	Herring	0	n per km²		
Raja clavata	Thornback ray	444	n per km²		
Raja microocellata	Small eyed ray	67	n per km²		
Raja brachyura	Blonde ray	200	n per km²		
Dicentrarchus labrax	Bass	22	n per km²		
Loligo vulgaris/forbesii	Squid	469	n per km²		
Salmo salmar	Salmon	1	n per license day		
Salmo trutta	Sea trout	1	n per license day		
Cancer pagurus	Crab				
Homarus gammarus	Lobster				
Petalophyllum ralfsii	Petalwort				
Palinurus elephas	Spiny lobster				
Eunicella verrucosa	Pink sea-fan				
Catinella arenaria	Sandbowl Snail				
Buccinum undatum	Common whelk				
Halichoerus grypus	Grey seal				
Phocoena phocoena	Harbour porpoise	278-1713	individuals		

5 Ecosystem Services

Table 6. An inventory of the main ecosystem services provided by the North Devon marine area

Key: *Trend* Positive Stable Negative Insufficient data

Category	Services/benefits delivered	Quantity	Trend	Value
Food: Cultivated seafood	Oysters	Low		
Foraged plants	Purple laver (*Porphyra*)	Low		
Game and wild fish (commercial harvesting)	Cod	2.82 t/yr		£13,206
	Plaice	3.37 t/yr		£5,728
	Sole	4.75 t/yr		£111,799
	Herring	0.17 t/yr		£441
	Thornback ray	71.07 t/yr		
	Small eyed ray	7.25 t/yr		£480,906
	Blonde ray	93.02 t/yr		
	Crab	16.18 t/yr		£95,107
	Lobster	14.61 t/yr		£285,213
	Whelk	117.97 t/yr		£400,226
	Squid	0.05 t/yr		£39,376
	Bass	2.46 t/yr		£20,058
	Other marine species	222 t		£128,324
	Mussels	Moderate		
	Cockles/whelk	Low		
Materials: Non-food products	Bait	High		
Genetic resources	Mussel spat	Inactive		
Energy: Energy from non-living sources	Tidal energy testing	Inactive		
Carrier: Commercial and other transport	Commercial shipping	Low		
Military training/operations	Amphibious craft training	Moderate		
Environmental quality: Water quality	Bioremediation, filtration, dilution	4,607km^{2}*		
Maintaining wild populations:	Nursery habitat	3,400km^{2}*		
Hazard and nuisance reduction: Erosion control	Sea defence	47km^{2}*		
Flood protection				
Pest and disease control				
Climate regulation	Carbon sequestered	7,572 t/yr		£168,689
Physical, experiential, intellectual interactions:				
Recreation, tourism, other experiential opportunities	Watersports participation#	34,070 people		£28million
Scientific and educational opportunities		Moderate		
Cultural significance of nature: Aesthetic		High		
Heritage, spiritual and representational significance		High		
Non-use values				

* Area of habitat providing moderate or significant contribution to the service

By local residents. Includes swimming and angling

5.1 Risk register summary

Table 7. The risk to the continued delivery of ecosystem services (ES) by key assets in the North Devon marine area (reproduced from Rees et al., 2019)

For each ES the top row is risk assessed in relation to analysis of indicator data in relation to policy targets, the lower row for each ES is risk assessed in relation to (local) community based knowledge of risk.
Risk register confidence assessment in relation to robustness and agreement of evidence (confidence was assessed for status and trend and therefore confidence is sum of both)

		Agreement	
		High	Low
Robustness	*Significant evidence*	1	3
	Limited evidence	2	4

	High confidence	Low confidence
Low risk	*A*	*A*
High (or unknown) risk	*B*	*B-C*
Very high risk	*C*	*C*

		Assets																		
		Saltmarsh	Littoral rock	Littoral coarse sediments	Littoral sand and muddy sand	Littoral mud	Littoral mixed sediments	Littoral biogenic reefs	Infralittoral rock	Circalittoral rock	Sublittoral coarse sediment	Sublittoral sand	Sublittoral mud	Sublittoral mixed sediments	Water bodies	Bathing waters	Shellfish waters	Fish (quota species)	Fish (non-quota species)	Fish (migratory species (salmon and sea trout)
	Risk category policy	Qun Qal Sp.	Qun Qal Sp.	Qun Qal Sp.	Qun Qal Sp.	Qun Qal Sp.	Qun Qal Sp.	Qun Qal Sp.	Qun Qal Sp.	Qun Qal Sp.	Qun Qal Sp.	Qun Qal Sp.	Qun Qal Sp.	Qun Qal Sp.	Qun Qal Sp.	Qun Qal Sp.	Qun Qal Sp.	Qun Qal Sp.	Qun Qal Sp.	Qun Qal Sp.
	Risk cat. Community	Risk: Local community	Risk: Local community	Risk: Local community	Risk: Local community	Risk: Local community	Risk: Local community	Risk: Local community	Risk: Local community	Risk: Local community	Risk: Local community	Risk: Local community	Risk: Local community	Risk: Local community	Risk: Local community	Risk: Local community	Risk: Local community	Risk: Local community	Risk: Local community	Risk: Local community
Ecosystem Service Benefits	Food (Wild Food - fish and shellfish).	*					*	*	* *	*	*	*	*	*		* *		* *	* (Lob, (Medium risk) Crab, (Low risk)	* *
	Food - local																			
	Healthy climate (carbon sequestration).	*						*	* *											
	Climate -local																			
	Sea defence. (natural hazard regulation / flood prevention).	*					*	*	* *											
	Sea defence - local																			
	Recreation and Tourism	*							* *	*						* *		* *	* (Lob, (Medium) Crab, (Low)	* *
	Recreation and Tourism - local																			
	Clean water and sediments.	*						*			*	*	*	*		* *				
	Clean water -local																			

6 Sustainability Assessment Framework

6.1 Objectives and indicators

The sustainability assessment framework, with indicators, objectives and the sources of data for the indicators is presented in Table 8 (see following page). Indicators are suggested for each objective, but it is not always the case that the relevant data is currently available (either it is not yet collected at all, not at an appropriate resolution, or not publicly available). However, these indicators have been included as it is anticipated that data gathering and information sharing will be strengthened under the MNCP, allowing these indicators to be monitored in the future.

6.2 Targets

Policy targets relevant to the sustainability assessment are listed in Table 9. Although currently there are few, more targets are likely to be defined as actions within the MNCP (such as the development of fisheries management plans) progress.

Table 9. Policy targets relevant to the sustainability assessment objectives and indicators.

Objective	Indicator	Target	Source
All mussel beds in the Taw Torridge estuary rated at least Class B by 2030	Annual rating of shellfish water quality	Harmful plankton and reported toxin levels are below action levels	Water Framework Directive
All designated bathing waters reach guideline standards by 2025	Annual rating of bathing water quality	Number of designated bathing waters maintained or increased. All bathing waters are at least 'sufficient'	Bathing Waters Directive
All estuarine and coastal water bodies reach appropriate standards under the Water Framework Directive	Annual water body status rating	All water bodies achieve 'good' or 'high' status	Water Framework Directive
Stocks of salmon and sea trout are maintained above their conservation limits	Stock status category	Conservation limits are met or exceeded in at least four out of five years	Cefas, Environment Agency and Natural Resources Wales, 2017
Levels of protection for environmental assets are maintained and where possible improved	Percentage area within designated and voluntary marine protected areas	10% of habitats are within marine protected areas	CBD, 2010
Environmental quality in protected areas reaches at least minimum acceptable status	Condition assessment in protected area monitoring reports	At least 95% of habitats within marine protected areas has the conservation objective 'maintain' or is in 'favourable' condition	Natural England, 2017

Table 8. The sustainability objectives and indicators, including the expected sources of data for monitoring the indicators, and the likely availability of those data.

Objectives	Indicators	Data source and availability*	
Natural Capital (including heritage)			
Disturbance of waterbirds, sea birds and marine mammals is reduced	Number of disturbance incidents (from disturbance surveys)	NDBR[1]	C
All mussel beds in the Taw Torridge estuary rated at least Class B by 2030	Annual rating of shellfish water quality	CEFAS[2]	A
All designated bathing waters reach guideline standards by 2025	Annual rating of bathing water quality	Environment Agency	A
All estuarine and coastal water bodies reach appropriate standards under the Water Framework Directive	Annual water body status rating	Environment Agency	A
Commercial stocks of fish and shellfish (wild capture) are within safe biological limits, and where possible are increased	(i) Stock sizes for, particularly, herring, bass, whelk, squid, skates and rays; (ii) Extent of Taw Torridge mussel beds; (iii) Size structure of Taw Torridge mussel beds	(i) CEFAS, IFCA[3] (ii) IFCA (III) IFCA	B B B
Stocks of salmon and sea trout are maintained above their conservation limits	(i) Catch per unit effort (from stock surveys) (ii) Stock status category	CEFAS, Environment Agency	A
Health of fish habitats is maintained and where possible improved	Extent and condition of spawning and nursery habitats	CEFAS	B
Disturbance of intertidal mudflats in the Taw Torridge estuary from recreational bait collection (bait digging, crab tiling) is reduced	Size of disturbed area (from aerial photography)	IFCA, NDBR	C
The quantity of plastic waste and litter on beaches is reduced	Quantity of litter removed from beaches	MCS[4]	B A
Carbon storage capacity of the Taw Torridge estuary is increased	Extent/condition of saltmarsh (from aerial photography/LiDAR)	NDBR	B
Disturbance (scour) of subtidal sediments is reduced	(i) Frequency of anchoring within restricted zones (from aerial photography) (ii) Area of scoured seabed around moorings (from surveys)	NDBR	C
Levels of protection for environmental assets are maintained and where possible improved	(i) Percentage area within designated and voluntary marine protected areas; (ii) Percentage area protected by management measures;	Natural England, IFCA	A
Environmental quality in protected areas reaches at least minimum acceptable status	Condition assessment in protected area monitoring reports	Natural England	A
Likely relative condition of subtidal habitats is maintained and where possible improved	Intensity of fishing and other activities (e.g. aggregate extraction) that impact on the seabed	IFCA, MMO[5]	B
The cultural heritage value of ongoing inshore fisheries is maintained	Number of licenced inshore fishing vessels	MMO, IFCA	A

* Baseline data for the indicators, where available, has already been compiled within the asset and risk register (see Rees et al., 2019 and Ashley et al., 2018)

Data key: A = Appropriate data currently available; B = Some available data but may be issues with e.g. access to it or spatial resolution; C = Data not yet available

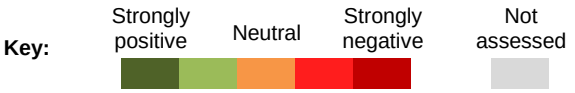
Acronyms: 1 = North Devon Biosphere Reserve; 2 = Centre for the Environment, Fisheries and Aquaculture Science; 3 = Inshore Fisheries and Conservation Authority; 4 = Marine Conservation Society; 5 = Marine Management Organisation; 6 = Office for National Statistics.

Objectives	Indicators	Data source and availability*	
Human Capital			
Employment opportunities increase in mariculture, shellfish hand-harvesting, and value-added activities for wild capture fisheries, where these do not exceed levels of sustainable exploitation	(i) Number of new businesses and employees (ii) Number of new shellfish/mariculture licences (iii) Number/extent of mariculture areas	(i) ONS[6] (Nomis) (ii) IFCA (iii) IFCA	B A A
The availability of data on (and therefore knowledge of) environmental, social and economic issues related to marine areas is increased	Number of datasets added to the NDBR centralised database	NDBR	C
Local people are motivated to take part in environmental initiatives	Number of people engaged in beach clean ups Number of people engaged in citizen science	MCS	A
Members of the public are motivated to improve their behaviour around waste disposal	Quantity of locally-derived litter on beaches	MCS Environment Agency	A
Recreational users are motivated to improve their behaviour in order to minimise environmental disturbance	(i) Number of disturbance incidents (ii) Number of accredited recreational boats (iii) Frequency of use of eco-moorings	NDBR	C B C
Fishers and harvesters are more engaged in sustainable fisheries management	Number of fishermen supplying data to the NDBR centralised database	NDBR	C
Social Capital			
Networks for sustainable management of coastal and marine areas are strengthened	Number/diversity of individuals and organisations involved within the NDBR marine governance structure	NDBR	A
Recreational users are more engaged with sustainable management	Number of individuals/businesses adopting and promoting codes of conduct	NDBR	C
Conflict amongst marine users is reduced	Number of infringements of recreational code of conduct and zoning restrictions reported	NDBR	C
The use of citizen science data in decision making is increased	Examples of use in management plans	NDBR, IFCA	C
Manufactured Capital			
New infrastructure for renewable energy and mariculture conforms to sustainability criteria	Number of consent applications adhering to the recommendations	Council, MMO, IFCA	C
New mooring infrastructure is installed to reduce habitat damage due to anchoring and scour (from traditional moorings)	Number of eco-mooring buoys installed	NDBR	C
Financial Capital			
Incomes for fishers/harvesters using low-impact techniques are maintained, and where appropriate increased, through sustainable management of resources and value-added activities	(i) Value of landings/sales (ii) Landings per unit effort	MMO IFCA	B
The economic contribution of recreation and tourism linked to marine and coastal natural capital is maintained	Number of visitors undertaking fishing, outdoor swimming, visits to beaches, coastal walking, wildlife watching and watersports	Natural England	A
New financial mechanisms and products are established to support maritime activities and environmental protection	(i) Number of new blue investment funds (ii) Amount of new blue funding invested in North Devon	NDBR	C

7 Comparing Plan Alternatives

In its current phase, the MNCP does not propose different options for achieving specific plan objectives, as in most cases the objectives relate to very specific high-level tasks (such as the development of codes of conduct or management plans). In the absence of alternative options, this sustainability assessment considers the binary choice of implementing the plan versus not doing so. The expected impacts of implementing the MNCP in terms of the degree to which it will have positive, negative or neutral effects, are made using expert judgment and are summarised in Table 10, which considers both the short (1-5 years) and longer term (more than five years). The assessment of longer term implications is particularly speculative as it relies, for example, on the management plans that are being developed in the first phase of the MNCP resulting in the expected actions that will protect stocks and habitats and support local fisheries. Similarly, the projections assume that governance structures are accepted and maintained and that new financing mechanisms are sufficiently successful to become self-sustaining. More accurate assessment of the outcomes of these strategies and actions will be possible in future phases of the MNCP.

Table 10. The expected direction of impacts of the marine natural capital plan on assets, ecosystem services and benefits, and human, social, and financial capital, when compared to not implementing the plan



	Short term (1-5yrs)	Longer term (>5yrs)
Natural capital assets		
Geology		
Supralittoral rock		
Supralittoral sediment		
Littoral rock		
Littoral sediment		
Saltmarsh		
Mussel beds		
Sublittoral rock		
Sublittoral sediment		
Commercial finfish		
Crab and lobster		
Wetland birds		
Seabirds		
Marine mammals		
Heritage assets		
Designated and non-designated sites		
Ecosystem services and benefits		
Cultivated seafood		
Foraged plants		
Game and wild fish		
Non-food products from plants, animals & algae:		
Bait		
products from cultivated macroalgae		
Genetic resources (*mussel spat*)		
Energy from non-living sources (*tidal energy*)		
Commercial and other transport		
Water quality		
Maintenance of nursery populations and habitats		
Erosion control		
Flood protection		
Climate regulation		
Recreation, tourism and other experiential opportunities		
Scientific and educational opportunities		
Aesthetic		
Heritage, spiritual and representational significance		
Existence, bequest and option values		
Social and human capital		
Community networks		
Knowledge, skills and capabilities		
Financial capital		
Inward investment		

In the short term, the principal positive impacts of implementing the MNCP relate to human, social and financial capital, due to the expected strengthening of community networks, improved governance structures, data-sharing, raising awareness and the inward investment from new sustainable finance initiatives. There is the potential for increased positive impact on financial capital in the longer term, as successful funds attract snowballing investment. As the Marine Pioneer, SWEEP and similar recent activities in North Devon have demonstrated, the MNCP area has provided significant opportunities for research, which are expected to continue in the future now that key partnerships have been established. The MNCP is also expected to have a positive impact on education through proposed citizen science and wider engagement initiatives, and on non-use values (existence and bequest) as awareness and understanding of the marine environment increases.

Impacts on natural capital assets, ecosystem services and benefits are largely neutral in the short term. In this inception phase, the MNCP is seeking to put in place the necessary structures to support environmental growth and to aid the development of management plans for specific natural capital assets and ecosystem services, such as those related to fisheries. Thus, direct impacts on the environment in the initial years will be limited. Improvements in the quality of subtidal habitats are expected where eco-moorings are installed and recreational anchoring reduced (and so scour and abrasion impacts decrease) although the spatial scale of these will be small. Management of bait digging is likely to reduce disturbance of intertidal mud. Further increases in the extent or quality of species and habitats may also be secured as sustainable finance allows investment in local conservation initiatives, although these cannot be predicted at this stage.

Even in the longer term when more detailed management plans have been put in place, impacts may not be universally positive. The fisheries management plans are expected to focus on improving the status of species and habitats of particular local importance, and to have impacts in the longer term when the resulting management measures have had time to take effect. Positive impacts are expected for sudtidal sedimentary habitats in inshore areas where fisheries management measures reduce sea bed abrasion and for local stocks which have limited exposure to external pressures. However, these external pressures (such as fishing activity beyond the 6nm limit) as well as climate change will influence the condition, and indeed the continuing presence, of many of the fisheries species important in North Devon. Similarly, the impacts on services and benefits from wild capture fisheries are expected to be broadly neutral even in the longer term, although improved shellfish water quality is likely to increase the economic viability of mussel harvesting resulting in a positive outcome. It is expected that fisheries management plans will seek to maintain the livelihoods of inshore fishermen. Ensuring the continuation of an active inshore fishing fleet in North Devon also secures the connection to the maritime history of the area, preventing a decline in the value of cultural heritage. There is greater potential for measurable positive impact on the supply of cultivated seafood and macro-algae as well as tidal energy if the MNCP intention to support mariculture and other maritime industries is realised through the establishment of new businesses. Similarly, opportunities to re-establish a limited export of mussel spat may be explored, which could also bring economic benefit.

Water quality is expected to improve in the long term as the MNCP supports actions within the North Devon Catchment Management Plan to reduce diffuse pollution, although this is reliant on suitable investment being secured. An increase in the aesthetic quality of the area is also expected. The main land/seascape features (such as cliffs) will not be affected, but a reduction in litter is likely to improve aesthetic quality of specific sites, with improvements potentially occurring quickly as a result of increasing support for ongoing initiatives. The expansion of saltmarsh may also improve visual amenity, although aesthetic judgements are subjective and benefits will depend on relative perception of the current landscape. Increasing the extent and quality of saltmarsh will also provide nursery habitat, with benefits increasing with further expansion in the longer term. Fisheries management plans may have positive impacts on wider nursery habitats in the longer term through the potential protection of important subtidal areas. New areas of saltmarsh will also increase climate regulation, although benefits may be relatively limited, depending on the extent to which current land use promotes carbon uptake. The rate of carbon sequestration in saltmarsh decreases as the habitat matures, tempering the scale of the longer term

benefits of continuing to create new areas of saltmarsh in the future. Saltmarsh areas also support significant recreational benefits. Recreation more generally may see a possible slight negative impact for those whose activities are restricted by codes of conduct, although this is likely to be balanced by the increased positive experience of others who benefit from improved environmental quality and noise reduction. There may be a decline in benefits from bait digging, as future management of effort may restrict opportunities for individuals and prohibit expansion.

The implications of the MNCP for erosion control and flood protection have not been assessed. Changes in these services would be related primarily to the expansion of saltmarsh and its role in moderating tidal inundation and attenuating wave action. However, these issues are very complex and require consideration of factors such as whether the saltmarsh replaces hard defences, the extent to which landward expansion is possible, and wider topographical and hydrographic parameters within the estuary. Without sophisticated modelling, it is not possible to make useful judgments about the likelihood of positive or negative effects.

The limited positive benefits of the MNCP are also a reflection of the limitations of local management effectiveness where access rights or species' ranges exceed the governance jurisdiction (as is the case for example with wetland and sea birds and most commercial fisheries species). Ensuring positive outcomes for natural capital in these cases is therefore also dependent on national and international governance. The legislative landscape is particularly uncertain at present (especially for fisheries) with the UK's exit from the European Union and the forthcoming Agriculture, Fisheries and Environment Bills. Local management nonetheless remains extremely important, as any reduction in stress will benefit the resilience of species and habitats, and exemplary management practices may be adopted more widely, increasing the scale of benefits to natural capital.

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APPENDIX 3: Full classification for the habitat component of natural capital assets

Table A6. The proposed natural capital asset classification for terrestrial, freshwater and intertidal habitats (UK Habitat Classification Working Group, 2018).

Broad group (UKHab Level 2)	Component (UKHab Level 3)	Type (UKHab Level 4)	Additional detail (UKHab Level 5)
Grassland	Acid grasslands	Lowland dry acid grassland	Inland dunes with open grasslands (H2330)
			Other lowland dry acid grassland
		Upland acid grassland	Montane acid grasslands (H6210)
			Other upland acid grasslands
		Bracken	
		Other lowland grassland	
	Calcareous grasslands	Lowland calcareous grassland	Dry grasslands and scrub on chalk or limestone; lowland (H6210)
			Dry grasslands and scrub on chalk or limestone; important orchid sites (H6210)
		Upland calcareous grassland	Alpine and subalpine calcareous grasslands (H6170)
			Species-rich grassland with mat-grass in upland areas (H6230)
			Dry grasslands and scrub on chalk or limestone; upland (H6210)
	Neutral grasslands	Lowland meadows	Lowland hay meadows (H6510)
		Upland hay meadows	Mountain hay meadows (H6520)
		Other neutral grassland	Arrhenatherum neutral grassland
			Lolium-Cynosurus neutral grassland
			Deschampsia neutral grassland
			Holcus-Juncus neutral grassland
	Modified grassland		
Woodland and forest	Broadleaved, mixed and yew woodlands	Upland oakwood	Western acidic oak woodland (H91A0)
		Upland mixed ashwoods	Lime-maple woodlands of rocky slopes (H9180)
			Other upland mixed ashwoods
		Lowland beech and yew woodland	Beech forests on acid soils (H9120)
			Beech forests on neutral to rich soils (H9130)
			Yew-dominated woodland (H91J0)
			Natural box scrub (H5110)
		Wet woodland	Alder woodland on floodplains (H91E0)
			Bog woodland (H91D0)
		Upland birchwoods	
		Lowland mixed deciduous woodland	Dry oak-dominated woodland (H9190)
			Oak-hornbeam forests (H9160)
			Other Lowland mixed deciduous woodland
		Other woodland; broadleaved	Line of trees
			Other broadleaved woodland types
		Other woodland; mixed	Other woodland; mixed; mainly broadleaved
			Other woodland; mixed; mainly conifer
	Coniferous woodlands	Native pine woodlands	Caledonian forest (H91C0)
		Other Scot's Pine woodland	
		Other coniferous woodland	

Broad group (UKHab Level 2)	Component (UKHab Level 3)	Type (UKHab Level 4)	Additional detail (UKHab Level 5)
Heathland and shrub	Dwarf shrub heath	Lowland Heathland	Dry heaths; lowland (H4030)
			Dry coastal heaths with Cornish heath (H4040)
			Wet heathland with cross-leaved heath; lowland (H4010)
			Wet heathland with Dorset heath and cross-leaved heath (H4020)
		Upland Heathland	Dry heaths; upland (H4030)
			Wet heathland with cross-leaved heath; upland (H4010)
		Mountain heaths and willow scrub	Alpine and subalpine heaths (H4060)
			Mountain willow scrub (H4080)
	Hedgerows	Hedgerow (priority habitat)	
		Other hedgerows	
	Dense scrub	Blackthorn scrub	West coast blackthorn scrub
			Other blackthorn scrub
		Hazel scrub	Atlantic hazel
			Other hazel scrub
		Sea buckthorn scrub	Dunes with sea buckthorn (H2160)
			Other sea buckthorn scrub
		Bramble scrub	
		Gorse scrub	
		Hawthorn scrub	
		Rhododendron scrub	
		Mixed scrub	
Wetland	Bog	Blanket bog	Blanket bog (H7130)
			Degraded blanket bog
		Lowland raised bog	Active raised bogs (H7110)
			Degraded raised bog (H7120)
			Other degraded raised bog
	Fen, marsh and swamp	Lowland fens	Calcium-rich fen dominated by great fen sedge (H7210)
			Hard-water springs depositing lime; lowland (H7220)
			Calcium-rich springwater-fed fens; lowland (H7230)
			Transition mires and quaking bogs; lowland (H7140)
		Purple moor grass and rush pastures	Purple moor-grass meadows (H6410)
		Upland flushes, fens and swamps	Alpine pioneer formations (H7240)
			Hard-water springs depositing lime; upland (H7220)
			Calcium-rich springwater-fed fens; upland (H7230)
			Transition mires and quaking bogs; upland (H7140)
		Aquatic marginal vegetation	
		Reedbeds	
		Other swamps	

Broad group (UKHab Level 2)	Component (UKHab Level 3)	Type (UKHab Level 4)	Additional detail (UKHab Level 5)
Cropland	Arable and horticultural	Arable field margins	Arable margins sown with tussocky grasses
			Arable margins sown with wild flowers or a pollen and nectar mix
			Arable margins cultivated annually with an annual flora
			Game bird mix strips and corners
		Temporary grass and clover leys	
		Cereal crops	Winter stubble
			Game bird mix fields
			Other cereal crops
		Non-cereal crops	Miscanthus
			Short-rotation copppice
			Vineyards
			Other non-cereal crops
		Intensive orchards	
		Horticulture	
Urban	Built up areas and gardens	Open Mosaic Habitats on Previously Developed Land	
		Developed land; sealed surface	Buildings
			Other developed land
		Artificial unvegetated, unsealed surface	
		Suburban/ mosaic of developed/ natural surface	
		Built linear features	
Sparsely vegetated land	Inland rock	Inland rock outcrop and scree habitats	Acidic scree (H8110)
			Base-rich scree (H8120)
			Plants in crevices in base-rich rocks (H8210)
			Plants in crevices in acid rocks (H8220)
			Tall herb communities (H6430)
		Limestone pavement	Limestone pavements (H8240)
		Calaminarian grasslands	Grasslands on soils rich in heavy metals (H6130)
		Other inland rock and scree	
	Supralittoral rock	Maritime cliff and slopes	Vegetated sea cliffs (H1230)
			Soft rock sea cliffs
	Supralittoral sediment	Coastal sand dunes	Humid dune slacks (H2190)
			Dunes with juniper thickets (H2550)
			Embryonic shifting dunes (H2110)
			Shifting dunes with marram (H2120)
			Dune grassland (H2130)
			Lime-deficient dune heathland with crowberry (H2140)
			Coastal dune heathland (H2150)
		Coastal vegetated shingle	Perennial vegetation on coastal shingle (H1220)
			Annual vegetation of drift lines (H1210)

Broad group (UKHab Level 2)	Component (UKHab Level 3)	Type (UKHab Level 4)	Additional detail (UKHab Level 5)
Rivers and lakes	Standing open waters and canals	Eutrophic standing waters	Naturally nutrient-rich lakes or lochs (H3150)
			Other eutrophic standing waters
		Mesotrophic lakes	Calcium-rich nutrient-poor lakes lochs and pools (H3140)
		Oligotrophic and dystrophic lakes	Clear-water lakes or lochs with aquatic vegetation (H3130)
			Nutrient-poor shallow waters with aquatic vegetation on sand (H3110)
		Aquifer fed naturally fluctuating water bodies	
		Canals	
	Rivers and streams	Rivers (priority habitat)	Rivers with floating vegetation (H3260)
			Other priority habitat rivers
		Other rivers and streams	
Marine inlets and transitional waters	Littoral rock	Intertidal chalk	
		Sabellaria alveolata reefs	
		Intertidal underboulder communities	
		Estuarine rocky habitats	
		Splash zone with lichens	
		Other littoral rock	
	Littoral sediment	Coastal saltmarsh	Glasswort and other annuals colonising mud and sand (H1310)
			Cord-grass swards (H1320)
			Atlantic salt meadows (H1330)
			Mediterranean saltmarsh scrub (H1420)
		Blue mussel beds on sediment	
		Seagrass beds [Zostera noltii]	
		Intertidal mudflats	Intertidal mudflats and sandflats (H1140)
		Sheltered muddy gravels	
		Peat and clay exposures with piddocks	
		Saline lagoons	Saline lagoons (H1150)
		Beach	

Table A7. Examples of EUNIS habitat codes applicable to habitats at UKHab Level 4 (UK Habitat Classification Working Group, 2018). Based on Potts et al. (2014) and with the caveat that the relationship is not directly equivalent in all cases.

UKHab categories			
Level 3	**Level 4**	**EUNIS code**	**Description**
t1. Littoral rock	t1a. Intertidal chalk	A1.126, A1.243, A1.441, B3.114, B3.115	Littoral chalk communities
	t1b. Sabellaria alveolata reefs	A2.71, A5.612	Honeycomb worm *Sabellaria alveolata* reef
	t1c. Intertidal underboulder communities	A1.2142, A3.2112	Intertidal under boulder communities
	t1d. Estuarine rocky habitats	A1.32	Estuarine rocky habitats
	t1e. Splash zone with lichens	*Supralittoral habitat (not included in Potts et al., 2014)*	
	t1f. Other littoral rock	A1.1	High energy intertidal rock
		A1.2	Moderate energy intertidal rock
		A1.3	Low energy intertidal rock
t2. Littoral sediment	t2a. Coastal saltmarsh	A2.5	Coastal saltmarshes and saline reedbeds
	t2b. Blue mussel beds on sediment	A2.2, A2.7	Blue Mussel beds
	t2c. Seagrass beds [Zostera noltii]	A2.61	Seagrass beds
	t2d. Intertidal mudflats	A2.3	Intertidal mud
		A2.2	Intertidal sand and muddy sand
	t2e. Sheltered muddy gravels	A5.43, A2.41, A2.42, A5.44	Sheltered muddy gravels
	t2f. Peat and clay exposures with piddocks	A1.127, A1.223, A4.231	Peat and clay exposures
	t2g. Saline lagoons	X02	Saline lagoons
	t2h. Beach	A2.2	Intertidal sand and muddy sand

Table A8. The truncated EUNIS classification proposed for identifying key marine habitats (Adapted from https://eunis.eea.europa.eu/habitats-code-browser.jsp)

Broad group (EUNIS Level 1)	Component (EUNIS Level 2)	Type (EUNIS Level 3)	Additional detail (EUNIS Level 4)
Sublittoral habitats	A3. Infralittoral rock and other hard substrata	A3.1. Atlantic and Mediterranean high energy infralittoral rock	A3.11-15. Kelp, seaweed and algal communities
		A3.2. Atlantic and Mediterranean moderate energy infralittoral rock	A3.21-22. Kelp and seaweed communities
			A3.24. Faunal communities
		A3.3. Atlantic and Mediterranean low energy infralittoral rock	A3.31-34. Kelp, fucoid and seaweed communities
			A3.35-36. Faunal communities
		A3.7. Features of infralittoral rock	A3.71. Robust faunal cushions and crusts in surge gullies and caves
			A3.72. Infralittoral fouling seaweed communities
			A3.73. Vents and seeps in infralittoral rock
			A3.74. Caves and overhangs in infralittoral rock
	A4. Circalittoral rock and other hard substrata	A4.1. Atlantic and Mediterranean high energy circalittoral rock	A4.11-13. Faunal, sponge and faunal turf communities
		A4.2. Atlantic and Mediterranean moderate energy circalittoral rock	A4.21. Echinoderms and crustose communities on circalittoral rock
			A4.22. Sabellaria reefs on circalittoral rock
			A4.24. Mussel beds on circalittoral rock
			A4.23, 25, 27. Other faunal communities
		A4.3. Atlantic and Mediterranean low energy circalittoral rock	A4.31 & A4.33. Brachiopod, ascidian and other faunal communities
		A4.7. Features of circalittoral rock	A4.71. Communities of circalittoral caves and overhangs
			A4.72. Circalittoral fouling faunal communities
			A4.73. Vents and seeps in circalittoral rock
	A5. Sublittoral sediment	A5.1. Sublittoral coarse sediment	
		A5.2. Sublittoral sand	
		A5.3. Sublittoral mud	
		A5.4. Sublittoral mixed sediments	
		A5.5. Sublittoral macrophyte-dominated sediment	A5.51. Maerl beds
			A5.52. Kelp and seaweed communities on sublittoral sediment
			A5.53. Sublittoral seagrass beds
			A5.54. Angiosperm communities in reduced salinity
		A5.6. Sublittoral biogenic reefs	A5.61. Sublittoral polychaete worm reefs on sediment
			A5.62. Sublittoral mussel beds on sediment
			A5.63. Circalittoral coral reefs
		A5.7. Features of sublittoral sediments	A5.71. Seeps and vents in sublittoral sediments
			A5.72. Organically-enriched or anoxic sublittoral habitats
	A7. Pelagic water column	A7.1. Neuston	
		A7.2. Completely mixed water column with reduced salinity	
		A7.3. Completely mixed water column with full salinity	
		A7.4. Partially mixed water column with reduced salinity and medium or long residence time	
		A7.5. Unstratified water column with reduced salinity	
		A7.6. Vertically stratified water column with reduced salinity	
		A7.7. Fronts in reduced salinity water column	
		A7.8. Unstratified water column with full salinity	
		A7.9. Vertically stratified water column with full salinity	
		A7.A. Fronts in full salinity water column	

APPENDIX 4: Common International Classification of Ecosystem Services

Table A9. A summary of the Common International Classification of Ecosystem Services (CICES) v.5.1 (Haines-Young and Potschin, 2018)

Ecosystem Services		Examples*
Provisioning		
Food	• Cultivated and wild harvested terrestrial and aquatic plants	• Wheat, edible seaweed
	• Reared and wild capture animals and aquatic animals	• Beef cattle, mussels
	• Mineral and non-mineral substances	• Salt
Fibres and other materials (for direct use)	• Cultivated and wild harvested terrestrial and aquatic plants	• Timber
	• Reared and wild capture animals and aquatic animals	• Oyster pearls, hides
	• Mineral and non-mineral substances	• Pigments
Energy	• Cultivated and wild harvested terrestrial and aquatic plants	• Biofuel crops
	• Reared and wild capture animals and aquatic animals	• Biofuel from manure
	• Surface and ground water	• Hydro-electricity
	• Coastal and marine waters	• Tidal and wave power
	• Mineral and non-mineral substances	• Wind, solar, geothermal energy
Genetic materials	• Seeds, spores and other plant and animal material	• Spat for aquaculture
	• Higher and lower plants and wild animals (whole organisms)	• Animals in breeding programmes
	• Individual genes	• For pharmaceutical products
Water (surface and ground)	• Drinking	• Drinking water
	• Non-drinking purposes	• Agricultural irrigation
Regulation and Maintenance		
Mediation of waste or toxic substances	• Bioremediation by micro-organisms, algae, plants, and animals	• Bacterial breakdown of oil
	• Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals and mineral substances	• Trapping of dust by urban trees and particles by salt marsh
	• Dilution by freshwater, marine systems and the atmosphere	• Use as a pollution sink
Mediation of nuisances	• Smell reduction	• Vegetated shelter belts around animal lots, motorways, industrial structures
	• Noise attenuation	
	• Visual screening	• Screening effect of topography
Regulation of flows and extreme events	• Control of erosion rates	• Vegetation providing soil stability
	• Control of mass movement	• Forest cover mitigating avalanche
	• Flood control	• Vegetation slowing water release, natural levees providing protection
	• Coastal protection	• Biogenic reefs and sand bars attenuating waves
	• Wind protection	• Trees/topography providing wind break
	• Fire protection	• Fire belts in forests
Lifecycle maintenance, gene pool protection	• Pollination (or gamete dispersal in a marine context)	• Habitat for native pollinators
	• Seed dispersal	• Acorn dispersal by Jays
	• Maintaining nursery populations	• Seaweed rafts as juvenile fish habitat
Pest and disease control	• Pest control (including invasive species)	• Recovery of predator populations
	• Disease control	• Microbes to control crop diseases
Regulation of soil quality	• Weathering processes	• Inorganic nutrient release
	• Decomposition and fixing processes	• Nitrogen fixation by legumes
Regulation of water quality	• Regulation of freshwater	• Buffer strips to filter nutrients
	• Regulation of salt water	• Eutrophication resistance/resilience
Regulation of atmospheric conditions	• Carbon sequestration	• Carbon storage by forests, peatlands
	• Temperature regulation	• Cooling provided by urban trees
Cultural		
Direct physical and experiential interactions	• Active recreation/leisure interaction	• Opportunities for hiking, climbing
	• Passive or observational recreation/leisure interaction	• Opportunities for wildlife watching
	• Scientific investigation or creation of traditional knowledge	• Opportunities for research/study
	• Education and training	• Volunteer conservation activities
	• Culture and heritage	• Ancient woodlands
	• Aesthetic experiences	• Areas of outstanding natural beauty
Indirect, remote interactions	• Symbolic meanings	• Species used as national symbols
	• Sacred or religious meanings	• Totemic species, iconic mountains
	• Entertainment or representation	• Media features
	• Existence, bequest and option value	• Wilderness areas, charismatic or endangered species

* It is important to note that the original wording within CICES emphasises that ecosystem services are ecological end points (e.g. standing crops of wheat, not the harvested quantity).

Table A10. The complete list of ecosystem service classes defined by the Common International Classification of Ecosystem Services (CICES; Haines-Young and Potschin, 2018)

a) Provisioning services

Provisioning (Biotic)

- Biomass
  - Cultivated terrestrial plants for nutrition, materials or energy
    - Cultivated terrestrial plants (including fungi, algae) grown for nutritional purposes
    - Fibres and other materials from cultivated plants, fungi, algae and bacteria for direct use or processing (excluding genetic materials)
    - Cultivated plants (including fungi, algae) grown as a source of energy
  - Cultivated aquatic plants for nutrition, materials or energy
    - Plants cultivated by in- situ aquaculture grown for nutritional purposes
    - Fibres and other materials from in-situ aquaculture for direct use or processing (excluding genetic materials)
    - Plants cultivated by in- situ aquaculture grown as an energy source
  - Reared animals for nutrition, materials or energy
    - Animals reared for nutritional purposes
    - Fibres and other materials from reared animals for direct use or processing (excluding genetic materials)
    - Animals reared to provide energy (including mechanical)
  - Reared aquatic animals for nutrition, materials or energy
    - Animals reared by in-situ aquaculture for nutritional purposes
    - Fibres and other materials from animals grown by in-situ aquaculture for direct use or processing (excluding genetic materials)
    - Animals reared by in-situ aquaculture as an energy source
  - Wild plants (terrestrial and aquatic) for nutrition, materials or energy
    - Wild plants (terrestrial and aquatic, including fungi, algae) used for nutrition
    - Fibres and other materials from wild plants for direct use or processing (excluding genetic materials)
    - Wild plants (terrestrial and aquatic, including fungi, algae) used as a source of energy
  - Wild animals (terrestrial and aquatic) for nutrition, materials or energy
    - Wild animals (terrestrial and aquatic) used for nutritional purposes
    - Fibres and other materials from wild animals for direct use or processing (excluding genetic materials)
    - Wild animals (terrestrial and aquatic) used as a source of energy
- Genetic material from all biota (including seed, spore or gamete production)
  - Genetic material from plants, algae or fungi
    - Seeds, spores and other plant materials collected for maintaining or establishing a population
    - Higher and lower plants (whole organisms) used to breed new strains or varieties
    - Individual genes extracted from higher and lower plants for the design and construction of new biological entities
  - Genetic material from animals
    - Animal material collected for the purposes of maintaining or establishing a population
    - Wild animals (whole organisms) used to breed new strains or varieties
    - Individual genes extracted from organisms for the design and construction of new biological entities

Provisioning (Abiotic)

- Water
  - Surface water used for nutrition, materials or energy
    - Surface water for drinking
    - Surface water used as a material (non-drinking purposes)
    - Freshwater surface water used as an energy source
    - Coastal and marine water used as energy source
  - Ground water used for nutrition, materials or energy
    - Ground water (and subsurface) used as a material (non-drinking purposes)
    - Ground water (and subsurface) used as a material (non-drinking purposes)
    - Ground water (and subsurface) used as an energy source
- Non-aqueous natural abiotic ecosystem outputs
  - Mineral substances used for nutrition, materials or energy
    - Mineral substances used for nutritional purposes
    - Mineral substances used for material purposes
    - Mineral substances used for as an energy source
  - Non-mineral substances or ecosystem properties used for nutrition, materials or energy
    - Non-mineral substances or ecosystem properties used for nutritional purposes
    - Non-mineral substances used for materials
    - Wind energy
    - Solar energy
    - Geothermal energy

b) Regulation and Maintenance

Regulation & Maintenance (Biotic)

- Transformation of biochemical or physical inputs to ecosystems
  - Mediation of wastes or toxic substances of anthropogenic origin by living processes
    - Bio-remediation by micro-organisms, algae, plants, and animals
    - Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals
  - Mediation of nuisances of anthropogenic origin
    - Smell reduction
    - Noise attenuation
    - Visual screening
- Regulation of physical, chemical, biological conditions
  - Regulation of baseline flows and extreme events
    - Control of erosion rates
    - Buffering and attenuation of mass movement
    - Hydrological cycle and water flow regulation (Including flood control, and coastal protection)
    - Wind protection
    - Fire protection
  - Lifecycle maintenance, habitat and gene pool protection
    - Pollination (or 'gamete' dispersal in a marine context)
    - Seed dispersal
    - Maintaining nursery populations and habitats (Including gene pool protection)
  - Pest and disease control
    - Pest control (including invasive species)
    - Disease control
  - Regulation of soil quality
    - Weathering processes and their effect on soil quality
    - Decomposition and fixing processes and their effect on soil quality
  - Water conditions
    - Regulation of the chemical condition of freshwaters by living processes
    - Regulation of the chemical condition of salt waters by living processes
  - Atmospheric composition and conditions
    - Regulation of chemical composition of atmosphere and oceans
    - Regulation of temperature and humidity, including ventilation and transpiration

Regulation & Maintenance (Abiotic)

- Transformation of biochemical or physical inputs to ecosystems
  - Mediation of waste, toxics and other nuisances by non-living processes
    - Dilution by freshwater and marine ecosystems
    - Dilution by atmosphere
    - Mediation by other chemical or physical means (e.g. via Filtration, sequestration, storage or accumulation)
  - Mediation of nuisances of anthropogenic origin
    - Mediation of nuisances by abiotic structures or processes
- Regulation of physical, chemical, biological conditions
  - Regulation of baseline flows and extreme events
    - Mass flows
    - Liquid flows
    - Gaseous flows
  - Maintenance of physical, chemical, abiotic conditions
    - Maintenance and regulation by inorganic natural chemical and physical processes

c) Cultural services

Cultural (Biotic)

- Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting
  - Physical and experiential interactions with natural environment
    - Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions
    - Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through passive or observational interactions
  - Intellectual and representative interactions with natural environment
    - Characteristics of living systems that enable scientific investigation or the creation of traditional ecological knowledge
    - Characteristics of living systems that enable education and training
    - Characteristics of living systems that are resonant in terms of culture or heritage
    - Characteristics of living systems that enable aesthetic experiences
- Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting
  - Spiritual, symbolic and other interactions with natural environment
    - Elements of living systems that have symbolic meaning
    - Elements of living systems that have sacred or religious meaning
    - Elements of living systems used for entertainment or representation
  - Other biotic characteristics that have a non-use value
    - Characteristics or features of living systems that have an existence value
    - Characteristics or features of living systems that have an option or bequest value

Cultural (Abiotic)

- Direct, in-situ and outdoor interactions with natural physical systems that depend on presence in the environmental setting
  - Physical and experiential interactions with natural abiotic components of the environment
    - Natural, abiotic characteristics of nature that enable active or passive physical and experiential interactions
  - Intellectual and representative interactions with abiotic components of the natural environment
    - Natural, abiotic characteristics of nature that enable intellectual interactions
- Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting
  - Spiritual, symbolic and other interactions with the abiotic components of the natural environment
    - Natural, abiotic characteristics of nature that enable spiritual, symbolic and other interactions
  - Other abiotic characteristics that have a non-use value
    - Natural, abiotic characteristics or features of nature that have either an existence, option or bequest value

Note. *The arrangement of the hierarchy levels is as follows:*

Section

- Division
  - Group
    - Class

APPENDIX 5: Ecosystem Services Classification Hierarchy

Table A11. The complete ecosystem service hierarchy proposed for Sustainability Appraisal, (developed from Sunderland et al., 2018 and Haines-Young and Potschin, 2018).

a) Provisioning services

Level 2	Level 3	Level 4 (CICES class)
Food	Cultivated food crops	Cultivated terrestrial plants (including fungi, algae) grown for nutritional purposes
	Livestock	Animals reared for nutritional purposes
	Cultivated seafood	Plants cultivated by in- situ aquaculture grown for nutritional purposes
		Animals reared by in-situ aquaculture for nutritional purposes
	Foraged plants	Wild plants (terrestrial and aquatic, including fungi, algae) used for nutrition
	Game and wild fish	Wild animals (terrestrial and aquatic) used for nutritional purposes
	Food products from non-living sources	Mineral substances used for nutritional purposes
		Non-mineral substances or ecosystem properties used for nutritional purposes
Materials	Non-food products from plants, animals & algae	Fibres and other materials from cultivated plants, fungi, algae and bacteria for direct use or processing (excluding genetic materials)
		Fibres and other materials from in-situ aquaculture for direct use or processing (excluding genetic materials)
		Fibres and other materials from reared animals for direct use or processing (excluding genetic materials)
		Fibres and other materials from animals grown by in-situ aquaculture for direct use or processing (excluding genetic materials)
		Fibres and other materials from wild plants for direct use or processing (excluding genetic materials)
		Fibres and other materials from wild animals for direct use or processing (excluding genetic materials)
	Non-food products from non-living sources	Mineral substances used for material purposes
		Non-mineral substances used for materials
	Genetic resources	Seeds, spores and other plant materials collected for maintaining or establishing a population
		Higher and lower plants (whole organisms) used to breed new strains or varieties
		Individual genes extracted from higher and lower plants for the design and construction of new biological entities
		Animal material collected for the purposes of maintaining or establishing a population
		Wild animals (whole organisms) used to breed new strains or varieties
		Individual genes extracted from organisms for the design and construction of new biological entities
Water	Water supply	Surface water for drinking
		Surface water used as a material (non-drinking purposes)
		Ground (and subsurface) water for drinking
		Ground water (and subsurface) used as a material (non-drinking purposes)
Energy	Energy from non-living sources	Freshwater surface water used as an energy source
		Coastal and marine water used as energy source
		Ground water (and subsurface) used as an energy source
		Wind energy
		Solar energy
		Geothermal
		Mineral substances used as an energy source
		Other mineral or non-mineral substances or ecosystem properties used for nutrition, materials or energy
	Energy from plants	Cultivated plants (including fungi, algae) grown as a source of energy
		Plants cultivated by in- situ aquaculture grown as an energy source
		Wild plants (terrestrial and aquatic, including fungi, algae) used as a source of energy
	Energy from animals	Animals reared to provide energy (including mechanical)
		Animals reared by in-situ aquaculture as an energy source
		Wild animals (terrestrial and aquatic) used as a source of energy
Carrier	Commercial and other transport	*Not included within CICES*

b) Regulation and maintenance services

Level 2	Level 3	Level 4 (CICES class)
Environmental quality	Water quality	Bio-remediation by micro-organisms, algae, plants, and animals
		Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals
		Regulation of the chemical condition of freshwaters by living processes
		Regulation of the chemical condition of salt waters by living processes
		Dilution by freshwater and marine ecosystems
		Mediation by other chemical or physical means (e.g. via Filtration, sequestration, storage or accumulation)
		Mediation of nuisances by abiotic structures or processes
		Maintenance and regulation by inorganic natural chemical and physical processes
	Air quality	Bio-remediation by micro-organisms, algae, plants, and animals
		Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals
		Smell reduction
		Dilution by atmosphere
		Mediation by other chemical or physical means (e.g. via Filtration, sequestration, storage or accumulation)
	Soil health	Weathering processes and their effect on soil quality
		Decomposition and fixing processes and their effect on soil quality
Maintaining wild populations	Pollination & seed dispersal	Pollination (or 'gamete' dispersal in a marine context)
		Seed dispersal
	Maintenance of nursery populations and habitats	Maintaining nursery populations and habitats (Including gene pool protection)
Hazard and nuisance reduction	Erosion control	Control of erosion rates
		Buffering and attenuation of mass movement
		Mass flows
	Flood protection	Hydrological cycle and water flow regulation (Including flood control, and coastal protection)
		Liquid flows
	Storm protection	Wind protection
		Gaseous flows
	Pest and disease control	Pest control (including invasive species)
		Disease control
	Fire protection	Fire protection
	Noise reduction	Noise attenuation
	Visual screening	Visual screening
Climate regulation	Climate regulation	Regulation of chemical composition of atmosphere and oceans
		Regulation of temperature and humidity, including ventilation and transpiration

c) Cultural services

Level 2	Level 3	Level 4 (CICES class)
Physical, experiential and intellectual interactions	Recreation, tourism, other experiential opportunities	Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions
		Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through passive or observational interactions
		Natural, abiotic characteristics of nature that enable active or passive physical and experiential interactions
	Scientific, educational opportunities	Characteristics of living systems that enable scientific investigation or the creation of traditional ecological knowledge
		Characteristics of living systems that enable education and training
Cultural significance of nature	Aesthetic	Characteristics of living systems that enable aesthetic experiences
	Heritage, spiritual and representational significance	Characteristics of living systems that are resonant in terms of culture or heritage
		Elements of living systems that have symbolic meaning
		Elements of living systems that have sacred or religious meaning
		Elements of living systems used for entertainment or representation
		Natural, abiotic characteristics of nature that enable intellectual interactions
		Natural, abiotic characteristics of nature that enable spiritual, symbolic and other interactions
Non-use values	Existence, bequest and option values	Characteristics or features of living systems that have an existence value
		Characteristics or features of living systems that have an option or bequest value
		Natural, abiotic characteristics or features of nature that have either an existence, option or bequest value